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<th>Course Code</th>
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<tr>
<td>BIOST 2000</td>
<td>TEACHING PRACTICUM</td>
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<tr>
<td>BIOST 2011</td>
<td>PRINCIPS STATISTICAL REASNING - RECITATION</td>
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<td>BIOST 2015</td>
<td>ELEMENTS STATISTICAL LEARNING</td>
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<td>BIOST 2016</td>
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<td>BIOST 2018</td>
<td>STATISTICAL FDS BIOINF DATA MINING</td>
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### BIOST 2000 TEACHING PRACTICUM

This course will provide doctoral students with an opportunity to obtain teaching experience. This course is intended for doctoral students during their dissertation stage. Teaching experience will enhance the professional growth of students. Students will further develop oral and written communication skills and an art for explaining material, which is an integral part of a biostatistician's career.

### BIOST 2011 PRINCIPS STATISTICAL REASNING - RECITATION

Classroom instruction usually associated with a lecture which facilitates interaction between the student and the instructor.

Recitation for BIOST 2011 effective 2016, Term 2171
(When enrolling in BIOST 2011 you will also enroll in one of the two required Recitations)

### BIOST 2015 ELEMENTS STATISTICAL LEARNING

The purpose of the course is to present the theory and practice of statistical learning algorithms, placing "Statistical Learning" or "Data Mining" techniques in the proper context with regard to their origins in simple classical methods like linear regression, to clarify the strengths and weaknesses from theoretical and practical sides. "Supervised Learning" techniques studied include using regularization and Bayesian methods kernel methods, basis function methods, neural networks, support vector machines, additive trees, boosting, bootstrap-based methods. Unsupervised learning techniques studied include cluster analysis self-organizing maps, independent component analysis and projection pursuit.

### BIOST 2016 SAMPLING DESIGN AND ANALYSIS

**Prerequisite(s):** BIOST 2011 or BIOST 2041 and BIOST 2093

This is an applied statistical methods course designed to provide students with a working knowledge of introductory and intermediate-level sampling designs and associated methods of statistical analysis along with a basic understanding of the theoretical underpinnings. Students will also learn survey procedures in the SAS and STATA software packages. Emphasis is placed on sampling human populations in large communities. Lecture topics include: simple probability samples, stratified sampling, ratio and regression estimation, cluster sampling, sampling with unequal probabilities, variance estimation and weighting in complex surveys, two-phase sampling, estimating population size and estimation of rare populations and small areas. The course will consist of two weekly 1.5 hour lectures including two special classes devoted to using SAS and STATA.

(A working knowledge of first-term level calculus (e.g. BIOST 2081) is recommended but not required.)

### BIOST 2018 STATISTICAL FDS BIOINF DATA MINING

COURSE INTRODUCES DATA ANALYSIS METHODS WIDELY USED OR GAINING USE IN BIOINFORMATICS. METHODS DEAL WITH PREDICTION, CLASSIFICATION, OPTIMIZATION, AND CLUSTERING; INCLUDE CLASSIFICATION TREES, FLEXIBLE VARIETIES OF DISCRIMINANT ANALYSIS INCLUDING SUPPORT VECTOR MACHINES, EM ALGORITHM AND MONTE CARLO MARKOV CHAIN, BOOTSTRAP AND BAGGING, BOOSTING AND SELF-ORGANIZING MAPS. METHODS ARE IN CONTEXT OF PRINCIPLES AND MODELS OF STATISTICAL SCIENCE, WITH EMPHASIS ON BAYESIAN METHODS. EXAMPLES ARE FROM MICROARRAYS, ANALYSIS OF GENETIC NETWORKS, PROTEONICS, COMPUTATIONAL PHARMACOLOGY AND RESEARCH TEXT MINING.
QUALIFIED STUDENTS MAY UNDERTAKE ADVANCED WORK OR RESEARCH WITH THE APPROVAL AND UNDER THE GUIDANCE OF A MEMBER OF THE STAFF.

BIOMETRY SEMINARS INTRODUCE THE STUDENTS TO CURRENT HEALTH PROBLEMS INVOLVING THE APPLICATION AND DEVELOPMENT OF BIOSTATISTICS METHODS AND THEORY.

COVERS GENERATING FUNCTIONS AND CONVOLUTIONS OF RANDOM VARIABLES, THE POISSON AND COMPOUND POISSON DISTRIBUTIONS, BRANCHING PROCESSES, RANDOM WALK, AND THE GAMBLER'S RUIN PROBLEM, MARKOV CHAINS, AND SIMPLE BIRTH AND DEATH PROCESSES.

DISCUSSES TECHNIQUES FOR THE APPLICATION OF STATISTICAL THEORY TO ACTUAL DATA. TOPICS INCLUDE PROBABILITY THEORY, ESTIMATION OF PARAMETERS, AND TESTS OF HYPOTHESIS FOR BOTH THE DISCRETE AND CONTINUOUS CASE.

CLASSROOM INSTRUCTION USUALLY ASSOCIATED WITH A LECTURE WHICH FACILITATES INTERACTION BETWEEN THE STUDENT AND THE INSTRUCTOR.

CLASSROOM INSTRUCTION USUALLY ASSOCIATED WITH A LECTURE WHICH FACILITATES INTERACTION BETWEEN THE STUDENT AND THE INSTRUCTOR.

MORE TECHNIQUES ARE GIVEN FOR THE APPLICATION OF STATISTICS TO ACTUAL DATA WITH EMPHASIS ON DISTRIBUTION-FREE AND MULTIVARIATE METHODS. INTERPRETATION OF RESULTS AND CONCEPTS WILL BE STRESSED.

COVERS JOINT, MARGINAL, AND CONDITIONAL PROBABILITIES; DISTRIBUTIONS OF RANDOM VARIABLES AND FUNCTIONS OF RANDOM VARIABLES; EXPECTATIONS OF RANDOM VARIABLES AND MOMENT GENERATING FUNCTIONS; LAW OF LARGE NUMBERS; CENTRAL LIMIT THEOREM.
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<tr>
<td>BIOST 2044</td>
<td>INTRO TO STATISTICAL THEORY 2</td>
<td>03.0</td>
<td>BIOST 2043</td>
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<td></td>
<td>Covers elements of statistical inference; sampling distributions of estimators; Rao-Cramér's inequality; problems of testing statistical hypotheses; Neyman-Pearson Lemma; likelihood ratio tests.</td>
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<td>BIOST 2046</td>
<td>ANALYSIS OF COHORT STUDIES</td>
<td>03.0</td>
<td>BIOST 2042 and BIOST 2049</td>
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<td>This introductory applied course in statistical modeling focuses on maximum likelihood and related regression methods for the analysis of cohort data. Topics include generalized linear models, generalized estimating equations, and generalized linear mixed models. The course emphasizes logistic and Poisson regression, and discrete survival models with time-dependent covariates. Students analyze several cohort data sets, assess the adequacy of their models, and interpret their results.</td>
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<tr>
<td>BIOST 2049</td>
<td>APPLIED REGRESSION ANALYSIS</td>
<td>03.0</td>
<td>BIOST 2042</td>
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<td>Deals with basic analytic techniques of regression analysis with special emphasis on valid interpretations of results using such techniques. Analysis with computer packaged programs is stressed.</td>
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<tr>
<td>BIOST 2051</td>
<td>STATISTICAL ESTIMATION THEORY</td>
<td>03.0</td>
<td>BIOST 2042 and BIOST 2044</td>
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<td>Fisher's information; Rao-Cramér inequality and sufficient statistics; Bhattacharyya bounds; Rao-Blackwell theorem; methods of moments; the method of maximum likelihood; Newton-Raphson method and Rao's scoring for parameters; estimation of several parameters; order statistics and life-testing problems; estimation with censored data and survival analysis.</td>
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<tr>
<td>BIOST 2052</td>
<td>MULTIVARIATE ANALYSIS</td>
<td>03.0</td>
<td>BIOST 2044</td>
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<td>Multivariate normal distribution, estimation of the mean vector and covariance matrix, distributions and uses of simple, partial and multiple correlation correlation coefficients, the generalized t2 statistic, the distribution of the sample generalized variance, multivariate analysis of variance and the multivariate Behrens-Fisher problem. Multivariate methods are applied to repeated measures analysis, factor analysis, and discriminant analysis. The beginning of the course emphasizes theory. Later applications and computational methods are emphasized. Lectures are of current and classical literature. Prerequisite: Biost 2044 or permission of instructor.</td>
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<tr>
<td>BIOST 2054</td>
<td>SURVIVAL ANALYSIS</td>
<td>03.0</td>
<td>BIOST 2042 and BIOST 2044</td>
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<td>Introduces the student to the design considerations and statistical analysis of clinical trials. Covers the theoretical aspects of various models in reliability theory and the proportional hazards model, as well as the more applied problems of interpreting specific data sets and designing large-scale trials.</td>
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<tr>
<td>BIOST 2055</td>
<td>INTROD GONMC ANAL 1: APPLCS</td>
<td>03.0</td>
<td>BIOST 2094</td>
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<td>This 3-credit course is a graduate level introduction and overview of modern high-throughput genomic data analysis. It is designed for graduate students in biostatistics and human genetics who are interested in the technology and elementary data mining of high-throughput genomic data (including but not limited to classical expression arrays, various array-based applications, next-generation sequencing and proteomics). The course is also helpful for biology students with basic quantitative training (e.g. two elementary statistics courses and R programming) who have interests in understanding the intuition and logic underlying the data analysis methods. R is the major language used in the course.</td>
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BIOST 2056 INTRO TO DIAG TEST EVAL & ROC  Credit(s): 03.0
Prerequisite(s): BIOST 2041 and BIOST 2042 and BIOST 2043 and BIOST 2044
THE COURSE OFFERS AN INTRODUCTION TO CONCEPTS AND APPROACHES FOR STATISTICAL ASSESSMENT OF DIAGNOSTIC SYSTEMS AND ROC ANALYSIS. THE COVERED MATERIAL INCLUDES DIFFERENT MEASURES OF DIAGNOSTIC ACCURACY, ASPECTS OF THE DESIGN OF ACCURACY STUDIES, STATISTICAL ESTIMATION AND HYPOTHESIS TESTING, SAMPLE SIZE CALCULATION AND SOME ADVANCED TOPICS. GENERAL PREREQUISITES INCLUDE KNOWLEDGE OF BASIC STATISTICAL CONCEPTS AND APPROACHES RELATED TO ESTIMATION AND HYPOTHESIS TESTING; SOME KNOWLEDGE OF REGRESSION MODELING AND SAS IS DESIRABLE. (Prerequisites: Bio 2041, 2042, 2043, 2044)

BIOST 2058 SCIENTIFIC COMMUNICATION SKILLS  Credit(s): 02.0
THIS COURSE IS MEANT TO HELP STUDENTS DEVELOP ORAL, VISUAL AND WRITTEN SCIENTIFIC COMMUNICATION SKILLS AND TO FAMILIARIZE STUDENTS WITH RESEARCH RESOURCES. STUDENTS MAY USE THEIR OWN RESEARCH TOPIC, INCLUDING WORK ON A THESIS OR DISSERTATION, OR HELP WILL BE PROVIDED IN SELECTING ONE.

BIOST 2061 LIKELIHOOD THEORY & APPLICATN  Credit(s): 02.0
Prerequisite(s): BIOST 2044
THE PURPOSE OF THIS COURSE IS TO INTRODUCE THE STUDENT TO MODERN LIKELIHOOD THEORY AND ITS APPLICATIONS. THE COURSE WILL COVER MAXIMUM LIKELIHOOD THEORY, PROFILE LIKELIHOOD THEORY, PSEUDO LIKELIHOOD THEORY AND GENERALIZED ESTIMATING EQUATIONS. THE COURSE IS TAUGHT AT A DOCTORAL LEVEL AND MUCH OF THE THEORY IS ILLUSTRATED THROUGH APPLICATIONS.

BIOST 2062 CLINICAL TRIALS: METHODS & PRACT  Credit(s): 03.0
COURSE CONSISTS OF TWO WEEKLY LECTURES, POSTED ON THE WEB IN ADVANCE, AND TWO IN-CLASS SESSIONS WHICH CONSIST OF QUESTIONS AND ANSWERS RELATED TO THE WEB-BASED INFORMATION, PROBLEM-SOLVING, OR DISCUSSION OF CASE STUDIES. IT COVERS FUNDAMENTAL CONCEPTS IN THE DESIGN AND CONDUCT OF MODERN CLINICAL TRIALS. TOPICS INCLUDE: EXPERIMENTAL DESIGNS FOR SAFETY AND EFFICACY TRIALS, QUANTITATIVE METHODS FOR DESIGN, INTERIM MONITORING, AND ANALYSIS OF RANDOMIZED COMPARATIVE CLINICAL TRIALS INCLUDING CROSSOVER, FACTORIAL AND EQUIVALENCE DESIGNS, ETHICAL, ORGANIZATIONAL, AND PRACTICAL CONSIDERATIONS OF DESIGN AND CONDUCT OF SINGLE AND MULTICENTER STUDIES ARE INTEGRATED IN LECTURES AND CASE STUDIES. THE COURSE ALSO COVERS INTERNATIONAL GUIDELINES ON STATISTICAL CONSIDERATIONS FOR DRUG DEVELOPMENT, GUIDELINES ADOPTED FOR PUBLICATION OF TRIALS IN MAJOR MEDICAL JOURNALS, AND RECOMMENDED APPROACHES FOR META-ANALYSES.

BIOST 2065 ANALYSIS OF INCOMPLETE DATA  Credit(s): 03.0
Prerequisite(s): BIOST 2049 and BIOST 2051 and BIOST 2061
THIS COURSE WILL PRESENT MISSING DATA PROBLEMS IN STATISTICS AND DISCUSS NAIVE METHODS SUCH AS COMPLETE CASE ANALYSIS, AVAILABLE CASE ANALYSIS AND IMPUTATION; STANDARD LIKELIHOOD-BASED METHODS, THEORY AND APPLICATION OF MULTIPLE IMPUTATION, DATA AUGMENTATION, GIBBS SAMPLER, AND SOME RECENTLY DEVELOPED METHODOLOGIES IN THE MISSING DATA LITERATURE AND RELATED FIELDS.

BIOST 2066 APLD SURVIVAL ANAL METHS & PRA  Credit(s): 03.0
Prerequisite(s): BIOST 2042 and BIOST 2049
THIS COURSE COVERS FUNDAMENTAL CONCEPTS AND METHODS IMPORTANT FOR ANALYSIS OF DATASETS WHERE THE OUTCOME IS THE TIME TO AN EVENT OF INTEREST, SUCH AS DEATH, DISEASE OCCURRENCE OR DISEASE PROGRESSION. TOPICS INCLUDE: BASIC METHODS FOR SUMMARIZING AND PRESENTING TIME-TO-EVENT DATA IN TABULAR FORM AND GRAPHICALLY AS LIFE TABLES, NON-PARAMETRIC STATISTICAL TECHNIQUES FOR TESTING HYPOTHESES COMPARING LIFE TABLES FOR TWO OR MORE GROUPS; APPROACHES TO FITTING THE SEMI-PARAMETRIC COX PROPORTIONAL HAZARD MODEL AND OTHER COMMONLY USED PARAMETRIC MODELS THAT INCORPORATE STUDY COVARIABLES, METHODS FOR ASSESSING GOODNESS-OF-FIT OF THE MODELS, AND SAMPLE SIZE CONSIDERATIONS. IN ADDITION TO DIDACTIC LECTURES, THERE ARE GROUP PROJECTS THAT INVOLVE ANALYSIS OF DATASETS AND PRESENTATION OF ANALYTIC REPORTS IN THE CLASSROOM.

BIOST 2077 SPECIAL TOPICS  Credit(s): 03.0
INTRODUCES THE STUDENT TO SPECIALIZED TOPICS IN BIOSTATISTICS THAT ARE NOT COVERED IN THE FORMAL CURRICULUM.
BIOST 2078 INT GNOMC ANAL 2: THRY ALGRTHM  
Prerequisite(s): BIOST 2041 and BIOST 2042 and BIOST 2055 and BIOST 2094  
Credit(s): 03.0

THIS COURSE IS A GRADUATE LEVEL COURSE TO INTRODUCE THEORIES AND ALGORITHMS FOR STATISTICAL ANALYSIS OF HIGH-THROUGHPUT GENOMIC DATA. EMPHASES WILL BE GIVEN TO HIGH-DIMENSIONAL DATA ANALYSIS AND THEORIES BEHIND THE COMMONLY USED METHODS. IT IS DESIGNED FOR GRADUATE STUDENTS WHO ALREADY HAVE SUFFICIENT STATISTICAL BACKGROUND, HAVE BASIC KNOWLEDGE OF VARIOUS HIGH-THROUGHPUT GENOMIC EXPERIMENTS AND WISH TO LEARN ADVANCED STATISTICAL THEORIES FOR BIOINFORMATICS AND GENOMICS RESEARCH. 
[Prequisites: Biost 2041 and 2042 or equivalent; proficiency in R programming (Biost 2094 Statistical Computing in R) and high-throughput genomic data analysis experiences (Biost 2055).]

BIOST 2081 MATHEMATICAL METHODS FOR STAT  
Credit(s): 03.0

DIFFERENTIATION AND INTEGRATION OF FUNCTIONS OF SEVERAL VARIABLES. INFINITE SEQUENCES AND SERIES. FUNDAMENTALS OF MATRIX ALGEBRA. CLASS EXAMPLES AND HOMEWORK PROBLEMS WILL EMPHASIZE APPLICATIONS TO PROBABILITY AND STATISTICS.  
(Enrollment requirement: Biostatistics (PhD; MPH; MS) effective fall 2015, term 2161.)

BIOST 2083 LINEAR MODELS  
Prerequisite(s): BIOST 2044  
Credit(s): 03.0

ACQUAINTS STUDENTS WITH LINEAR MODEL TECHNIQUES FOR ANALYZING BOTH BALANCED AND UNBALANCED DATA. THE TOPICS COVERED INCLUDE GENERALIZED INVERSES, ORTHOGONAL CONTRASTS WITH UNBALANCED DATA, AND ANALYSIS OF COVARIANCE. ANALYSIS WITH COMPUTER PACKAGED PROGRAMS IS DISCUSSED.

BIOST 2086 APPLIED MIXED MODELS ANALYSIS  
Prerequisite(s): BIOST 2083  
Credit(s): 03.0

MIXED MODEL ANALYSIS PROVIDES A NEW APPROACH TO MODELING WHICH ALLOWS ONE TO RELAX THE USUAL INDEPENDENCE ASSUMPTIONS AND TAKE INTO ACCOUNT COMPLICATED DATA STRUCTURES. THIS COURSE WILL CONSIDER ALL TYPES OF MIXED MODELS INTO A GENERAL FRAMEWORK AND CONSIDER THE PRACTICAL IMPLICATIONS OF THEIR USE. TOPICS WILL INCLUDE: NORMAL MIXED MODELS, GENERALIZED MIXED MODELS, AND MIXED MODELS FOR CATEGORICAL DATA, REPEATED MEASURES DATA ANALYSIS AND CROSS-OVER TRIALS WITH MIXED MODELS. SOFTWARE FOR FITTING MIXED MODELS WILL BE DISCUSSED.

BIOST 2087 BIOST CONSULTING PRACTICUM  
Credit(s): 01.0

PROVIDES ADVANCED STUDENTS (SECOND-YEAR MASTERS AND DOCTORAL) WITH EXPOSURE AND PRACTICAL EXPERIENCE IN CONSULTING ON THE BIOSTATISTICAL ASPECTS OF RESEARCH PROBLEMS ARISING IN THE BIOMEDICAL OR OTHER ALLIED FIELDS. STUDENTS INITIALLY UNDER THE SUPERVISION OF A FACULTY MEMBER PARTICIPATE IN DISCUSSIONS WITH INVESTIGATORS LEADING TO THE DESIGN AND/OR ANALYSIS OF A CURRENT RESEARCH PROBLEM.

BIOST 2087 BIOST CONSULTING PRACTICUM - LAB  
Credit(s): 00.0

LABORATORY

BIOST 2093 SAS DATA MANAGEMENT & ANALYSIS  
Corequisite(s): BIOST 2041  
Credit(s): 02.0

THE GOAL OF THIS COURSE IS TO PROVIDE STUDENTS WITH AN UNDERSTANDING OF THE SAS PROGRAM ENVIRONMENT AS WELL AS THE SKILLS NEEDED TO USE SAS AS A TOOL TO CONDUCT RESEARCH, PREPARE DATA, AND PERFORM ANALYSES. UPON COMPLETION OF THE COURSE THE STUDENT WILL HAVE AN UNDERSTANDING OF SAS AT THE INTERMEDIATE LEVEL. THE COURSE COVERS THE UTILITY OF SAS AS A DATA MANAGEMENT, DATA MANIPULATION, AND DATA ANALYSIS TOOL. THE FOCUS WILL NOT BE STATISTICAL ANALYSIS, BUT RATHER HOW TO USE SAS AS A PROGRAMMING TOOL. EMPHASIS WILL BE PLACED ON PROGRAM CODE WRITING. CONCEPTS WILL BE ILLUSTRATED WITH NUMEROUS EXAMPLES FROM BASIC DESCRIPTIVE ANALYSIS.  
(Note: Students should have a basic understanding of the PC computer environment with some exposure to the Windows operating system.)
BIOST 2094 STATISTICAL COMPUTING IN R  
Credit(s):  02.0  
Prerequisite(s):  BIOST 2041 and BIOST 2042  
AN INTRODUCTION TO STATISTICAL COMPUTING USING R. THIS COURSE WILL SERVE TWO PURPOSES. IN THE FIRST PART OF THE COURSE STUDENTS WILL LEARN BASIC USE OF R PACKAGE INCLUDING ROUTINES THAT ARE USED IN DAY-TO-DAY STATISTICAL ANALYSIS. IN THE SECOND PART OF THIS COURSE, STUDENTS WILL LEARN ADVANCED COMPUTING TECHNIQUES UNINCLUDING FUNCTIONS, LOOPS, OPTIMIZATION AND SIMULATIONS.

BIOST 2096 NUMERICAL METHODS IN BIOSTATISTICS  
Credit(s):  03.0  
Prerequisite(s):  BIOST 2044 and BIOST 2049  
THE PURPOSE IS TO FAMILIARIZE STUDENTS WITH A BROADER RANGE OF NUMERICAL METHODS WHICH ARE USEFUL IN BIOSTATISTICAL RESEARCH. SELECTED COMPUTATIONAL TECHNIQUES USED IN STATISTICAL RESEARCH WILL BE COVERED. SOME BACKGROUND WILL BE PROVIDED TO FACILITATE UNDERSTANDING OF A FEW NUMERICAL ALGORITHMS WIDELY USED IN STATISTICS. THE FOLLOWING ARE COVERED: RECURRENCE RELATIONS, POWER SERIES AND ASYMPTOTIC EXPANSIONS, GENERATING PSEUDO-RANDOM DEVIATES, BASIC SIMULATION METHODOLOGY, SOLUTIONS OF NONLINEAR EQUATIONS, NEWTON'S METHOD, VECTOR AND MATRIX NORMS, LINEAR REGRESSION AND MATRIX INVERSION.

BIOST 3010 RESEARCH AND DISSERTATION PHD  
Credit(s):  01.0 to 15.0  
DISSERTATION CREDITS FOR QUALIFIED DOCTORAL STUDENTS IN THE DEPARTMENT OF BIOSTATISTICS.

FTDR 3999 FULL-TIME DISSERTATION RESEARCH  
Credit(s):  00.0  
DOCTORAL CANDIDATES WHO HAVE COMPLETED ALL CREDIT REQUIREMENTS FOR THE DEGREE, INCLUDING ANY MINIMUM DISSERTATION REQUIREMENTS, AND ARE WORKING FULL-TIME ON THEIR DISSERTATIONS MAY REGISTER FOR THIS COURSE. WHILE THE COURSE CARRIES NO CREDITS AND NO GRADE, STUDENTS WHO ENROLL IN "FULL-TIME DISSERTATION STUDY" ARE CONSIDERED BY THE UNIVERSITY TO HAVE FULL-TIME REGISTRATION STATUS.