Informatics

Chair
- Gregory R. Carmichael (Chemical and Biochemical Engineering/Civil and Environmental Engineering/Informatics/Nursing)

Graduate degrees: M.S. in informatics; Ph.D. in informatics
Graduate certificate: informatics
Faculty: https://informatics.uiowa.edu/about-us/people
Website: https://informatics.uiowa.edu/

The field of informatics springs from the intersection of computational disciplines related to the humanities, the arts, and the biological, health, natural, and social sciences. As the rapid development of information technology transforms the world of human pursuits, informatics offers ways to solve new problems and to examine existing problems from new perspectives.

The Informatics Program provides graduate students the opportunity to study informatics in the broadest sense. The program is interdisciplinary, involving the Graduate College, the Carver College of Medicine, the Tippie College of Business, and the Colleges of Dentistry, Engineering, Liberal Arts and Sciences, Nursing, Pharmacy, and Public Health.

The Master of Science and Doctor of Philosophy degrees in informatics, and the Certificate in Informatics, are offered in four subprograms: bioinformatics and computational biology, geoinformatics, health informatics, and information science.

Bioinformatics and computational biology are on the cutting edge intersecting basic life and biomedical science with high-performance computing and networking, mathematics, statistics, and engineering. They are strongly influenced and directed by the ongoing development of high-throughput data collection assays such as DNA sequencing, gene expression, and proteomics.

Geoinformatics provides methods and technologies needed to measure, store, analyze, manage, and visualize information about phenomena occurring on or near the earth's surface. It is an increasingly essential technology for understanding and managing the complex world.

Health informatics uses contemporary information technologies to improve the storage, organization, retrieval, and evaluation of health information in order to support clinical, clinical research, and public health applications.

Information science addresses the broad spectrum of data, information, and knowledge in seeking to identify and address recurring themes of representation, manipulation, retrieval, and comprehension. It draws from a diverse range of disciplines.

Programs

Graduate Programs of Study

Majors
- Master of Science in Informatics
- Doctor of Philosophy in Informatics

Certificate
- Certificate in Informatics

Courses

Informatics Courses

IGPI:3010 Geographic Information Systems and Science 3 s.h.
Solid foundation and introduction to GIS and digital map making; what GIS is and how GIS can contribute to research, careers, and everyday life; fundamentals that underlie GIS, including methods for GIS data collection and georeferencing, spatial modeling, spatial data analysis, and visualization; GIS trends including mobile GIS and the Web. Same as GEOG:3010.

IGPI:3011 Identifying and Developing a Global Health Project 2-3 s.h.
Review of major components of global health related research process; preparation for a local or international project which addresses a global health issue in a systematic way. Same as GHS:3010.

IGPI:3100 Introduction to Mathematical Statistics I 3 s.h.
Descriptive statistics, probability, discrete and continuous univariate and multivariate distributions, sampling distributions. Prerequisites: MATH:1860 or MATH:1560. Same as STAT:3100.

IGPI:3101 Introduction to Mathematical Statistics II 3 s.h.
Point and interval estimation, testing statistical hypotheses, simple regression, nonparametric methods. Prerequisites: STAT:3100. Same as STAT:3101.

IGPI:3120 Probability and Statistics 4 s.h.
Models, discrete and continuous random variables and their distributions, estimation of parameters, testing statistical hypotheses. Prerequisites: MATH:1560 or MATH:1860. Same as STAT:3120.

IGPI:3200 Applied Linear Regression 3 s.h.
Regression analysis with focus on applications; model formulation, checking, selection; interpretation and presentation of analysis results; simple and multiple linear regression; logistic regression; ANOVA; hands-on data analysis with computer software. Prerequisites: STAT:2010 or STAT:2010. Same as ESE:3760, STAT:3200.

IGPI:3314 Genomics 3 s.h.
Major areas of genomics, including DNA and protein sequence analysis, structural diversity of whole genomes, microarray applications, proteomics; computer workshop experience in applying bioinformatics tools. Prerequisites: BIOL:2512 or BIOL:3120 or BIOL:3110. Same as BIOL:3314.

IGPI:3330 Introduction to Software Design 3 s.h.
Design of software for engineering systems; algorithm design and structured programming; data structures; introduction to object-oriented programming in JAVA; applications to engineering problems; lab arranged. Prerequisites: ENGR:2730. Same as ECE:3330.

IGPI:3500 Introduction to Environmental Remote Sensing 3 s.h.
Basic concepts and principles of remote sensing; sources of data; georegistration; digital processing and classification of remotely sensed images for extraction of environmental information; linkage of remote sensing techniques with GIS analysis. Same as GEOG:3500.
IGPI:3510 Biostatistics 3 s.h.
Statistical concepts and methods for the biological sciences; descriptive statistics, elementary probability, sampling distributions, confidence intervals, parametric and nonparametric methods, one-way ANOVA, correlation and regression, categorical data. Requirements: MATH:0100 or MATH:1005 or ALEKS score of 30 or higher. Same as STAT:3510.

IGPI:3520 GIS for Environmental Studies 3 s.h.
Students learn new, more advanced techniques for the representation and study of human and natural systems using geographic information systems (GIS); application of this new knowledge to environmental management and problem solving. Prerequisites: GEOG:1050. Same as GEOG:3520.

IGPI:3540 Introduction to Geographic Visualization 3 s.h.
Introduction of basic concepts and techniques that underlie cartographic representation, interaction, and geovisualization; map symbolization and visual variables; spatiotemporal visualization, multivariate mapping, interactive cartography, animation, geovisual analytics, 3-D visualization, virtual and augmented reality. Prerequisites: GEOG:1050. Same as GEOG:3540.

IGPI:4100 Mathematical Statistics I 3 s.h.
Probability, conditional probability, random variables, distribution and density functions, joint and conditional distributions, various families of discrete and continuous distributions, mgf technique for sums, convergence in distribution, convergence in probability, central limit theorem. Prerequisites: MATH:2850 and MATH:2700. Same as STAT:4100.

IGPI:4101 Mathematical Statistics II 3 s.h.
Transformations, order statistics, point estimation, sufficient statistics, Rao-Blackwell Theorem, delta method, confidence intervals, likelihood ratio tests, applications. Prerequisites: STAT:4100. Same as STAT:4101.

IGPI:4115 Finite Element I 3 s.h.
One- and two-dimensional boundary value problems; heat flow, fluid flow, torsion of bars; trusses and frames; isoparametric mapping; higher order elements; elasticity problems; use of commercial software. Prerequisites: ENGR:2750. Same as CEE:4153.

IGPI:4150 Health and Environment: GIS Applications 3 s.h.
Introduction to how geographic information systems (GIS) and spatial statistics are used in the study of patterns of health and disease in space and time. Same as GEOG:4150, GHS:4150.

IGPI:4159 Air Pollution Control Technology 3 s.h.
Sources, environmental and health impacts, regulations, modeling of air pollution; processes and alternative strategies for control; global climate considerations. Same as CBE:4459, CEE:4159.

IGPI:4200 Statistical Methods and Computing 3 s.h.
Methods of data description and analysis using SAS; descriptive statistics, graphical presentation, estimation, hypothesis testing, sample size, power; emphasis on learning statistical methods and concepts through hands-on experience with real data. Recommendations: graduate standing in non-statistics or less quantitative major. Same as STAT:4200.

IGPI:4213 Bioinformatics 2,4 s.h.
Overview of bioinformatics topics, including access to sequence data, pairwise and multiple sequence alignment algorithms, molecular phylogeny, microarray data analysis, protein analysis, proteomics and protein structure analysis; emphasis on each topic includes biological motivation, computational approach (practical and theoretical), and interpretation of output. Prerequisites: BIOL:3120 or MSCI:3170 or BIOL:2512 or BIOL:3110. Recommendations: grade of B+ or higher in BIOL:2512 or BIOL:3120, or graduate standing. Same as BIOL:4213, GENE:4213.

IGPI:4220 Advanced Database Management and Big Data 3 s.h.
Advanced database management topics; basics of semi-structured data and web services; how to retrieve real-world big data sets from web services; use of SQL and PL/SQL to analyze data in relational databases; big data related topics such as Hadoop and Hive. Prerequisites: MSCI:3200. Same as MSCI:4220.

IGPI:4373 Molecular Evolution: Genes, Genomes, and Organisms 3 s.h.
Theory underlying phylogenetic analysis with application of these methods to molecular data sets; analysis of multigene data, organellar, and nuclear genome sequences to reconstruct the history of cells. Prerequisites: BIOL:3172 with a minimum grade of C-. Same as BIOL:4373.

IGPI:4500 Applications in Environmental Remote Sensing 4 s.h.
Theory and practice of remote sensing and digital image processing; practical applications to human-environment interactions. Recommendations: GEOG:3500 or EES:3110 or ENVS:3110. Same as GEOG:4500.

IGPI:4520 GIS for Environmental Studies: Applications 3 s.h.
Project-driven course to advance student knowledge of geographic information systems (GIS); application of GIS to environmental change analysis, environmental assessment, hazard/risk analysis, and environmental decision making. Prerequisites: GEOG:3520. Same as GEOG:4520.

IGPI:4522 Bayesian Statistics 3 s.h.
Bayesian statistical analysis, with focus on applications; Bayesian and frequentist methods compared; Bayesian model specification, choice of priors, computational methods; hands-on Bayesian data analysis using appropriate software; interpretation and presentation of analysis results. Prerequisites: STAT:3200 and (STAT:3101 or STAT:4101 or STAT:3120). Same as PSQF:4520, STAT:4520.

IGPI:4540 Statistical Learning 3 s.h.
Introduction to supervised and unsupervised statistical learning, with a focus on regression, classification, and clustering; methods will be applied to real data using appropriate software; supervised learning topics include linear and nonlinear (e.g., logistic) regression, linear discriminant analysis, cross-validation, bootstrapping, model selection, and regularization methods (e.g., ridge and lasso); generalized additive and spline models, tree-based methods, random forests and boosting, and support-vector machines; unsupervised learning topics include principal components and clustering. Requirements: an introductory statistics course and a regression course. Recommendations: prior exposure to programming and/or software, such as R, SAS, and Matlab. Same as STAT:4540.
IGPI:4580 Data Visualization and Data Technologies 3 s.h.
Introduction to common techniques for visualizing univariate and multivariate data, data summaries, and modeling results; students learn to create and interpret these visualizations, and assess effectiveness of different visualizations based on an understanding of human perception and statistical thinking; data technologies for obtaining and preparing data for visualization and further analysis. Requirements: an introductory statistics course and a regression course. Recommendations: prior exposure to basic use of statistical programming software (e.g., R or SAS) as obtained from a regression course strongly recommended. Same as GEOG:4580.

IGPI:4581 Introduction to Geographic Databases 3 s.h.
Introduction to basic building blocks of spatial database design, spatial data models, structures, relationships, queries (SQL), indexing, and geoprocessing; design and construction of various types of spatial databases, including relational and big data approaches such as ArcGIS geodatabase, PostGIS/PostgreSQL, and MongoDB. Prerequisites: GEOG:1050. Same as GEOG:4580.

IGPI:4740 Large Data Analysis 3 s.h.
Current areas that deal with problem of Big Data; techniques from computer science, mathematics, statistics; high performance and parallel computing, matrix techniques, cluster analysis, visualization; variety of applications including Google PageRank, seismology, Netflix-type problems, weather forecasting; fusion of data with simulation; projects. Prerequisites: (CS:1210 with a minimum grade of C- or ENGR:2730 with a minimum grade of C-) and (MATH:3800 or CS:3700) and (STAT:3200 or MATH:3760 or IGPI:3200). Same as CS:4740, MATH:4740, STAT:4740.

IGPI:5001 Introductory Methodology 3-4 s.h.
Introduction to quantitative techniques in political science; set theory, probability distributions, estimation, testing; emphasis on acquiring mathematical skills for more advanced quantitative work in political science. Requirements: M.A. or Ph.D. standing in political science. Same as POLI:5001.

IGPI:5010 Research for Master's Thesis arr.
Requirements: admission to M.S. program.

IGPI:5015 Independent Study arr.

IGPI:5043 Special Libraries 3 s.h.
Management, organizational structures, collections, client services in special libraries; site visits to a variety of special libraries, information centers; projects that apply theoretical principles. Prerequisites: SLIS:5010. Corequisites: SLIS:5010, if not taken as a prerequisite. Same as SLIS:5043.

IGPI:5110 Introduction to Informatics 3 s.h.
Fundamentals of computer science: algorithms, complexity, relational databases, systems concepts, programming in Python. Same as CS:5110.

IGPI:5120 Regression Modeling and ANOVA in the Health Sciences 3 s.h.
Continuation of BIOS:4120; correlation, simple and multiple linear regression, confounding, interactions, model selection, single and multiple factor ANOVA (analysis of variance) models, contrasts, multiple comparisons, nested and block designs, and an introduction to mixed models; designed for non-biostatistics majors. Offered spring semesters and summer sessions. Prerequisites: BIOS:4120. Same as BIOS:5120, STAT:5610.

IGPI:5130 Applied Categorical Data Analysis 3 s.h.
Analysis of proportions, risk measures, and measures of association; Mantel-Haenszel method; logistic regression for binary responses and for matched data; logistic regression for multi-category responses; analysis of count data (Poisson regression and negative binomial regression); analysis of clustered data (generalized estimating equations and generalized linear mixed effects model); special topics include the application of propensity score methods; designed for non-biostatistics majors. Offered fall semesters. Prerequisites: BIOS:5120. Same as BIOS:5130.

IGPI:5199 Applied Statistics I 4 s.h.
Descriptive statistics, basic inferential methods (confidence intervals, chi-square tests); linear models (regression and ANOVA models—specification and assumptions, fitting, diagnostics, selection, testing, interpretation); nonlinear models, logistic regression. Prerequisites: STAT:3101. Corequisites: STAT:4100 or STAT:5100. Requirements: facility with matrix algebra. Same as STAT:5200.

IGPI:5200 Health Informatics 3 s.h.
Technological tools that support health care administration, management, and decision making. Same as HMP:5370, ISE:5860, MED:5300, SLIS:5900.

IGPI:5203 User Education: Multimedia 3 s.h.
Develop multimedia projects for educational use in libraries; develop a portfolio of projects using multimedia technology; explore applications of multimedia for teaching and learning; explore and evaluate platforms for delivering multimedia in educational environments. Same as SLIS:5200.

IGPI:5206 Medical Imaging Physics 3 s.h.
Physics and data acquisition techniques of major medical imaging modalities (X-ray, CT, MR, ultrasound, PET, SPECT); physical interactions of energy with living tissue; principles and methods for acquiring imaging data and subsequent image construction; how individual modalities influence image quality; MATLAB programming required. Second in a medical imaging sequence. Prerequisites: BME:2200 and BME:2210. Same as BME:5210, ECE:5470.

IGPI:5211 Genes, Genomes, and the Human Condition Graduate Lecture 3 s.h.
Organization, expression, and evolution of genes in context of genomes; focus on human genome; distribution and transmission of variation in human population. Recommendations: BIOL:1411 highly recommended. Same as BIOL:5212.

IGPI:5212 Biomedical Signal Processing 3 s.h.
Application of signal processing methods (e.g., Fourier, Laplace, z-transforms) to biomedical problems, such as analysis of cardiac signals, circadian rhythm, the breathing cycle; computer simulation lab. Same as BME:5200.

IGPI:5220 Principles of Public Health Informatics 3 s.h.
Systematic applications of information science, computer science, and technology to public health practice, research, and learning; methods of disease surveillance, data collection, analysis, and reporting with health informatics. Same as EPID:5200.
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>IGPI:5251</td>
<td>Advanced Biosystems</td>
<td>3 s.h.</td>
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<tr>
<td>IGPI:5270</td>
<td>Pathogenesis of Major Human Diseases</td>
<td>3 s.h.</td>
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<tr>
<td>IGPI:5310</td>
<td>Research Data Management</td>
<td>3 s.h.</td>
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<td>IGPI:5311</td>
<td>Informatics for Sustainable Systems</td>
<td>3 s.h.</td>
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<tr>
<td>IGPI:5321</td>
<td>Bioinformatics Techniques</td>
<td>3 s.h.</td>
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<td>IGPI:5330</td>
<td>Computational Genomics</td>
<td>3 s.h.</td>
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<td>IGPI:5331</td>
<td>Graph Algorithms and Combinatorial Optimization</td>
<td>3 s.h.</td>
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<tr>
<td>IGPI:5400</td>
<td>Computing in Statistics</td>
<td>3 s.h.</td>
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<td>IGPI:5436</td>
<td>Electronic Structure and Informatics in Chemistry</td>
<td>3 s.h.</td>
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<td>IGPI:5450</td>
<td>Machine Learning</td>
<td>3 s.h.</td>
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<td>IGPI:5460</td>
<td>Digital Signal Processing</td>
<td>3 s.h.</td>
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<tr>
<td>IGPI:5480</td>
<td>Digital Image Processing</td>
<td>3 s.h.</td>
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<tr>
<td>IGPI:5510</td>
<td>Biostatistical Computing</td>
<td>2 s.h.</td>
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**IGPI:5251 Advanced Biosystems**

3 s.h.

Biological systems unique to systems analysis; operation under nonequilibrium conditions; tools for systems analysis developed from models of systems at equilibrium (i.e., mechanical systems); fundamental difference between biological and mechanical systems that impact systems analysis; expand knowledge of linear systems and begin work with nonlinear systems; various modeling and analysis approaches useful in biomedical and biomedical engineering research. Prerequisites: BME:2200. Same as BME:5251.

**IGPI:5270 Pathogenesis of Major Human Diseases**

3 s.h.

Critical analysis of pathogenesis models in a series of major human diseases; clinical presentation, analysis of cellular and molecular events leading to the disease, discussion of key papers. Offered spring semesters of even years. Same as MMED:5270, PATH:5270.

**IGPI:5310 Research Data Management**

3 s.h.

Introduction to data management techniques and problems encountered in gathering and processing data from biomedical investigations; introduction to SAS, techniques taught in SAS; designed for non-biostatistics majors. Offered fall and spring semesters. Recommendations: prior programming experience with C, C++, Python, Java, or other. Same as BIOS:5310, STAT:5810.

**IGPI:5311 Informatics for Sustainable Systems**

3 s.h.

Introduction to fundamental and advanced environmental informatics concepts and procedures including automated data collection, data management, data transformations, and processing to support modeling and analysis; scientific visualization of environmental data to support management of food, energy, and water (FEW) resources; sustainability in FEW systems. Same as CEE:5310.

**IGPI:5321 Bioinformatics Techniques**

3 s.h.

Informatics tools and techniques applied to modern problems in biomedicine and basic life sciences; common tools, experience applying tools in contemporary problem settings; genomics and genetics, how to sequence a genome, transcription and expression, SNPs, Perl, BioPerl, Perl modules, Ensembl API, BLAST/BLAT, NCBI, UCSC, Ensembl Genome browsers, linkage, association, disease gene identification. Prerequisites: BIOL:1411 and (ENGR:2730 or CS:2110 or CS:5110). Same as BME:5320, ECE:5210.

**IGPI:5330 Computational Genomics**

3 s.h.

Introduction to computational methods used in genome analysis and functional genomics; biological sequence analysis, sequence database search, microarray data analysis, biological network analysis; in-depth coverage of principal genome science challenges and recent solutions. Prerequisites: (BIOS:4120 or STAT:3510) and BME:5320 and (CS:5110 or ENGR:1300). Same as BIOL:5320, BME:5330, ECE:5220, GENE:5173.

**IGPI:5331 Graph Algorithms and Combinatorial Optimization**

3 s.h.

Combinatorial optimization problems; time complexity; graph theory and algorithms; combinatorial optimization algorithms; complexity theory and NP-completeness; approximation algorithms; greedy algorithms and matroids. Prerequisites: ECE:3330. Same as ECE:5330.

**IGPI:5400 Computing in Statistics**

3 s.h.

R; database management; graphical techniques; importing graphics into word-processing documents (e.g., LaTeX); creating reports in LaTeX; SAS; simulation methods (Monte Carlo studies; bootstrap, etc.). Prerequisites: CS:1210 and STAT:3200 and (STAT:3120 or STAT:3101 or STAT:4101). Corequisites: STAT:5100 and STAT:5200 if not already completed. Same as STAT:5400.

**IGPI:5415 Satellite Image Processing and Remote Sensing of Atmosphere**

3 s.h.

Introduction to principles of atmospheric radiation and techniques for satellite image processing; hands-on experience with data calibration, image registration and enhancement, noise filtering and (supervised and unsupervised) multi-spectral classification of satellite imageries; various satellite sensors used for monitoring of different atmospheric processes and constituents. Same as CBE:5415.

**IGPI:5436 Electronic Structure and Informatics in Chemistry**

3 s.h.

Basic principles of molecular electronic structure theory; molecular structure and reactivity; molecular orbital theory; density functional theory; introduction to informatics and data science; how calculations can be used to enhance experimental research projects. Recommendations: CHEM:4432. Same as CHEM:5436.

**IGPI:5450 Machine Learning**

3 s.h.

Mathematical foundations and practical techniques of pattern recognition; adaptation, learning, description; statistical pattern recognition; syntactic pattern recognition, neural networks for recognition; fuzzy logic for recognition; nonstandard and combined pattern recognition approaches. Prerequisites: ECE:2400. Same as ECE:5450.

**IGPI:5460 Digital Signal Processing**

3 s.h.

Theory, techniques used in representing discrete-time signals; system concepts in frequency and sampling domains; FIR and IIR digital filter theory, design and realization techniques; theory, application of discrete Fourier transforms/FFT. Prerequisites: ECE:3400. Same as ECE:5460.

**IGPI:5480 Digital Image Processing**

3 s.h.

Mathematical foundations and practical techniques for digital manipulation of images; image sampling, compression, enhancement, linear and nonlinear filtering and restoration; Fourier domain analysis; image pre-processing, edge detection, filtering; image segmentation. Prerequisites: ECE:2400 or BME:2200. Same as ECE:5480.

**IGPI:5510 Biostatistical Computing**

2 s.h.

Introduction to computer programming using SAS and R statistical software packages; programming language syntax, constructs, procedures, and techniques for data management, data analysis, and statistical programming commonly encountered in biostatistics; designed for first-year biostatistics majors. Offered fall semesters. Corequisites: BIOS:5710. Same as BIOS:5510.
<table>
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<tr>
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<th>Prerequisites</th>
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<tbody>
<tr>
<td>IGPI:5641</td>
<td>Computer-Based Control Systems</td>
<td>3 s.h.</td>
<td>Discrete and digital control systems; application of computers in control; sampling theorem; discrete time system models; analysis and design of discrete time systems; control design by state variable and input/output methods; advanced topics in digital controls; lab. Prerequisites: ECE:5600. Same as ECE:5640.</td>
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<tr>
<td>IGPI:5710</td>
<td>Biostatistical Methods I</td>
<td>4 s.h.</td>
<td>Probability distributions, moments, estimation, parametric and nonparametric inference for one-sample and two-sample problems, analysis of frequency data; emphasis on use of computers; designed for first-year biostatistics majors. Offered fall semesters. Requirements: two semesters of calculus. Same as BIOS:5710.</td>
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<tr>
<td>IGPI:5720</td>
<td>Biostatistical Methods II</td>
<td>4 s.h.</td>
<td>Continuation of BIOS:5710: multi-factor ANOVA (analysis of variance), multiple comparisons, orthogonal contrasts, linear regression and correlation, regression diagnostics and remedial measures, model selection, and mixed models; designed for first-year biostatistics majors. Offered spring semesters. Prerequisites: BIOS:5710. Requirements: one semester of linear algebra. Same as BIOS:5720.</td>
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<tr>
<td>IGPI:5730</td>
<td>Biostatistical Methods in Categorical Data</td>
<td>3 s.h.</td>
<td>Estimation of proportions, rates, risks, relative risks, and odds ratios; Mantel-Haenszel method; logistic regression (including ordinal logistic regression and multi-category nominal logistic regression); Poisson regression and negative binomial regression; methods for correlated or clustered data (conditional logistic regression, generalized estimating equations, and mixed effects models); special topics include an introduction to generalized linear models and likelihood-based inferential techniques in this framework; designed for first-year biostatistics majors. Offered spring semesters. Prerequisites: BIOS:5510 and BIOS:5710. Corequisites: BIOS:5720. Same as BIOS:5730.</td>
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<tr>
<td>IGPI:6100</td>
<td>Database Management</td>
<td>3 s.h.</td>
<td>Principles and practices of database design and management; discussion and practice cover database application lifecycle, data modeling, relational database design, SQL queries, reports and other interfaces to database data, documentation; individual and group projects. Prerequisites: SLIS:5020. Same as SLIS:6100.</td>
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<tr>
<td>IGPI:6120</td>
<td>Natural Language Processing</td>
<td>3 s.h.</td>
<td>Tools and techniques for computational processing of text, including lexical analysis, part-of-speech tagging, named entity recognition, relationship extraction, topic detection and tracking, sentiment analysis, question answering; example corpora and applications drawn from multiple disciplines including biomedicine, digital humanities, and social science. Prerequisites: SLIS:5020. Same as SLIS:6120.</td>
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<tr>
<td>IGPI:6140</td>
<td>Digital Environments</td>
<td>3 s.h.</td>
<td>Methods and models for building digital libraries; organization with metadata; standards such as those for object identifiers, open access, building cross-links between collections; automatic harvesting of content. Prerequisites: SLIS:5020. Same as SLIS:6140.</td>
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<tr>
<td>IGPI:6151</td>
<td>Environmental Systems Modeling</td>
<td>3 s.h.</td>
<td>Mathematical modeling of environmental systems, including rivers, lakes, estuaries, treatment systems for conventional and toxic pollutants. Prerequisites: CEE:5152 and CEE:2150 and CEE:3155. Same as CEE:6151.</td>
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<tr>
<td>IGPI:6155</td>
<td>Information Visualization</td>
<td>3 s.h.</td>
<td>Information visualization is to unveil the underlying structure of large or abstract data sets using visual representations that utilize the powerful processing capabilities of the human visual perceptual system; introduction to theories, techniques, and examples of information visualizations for different presentations of data. Prerequisites: SLIS:5020. Same as SLIS:6155.</td>
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<tr>
<td>IGPI:6210</td>
<td>Applied Survival Analysis</td>
<td>3 s.h.</td>
<td>Nonparametric, parametric, and semi-parametric methods for time-to-event data; types of censoring; Kaplan-Meier estimation; Cox proportional hazards models, including methods for assessing adequacy of the proportional hazards assumption; time varying covariates; sample size calculations for comparison of two or more groups; focus on analysis of real data sets and examples using statistical software. Offered spring semesters. Prerequisites: BIOS:5120 or BIOS:5720. Same as BIOS:6210.</td>
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<td>IGPI:6216</td>
<td>Finite Element II</td>
<td>3 s.h.</td>
<td>Computer implementation; plate and shell elements; mixed and hybrid formulations; nonlinear analysis; recent development; introduction to boundary element method. Prerequisites: CEE:4533. Same as CEE:6532, ME:6215.</td>
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<td>IGPI:6310</td>
<td>Introductory Longitudinal Data Analysis</td>
<td>3 s.h.</td>
<td>Introduction to statistical models and estimation methods for outcome variables (normal and non-normal) clustered or measured repeatedly in time or space; focus on applications and computer software methods for ANOVA based methods, hierarchical linear models, linear mixed models, correlated regression models, generalized estimating equations, and generalized linear mixed models. Offered fall semesters. Prerequisites: BIOS:5120 or STAT:3200. Same as BIOS:6310, STAT:6550.</td>
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<tr>
<td>IGPI:6380</td>
<td>Analysis of Scholarly Domains</td>
<td>3 s.h.</td>
<td>Information transfer in academic disciplines; scientific method, other means of knowledge construction, resulting literatures; reference tools used to control literature for a variety of audiences; emphasis on humanities, social sciences, or sciences. Same as SLIS:6380.</td>
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<tr>
<td>IGPI:6480</td>
<td>Knowledge Discovery</td>
<td>3 s.h.</td>
<td>Knowledge discovery process including data reduction, cleansing, and transformation; advanced modeling techniques from classification, prediction, clustering, and association; evaluation and integration. Same as MSCI:6480.</td>
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<tr>
<td>IGPI:6490</td>
<td>Information Policy and Ethics</td>
<td>3 s.h.</td>
<td>Ethical and legal issues as they relate to information policy development and interpretation; application of information policies to address problems in information organizations. Same as SLIS:6490.</td>
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<tr>
<td>IGPI:6501</td>
<td>Seminar in Spatial Analysis and Modeling</td>
<td>1-3 s.h.</td>
<td>Research themes in spatial analysis, GIScience, simulation, remote sensing. Same as GEOG:6500.</td>
<td></td>
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<tr>
<td>IGPI:6510</td>
<td>Readings in Informatics</td>
<td>arr.</td>
<td>Topics not covered in other courses; individual study.</td>
<td></td>
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<tr>
<td>IGPI:6511</td>
<td>Applied Generalized Regression</td>
<td>3 s.h.</td>
<td>Applications of semiparametric models, generalized linear models, nonlinear normal errors models, correlated response models; use of statistical packages, especially R and SAS. Requirements: introductory statistics and applied linear models. Same as STAT:6510.</td>
<td></td>
</tr>
<tr>
<td>IGPI:6515</td>
<td>Independent Study</td>
<td>arr.</td>
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</table>
IGPI:6520 Research for Dissertation arr.
Requirements: Ph.D. candidacy.

IGPI:6530 Environmental and Spatial Statistics 3 s.h.
Geostatistics kriging, variogram estimation, trend estimation, sampling design, extensions to river networks and the globe, lattice data analysis, analysis of spatial point patterns. Prerequisites: STAT:4101 and STAT:3200. Same as STAT:6530.

IGPI:6600 Linear Programming 3 s.h.
Mathematical programming models; linear and integer programming, transportation models, large-scale linear programming, network flow models, convex separable programming. Requirements: calculus and linear algebra. Same as ISE:6600, MSCI:6600.

IGPI:6610 Statistical Methods in Clinical Trials 3 s.h.
Survey of statistical methods commonly used in clinical trials; primary focus on methodologic perspective for the design, conduct, analysis, and interpretation of all phases of clinical trials; logistical and operational aspects of conducting multisite clinical trials; designed for biostatistics majors. Offered spring semesters. Prerequisites: BIOS:5720. Requirements: familiarity with SAS and R programming. Same as BIOS:6610.

IGPI:6650 Causal Inference 3 s.h.
Concepts of causal inference, counterfactuals, confounding, causal graphs, internal/external validity, heterogeneity of treatment effect; methods covered include propensity score matching (optimal pair, multiple control and full matching; near-exact, fine-balance, and risk set matching) and stratification; covariate balance checks; sensitivity analysis; inverse probability of treatment weighted estimation; doubly robust estimators; mediation analysis; marginal structural models. Offered fall semesters of odd years. Prerequisites: BIOS:5720 and BIOS:5730 and ((STAT:4100 and STAT:4101) or (STAT:5100 and STAT:5101)). Same as BIOS:6650.

IGPI:6700 Discrete Optimization 3 s.h.
Introduction to modeling and solving discrete optimization problems; integer programming, network flows, dynamic programming. Prerequisites: MSCI:6600. Same as MSCI:6700.

IGPI:7000 Management Sciences Topics 3 s.h.
Same as MSCI:7000.

IGPI:7210 Survival Data Analysis 3 s.h.
Types of censoring and truncation; survival function estimation; parametric inference using exponential, Weibull, and accelerated failure time models; nonparametric tests; sample size calculation; Cox regression with stratification and time-dependent covariates; regression diagnostics; competing risks; topics may include analysis of correlated survival data and/or recurrent events; designed for biostatistics and statistics majors. Offered fall semesters. Prerequisites: BIOS:5720 and ((STAT:4100 and STAT:4101) or (STAT:5100 and STAT:5101)). Same as BIOS:7210, STAT:7570.

IGPI:7310 Longitudinal Data Analysis 3 s.h.
Statistical models and estimation methods for outcome variables (normal and non-normal) clustered or measured repeatedly in time or space; includes ANOVA based methods, hierarchical linear models, linear mixed models, error structures, generalized estimating equations, and generalized linear mixed models; may include Bayesian approaches; designed for biostatistics and statistics majors. Offered spring semesters of odd years. Prerequisites: (BIOS:5720 and STAT:4100 and STAT:4101) or (STAT:5100 and STAT:5101). Same as BIOS:7310.

IGPI:7400 Computer Intensive Statistics 3 s.h.
Computer arithmetic; random variate generation; numerical optimization; numerical linear algebra; smoothing techniques; bootstrap methods; cross-validation; MCMC; EM and related algorithms; other topics per student/instructor interests. Prerequisites: (BIOS:5710 or STAT:5200) and STAT:3101. Requirements: proficiency in Fortran or C or C++ or Java. Same as STAT:7400.

IGPI:7470 Image Analysis and Understanding 3 s.h.
Mathematical foundations and practical techniques of digital image analysis and understanding; image segmentation (from edges and regions), object description (from boundaries, regions, scale, scale insensitive descriptions, 3-D shape, texture) pattern recognition (statistical and syntactic methods, cluster analysis), image understanding (knowledge representation, control strategies, matching, context, semantics), image analysis and understanding systems; lab arranged. Prerequisites: ECE:5480. Same as ECE:7470.

IGPI:7480 Advanced Digital Image Processing 3 s.h.
Advanced local operators (scale-space imaging, advanced edge detection, line and corner detection), image morphology (binary/gray scale operators, morphological segmentation and watershed), digital topology and geometry (binary/ fuzzy digital topology, distance functions, skeletonization), color spaces, wavelets and multi-resolution processing (Haar transform, wavelet transforms), image registration (intensity correlation, mutual information, and landmark-based deformable registration methods). Prerequisites: ECE:5460 and ECE:5480. Same as ECE:7480.

IGPI:7600 Advanced Biostatistics Seminar 0-3 s.h.
Current topics; supervised experience in reading and interpreting biostatistical literature. Same as BIOS:7600.