STATISTICS

Undergraduate Study

For the undergraduate curriculum in liberal arts and sciences, major in statistics, leading to the degree bachelor of science, see Liberal Arts and Sciences, Curriculum.

The curriculum in liberal arts and sciences with a major in statistics is designed to prepare students for (1) entry level statistics positions requiring the B.S. degree in statistics in business, industry or commerce, nonprofit institutions, and in state or federal government; (2) graduate study in statistics. Entry-level positions include the following types of work: statistical design, analysis and interpretation of experiments and surveys; data processing and analysis using modern computation facilities and statistical computing systems; application of statistical principles and methods in commercial areas such as finance, insurance, industrial research, marketing, manufacturing, and quality control. Nonprofit organizations such as large health study institutions have entry-level positions for B.S. graduates in statistics. Also, there are opportunities for work in statistics that require a major in a subject-matter field and a minor in statistics.

Students completing the undergraduate degree in statistics should have a broad understanding of the discipline of statistics. They should have a clear comprehension of the theoretical basis of statistical reasoning and should be proficient in the use of modern statistical methods and computing. Such graduates should have an ability to apply and convey statistical concepts and knowledge in oral and written form. They should be aware of ethical issues associated with polling and surveys and in summarizing the outcomes of statistical studies.

Undergraduate majors in this department usually include in their programs:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>STAT 100</td>
<td>Orientation in Statistics</td>
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<tr>
<td>STAT 201</td>
<td>Introduction to Statistical Concepts and Methods</td>
<td>4</td>
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<tr>
<td></td>
<td>One of the following options</td>
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<tr>
<td></td>
<td>Option I</td>
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<tr>
<td>MATH 165</td>
<td>Calculus I</td>
<td></td>
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<tr>
<td>MATH 166</td>
<td>Calculus II</td>
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<td>MATH 265</td>
<td>Calculus III</td>
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<td>Option II</td>
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<tr>
<td>MATH 165</td>
<td>Calculus I</td>
<td></td>
</tr>
<tr>
<td>MATH 166H</td>
<td>Calculus II, Honors</td>
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<tr>
<td>MATH 265H</td>
<td>Calculus III, Honors</td>
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<tr>
<td>MATH 207</td>
<td>Matrices and Linear Algebra</td>
<td>3-4</td>
</tr>
<tr>
<td>or MATH 317</td>
<td>Theory of Linear Algebra</td>
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These courses plus at least six additional credits in statistics at the 400 level or above (excluding STAT 401, 447, 495, 496) constitute the major. IE 361 Statistical Quality Assurance/STAT 361 Statistical Quality Assurance may be substituted for three credits of 400 level courses. It is advisable to have a minor in a field of application.

English and Speech proficiency requirement: The department requires a passing grade in ENGL 150 Critical Thinking and Communication, completion of ENGL 250 Written, Oral, Visual, and Electronic Composition (or ENGL 250H Written, Oral, Visual, and Electronic Composition: Honors) with a grade of C or better, and completion of one of ENGL 302 Business Communication or ENGL 314 Technical Communication with a grade of C- or better. The department requires a passing grade in COMST 102 Introduction to Interpersonal Communication or SP CM 212 Fundamentals of Public Speaking.

Students intending to do graduate work in statistics normally will take additional courses in mathematics.

Statistics, B.S.

Freshman

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credits Spring</th>
<th>Credits</th>
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<tbody>
<tr>
<td>ENGL 150</td>
<td>3 MATH 166 (or MATH 166H)</td>
<td>4</td>
</tr>
<tr>
<td>LIB 160</td>
<td>1 STAT 201</td>
<td>4</td>
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<tr>
<td>STAT 100</td>
<td>0 Social Science Choice</td>
<td>3</td>
</tr>
<tr>
<td>MATH 165 (or MATH 165H)</td>
<td>4 Humanities Choice</td>
<td>3</td>
</tr>
<tr>
<td>Humanities Choice</td>
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<tr>
<td>Natural Science Choice</td>
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<td></td>
<td>15</td>
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Sophomore

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<tr>
<th>Fall</th>
<th>Credits Spring</th>
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<tr>
<td>STAT 301</td>
<td>4 STAT 402</td>
<td>3</td>
</tr>
<tr>
<td>MATH 265 (or MATH 265H)</td>
<td>4 COM S 207 (or COM S 107)</td>
<td>3</td>
</tr>
<tr>
<td>ENGL 250</td>
<td>3 MATH 207 (or MATH 317)</td>
<td>3</td>
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</tbody>
</table>
Natural Science Choice | 4 | Humanities Choice | 3
Social Science Choice | 3
---|---|---|---
15 | 15

**Junior**

<table>
<thead>
<tr>
<th>Fall Credits</th>
<th>Spring Credits</th>
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<tbody>
<tr>
<td>STAT 341</td>
<td>3</td>
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<tr>
<td>STAT 479</td>
<td>3</td>
</tr>
<tr>
<td>SP CM 212 (or COMST 102)</td>
<td>3</td>
</tr>
<tr>
<td>Social Science Choice</td>
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</tr>
<tr>
<td>Foreign Language/Elective</td>
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<tr>
<td>Elective</td>
<td>3</td>
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**Senior**

<table>
<thead>
<tr>
<th>Fall Credits</th>
<th>Spring Credits</th>
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<tbody>
<tr>
<td>Statistics Choice - 400 Level</td>
<td>3</td>
</tr>
<tr>
<td>ENGL 302 (or ENGL 314)</td>
<td>3</td>
</tr>
<tr>
<td>Humanities Choice</td>
<td>3</td>
</tr>
<tr>
<td>Electives</td>
<td>9</td>
</tr>
</tbody>
</table>

**Elective** | 3 | **Elective** | 3 | **Credits** | 16 | **Credits** | 16

Students in all ISU majors must complete a three-credit course in U.S. diversity and a three-credit course in international perspectives. Discuss with your adviser how the two courses that you select can be applied to your graduation plan.

LAS majors require a minimum of 120 credits, including a minimum of 45 credits at the 300/400 level.

You must also complete the LAS foreign language requirement.

**Minor**

The department offers a minor in statistics which may be earned by completing one introductory course in statistics (STAT 101, 104, 105, 201, 226, 231, 305, 322 or 330); STAT 301 or 326; plus 9 additional credits from STAT 341, 342, 361, and 400 level or above (excluding STAT 401, 447, 495, 496) to yield a total of at least 15 credits in statistics courses.

**Graduate Study**

The department offers graduate programs leading to both Master of Science (M.S.) and Doctor of Philosophy (Ph.D.) degrees with a major in statistics. Graduate work leading to a minor in statistics is available for students majoring in other programs, at both the M.S. and Ph.D. levels. The Ph.D. degree is also offered as a co-major with other graduate programs. The department participates in inter-disciplinary graduate programs in Bioinformatics and Computational Biology, Ecology and Evolutionary Biology, Genetics, Human Computer Interaction, Nutritional Sciences, and Wind Energy Science, Engineering, and Policy.

Graduates of the M.S. program have an understanding of basic statistical theory and methods. Elective courses in the M.S. program provide an opportunity for students to emphasize particular areas of statistical methods or application in their program. Students complete a minimum of 34 semester credits, including work on a capstone project resulting in a written creative component under the direction of an individual major professor and presented in a final oral examination.

Graduates of the Ph.D. program in statistics have studied advanced theory and methods, and have demonstrated the ability to conduct independent research resulting in an original contribution to the discipline. Candidates for the Ph.D. degree in statistics complete a minimum of 72 semester credits, including at least 18 credits given for research activity, pass an oral preliminary examination, and submit a written dissertation containing original research that is defended in a final oral examination. Dissertation research is typically conducted in close collaboration with a major professor and usually results in publishable material. The department does not offer specific program tracks or areas of emphasis, but the diversity of elective courses and research areas of faculty allow students to tailor their individual programs to reflect areas of particular interest.

Graduates of co-major Ph.D. programs in statistics and an applied scientific discipline have mastered basic statistical theory and have studied advanced methodology. Students complete a minimum of 72 semester credits for courses in statistics and the chosen scientific discipline. Students conduct research that is a combination of statistical methodology and the scientific discipline. Co-major professors work with the student to prepare for an oral preliminary examination and conduct research leading to a single dissertation project that produces an original contribution to at least one of the two disciplines that is defended in a final oral examination.

Graduates of co-major Ph.D. programs in statistics and an area of theoretical mathematics have mastered basic statistical methods and have studied advanced statistical theory. Students complete a minimum of 72 semester credits. Co-major professors assist the student in preparing a dissertation that represents original research that makes a contribution at the interface of statistical theory and a sub-discipline of mathematics. The dissertation is defended in a final oral examination.

**Courses primarily for undergraduates:**

**STAT 100: Orientation in Statistics**

(1-0) Cr. R. F.

Opportunities, challenges, and the scope of the curriculum in statistics. For students planning or considering a career in this area.
STAT 101: Principles of Statistics
(3-2) Cr. 4. F.S.SS.
Prereq: 1 1/2 years of high school algebra
Statistical concepts in modern society; descriptive statistics and graphical displays of data; the normal distribution; data collection (sampling and designing experiments); elementary probability; elements of statistical inference; estimation and hypothesis testing; linear regression and correlation; contingency tables. Credit for only one of the following courses may be applied toward graduation: STAT 101, STAT 104, STAT 105, STAT 201, or STAT 226.

STAT 104: Introduction to Statistics
(2-2) Cr. 3. F.S.SS.
Prereq: 1 1/2 years of high school algebra
Statistical concepts and their use in science; collecting, organizing and drawing conclusions from data; elementary probability; binomial and normal distributions; regression; estimation and hypothesis testing. For students in the agricultural and biological sciences. Credit for only one of the following courses may be applied toward graduation: STAT 101, STAT 104, STAT 105, STAT 201, or STAT 226.

STAT 105: Introduction to Statistics for Engineers
(3-0) Cr. 3. F.S.
Prereq: MATH 165 (or MATH 165H)
Statistical concepts with emphasis on engineering applications. Data collection; descriptive statistics; probability distributions and their properties; elements of statistical inference; regression; statistical quality control charts; use of statistical software; team project involving data collection, description and analysis. Credit for only one of the following courses may be applied toward graduation: STAT 101, STAT 104, STAT 105, STAT 201, or STAT 226. Credit for both STAT 105 and STAT 305 may not be applied for graduation.

STAT 201: Introduction to Statistical Concepts and Methods
(3-2) Cr. 4. S.
Prereq: Credit or enrollment in MATH 165
Statistical thinking and applications of statistical concepts and methods in modern society. Display and summary of categorical and numerical data. Exploring relationships between variables, association, correlation, and regression. Observational studies and experiments. Probability concepts, random variables, discrete and continuous distributions. Elements of statistical inference; estimation and hypothesis testing. Credit for only one of the following courses may be applied toward graduation: STAT 101, STAT 104, STAT 105, STAT 201, or STAT 226.

STAT 226: Introduction to Business Statistics I
(3-0) Cr. 3. F.S.SS.
Prereq: MATH 150 or MATH 165
Obtaining, presenting, and organizing statistical data; measures of location and dispersion; the Normal distribution; sampling and sampling distributions; elements of statistical inference; estimation and confidence intervals; hypothesis testing; inference for simple linear regression analysis; use of computers to visualize and analyze data. Credit for only one of the following courses may be applied toward graduation: STAT 101, STAT 104, STAT 105, STAT 201, or STAT 226.

STAT 231: Probability and Statistical Inference for Engineers
(4-0) Cr. 4. S.
Prereq: Credit or enrollment in MATH 265
Emphasis on engineering applications. Basic probability; random variables and probability distributions; joint and sampling distributions. Descriptive statistics; confidence intervals; hypothesis testing; simple linear regression; multiple linear regression; one way analysis of variance; use of statistical software.

STAT 301: Intermediate Statistical Concepts and Methods
(3-2) Cr. 4. F.S.
Prereq: STAT 101 or STAT 104 or STAT 105 or STAT 201
Statistical concepts and methods used in the analysis of data. Statistical models. Analysis of single sample, two sample and paired sample data. Simple and multiple linear regression including polynomial regression. Analysis of residuals. Regression diagnostics. Model building. Regression with indicator variables. Credit for only one of the following courses may be applied toward graduation: STAT 301, STAT 326, or STAT 401

STAT 305: Engineering Statistics
(3-0) Cr. 3. F.S.SS.
Prereq: MATH 165 (or MATH 165H)
Statistics for engineering problem solving. Principles of engineering data collection; descriptive statistics; elementary probability distributions; principles of experimentation; confidence intervals and significance tests; one-, two-, and multi-sample studies; regression analysis; use of statistical software; team project involving engineering experimentation and data analysis. Credit for both Stat 105 and 305 may not be applied for graduation.
STAT 322: Probabilistic Methods for Electrical Engineers
(Cross-listed with E E). (3-0) Cr. 3. F.S.
Prereq: E E 224
Introduction to probability with applications to electrical engineering.
Sets and events, probability space, conditional probability, total probability and Bayes' rule. Discrete and continuous random variables, cumulative distribution function, probability mass and density functions, expectation, moments, moment generating functions, multiple random variables, functions of random variables. Elements of statistics, hypothesis testing, confidence intervals, least squares. Introduction to random processes.

STAT 326: Introduction to Business Statistics II
(2-2) Cr. 3. F.S.
Prereq: STAT 226
Multiple regression analysis; regression diagnostics; model building; applications in analysis of variance and time series; random variables; distributions; conditional probability; statistical process control methods; use of computers to visualize and analyze data. Credit for only one of the following courses may be applied toward graduation: STAT 301, STAT 326 or STAT 401.

STAT 330: Probability and Statistics for Computer Science
(3-0) Cr. 3. F.S.
Prereq: MATH 166
Topics from probability and statistics applicable to computer science. Basic probability; Random variables and their distributions; Stochastic processes including Markov chains; Queuing models; Basic statistical inference; Introduction to regression.

STAT 332: Visual Communication of Quantitative Information
(Cross-listed with ENGL). (3-0) Cr. 3. Alt. S., offered even-numbered years.
Prereq: STAT 101, STAT 104, STAT 201 or STAT 226; ENGL 250
Communicating quantitative information using visual displays; visualizing data; interactive and dynamic data displays; evaluating current examples in the media; color, perception, and representation in graphs; interpreting data displays.

STAT 341: Introduction to the Theory of Probability and Statistics I
(Cross-listed with MATH). (3-0) Cr. 3. F.S.
Prereq: MATH 265 (or MATH 265H)
Probability; distribution functions and their properties; classical discrete and continuous distribution functions; multivariate probability distributions and their properties; moment generating functions; simulation of random variables and use of the R statistical package. Credit for both STAT 341 and STAT 447 may not be applied toward graduation.

STAT 342: Introduction to the Theory of Probability and Statistics II
(Cross-listed with MATH). (3-0) Cr. 3. F.S.
Prereq: STAT 341; MATH 207 or MATH 317
Transformations of random variables; sampling distributions; confidence intervals and hypothesis testing; theory of estimation and hypothesis tests; linear model theory; use of the R statistical package for simulation and data analysis.

STAT 361: Statistical Quality Assurance
(Cross-listed with I E). (2-2) Cr. 3. F.S.
Prereq: STAT 231, STAT 301, STAT 326 or STAT 401

STAT 398: Cooperative Education
Cr. R. F.S.SS.
Prereq: Permission of department chair
Off-campus work periods for undergraduate students in a field of statistics.

STAT 401: Statistical Methods for Research Workers
(3-2) Cr. 4. F.S.SS.
Prereq: STAT 101 or STAT 104 or STAT 105 or STAT 201 or STAT 226
Graduate students without an equivalent course should contact the department. Methods of analyzing and interpreting experimental and survey data. Statistical concepts and models; estimation; hypothesis tests with continuous and discrete data; simple and multiple linear regression and correlation; introduction to analysis of variance and blocking. Credit for only one of the following courses may be applied toward graduation: STAT 301, STAT 326, or STAT 401.

STAT 402: Statistical Design and the Analysis of Experiments
(3-0) Cr. 3. F.S.
Prereq: STAT 301 or STAT 326 or STAT 401
The role of statistics in research and the principles of experimental design. Experimental units, randomization, replication, blocking, subdividing and repeatedly measuring experimental units; factorial treatment designs and confounding; extensions of the analysis of variance to cover general crossed and nested classifications and models that include both classificatory and continuous factors. Determining sample size.
STAT 404: Regression for Social and Behavioral Research
(2-2) Cr. 3. F.S.
Prereq: STAT 301 or STAT 326 or STAT 401
Applications of generalized linear regression models to social science data. Assumptions of regression; diagnostics and transformations; analysis of variance and covariance; path analysis; logistic, multinomial and Poisson regression.

STAT 406: Statistical Methods for Spatial Data
(3-0) Cr. 3. Alt. S., offered even-numbered years.
Prereq: Six hours of statistics at the 400-level
The analysis of spatial data; geostatistical methods, mapping and spatial prediction; methods for areal data; models and methods for spatial point processes. Emphasis on application and practical use of spatial statistical analysis. Use of R and R packages for spatial data analysis.

STAT 407: Methods of Multivariate Analysis
(2-2) Cr. 3. F.
Prereq: STAT 301 or STAT 326 or STAT 401, knowledge of matrix algebra
Techniques for displaying and analyzing multivariate data including plotting high-dimensional data using interactive graphics, comparing group mean vectors using Hotelling's T2, multivariate analysis of variance, reducing variable dimension with principal components, grouping/classifying observations with cluster analysis and discriminant analysis. Imputation of missing multivariate observations.

STAT 410: Statistical Methods for Mathematics Teachers
(6-0) Cr. 6. Alt. SS., offered odd-numbered years.
Prereq: STAT 341 or equivalent
Descriptive statistics; data collection through experimentation and sampling; univariate statistical inference; contingency tables; design of experiments and ANOVA; simple linear regression; logistic regression; multiple linear regression; statistics pedagogy.

STAT 415: Advanced Statistical Methods for Research Workers
(1-0) Cr. 1. Repeatable, maximum of 3 credits. S.
Prereq: STAT 301 or STAT 326 or STAT 401
Advanced statistical methods for modeling and analyzing data. Taught as separate 1 cr. sections, each of 5 weeks. Three sections taught in one semester. Areas covered: Logistic and Poisson regression; Structural equation modeling; Smoothing and nonparametric regression; Nonparametric and distribution free methods; Bootstrapping and randomization tests; Visualization of high dimensional data; Analysis of species composition data; Missing data and measurement error.

STAT 416: Statistical Design and Analysis of Gene Expression Experiments
(3-0) Cr. 3. S.
Prereq: STAT 301 or STAT 326 or STAT 401
Introduction to high-throughput technologies for gene expression studies (especially RNA-sequencing technology): the role of blocking, randomization, and biological and technical replication in the design of gene expression experiments; normalization methods; methods for identifying differentially expressed genes including mixed linear model analysis, generalized linear model analysis, generalized linear mixed model analysis, quasi-likelihood methods, empirical Bayes analysis, and resampling based approaches; procedures for controlling false discovery rate for multiple testing; clustering and classification problems for gene expression data; testing gene categories; emphasis on practical use of methods.

STAT 421: Survey Sampling Techniques
(2-2) Cr. 3. S.
Prereq: STAT 301 or STAT 326 or STAT 401
Concepts of sample surveys and the survey process; methods of designing sample surveys, including: simple random, stratified, and multistage sampling designs; methods of analyzing sample surveys including ratio, regression, domain estimation and nonresponse.

STAT 430: Empirical Methods for the Computational Sciences
(3-0) Cr. 3. F.
Prereq: STAT 330 or an equivalent course, MATH 166, knowledge of linear algebra.
Statistical methods for research involving computers; exploratory data analysis; selected topics from analysis of designed experiments - analysis of variance, hypothesis testing, interaction among variables; linear regression, logistic regression, Poisson regression; parameter estimation, prediction, confidence regions, dimension reduction techniques, model diagnostics and sensitivity analysis; Markov chains and processes; simulation techniques and bootstrap methods; applications to computer science, bioinformatics, computer engineering - programs, models and systems as objects of empirical study; communicating results of empirical studies. Statistical software: R.

STAT 432: Applied Probability Models
(3-0) Cr. 3. F.
Prereq: STAT 231 or STAT 341 or STAT 447
Probabilistic models in biological, engineering and the physical sciences. Markov chains; Poisson, birth-and-death, renewal, branching and queuing processes; applications to bioinformatics and other quantitative problems.
STAT 444: Bayesian Data Analysis
(2-2) Cr. 3. S.
Prereq: STAT 301 or STAT 326 or STAT 401; STAT 342 or STAT 447.
Probability models and prior distributions; updating priors through the
likelihood function. Computational and simulation-based methods for
deriving posterior distributions and for estimating parameters. Basic
statistical and hierarchical models. Model adequacy and posterior
predictive checks. Markov Chain Monte Carlo methods and introduction
to WinBUGS or similar software. Emphasis on applications and examples
from the social, biological and physical sciences.

STAT 447: Statistical Theory for Research Workers
(4-0) Cr. 4. F.S.S.
Prereq: MATH 151 and permission of instructor, or MATH 265
Primarily for graduate students not majoring in statistics. Emphasis
on aspects of the theory underlying statistical methods. Probability,
probability density and mass functions, distribution functions, moment
generating functions, sampling distributions, point and interval
estimation, maximum likelihood and likelihood ratio tests, linear model
theory, conditional expectation and minimum mean square error
estimation, introduction to posterior distributions and Bayesian analysis,
use of simulation to verify and extend theory. Credit for both STAT 341
and STAT 447 may not be applied toward graduation.

STAT 451: Applied Time Series
(3-0) Cr. 3. S.
Prereq: STAT 301 or STAT 326 or STAT 401
Meeker. Methods for analyzing data collected over time; review of
multiple regression analysis. Elementary forecasting methods: moving
averages and exponential smoothing. Autoregressive-moving average
(Box-Jenkins) models: identification, estimation, diagnostic checking,
and forecasting. Transfer function models and intervention analysis.
Introduction to multivariate time series methods.

STAT 457: Applied Categorical Data Analysis
(3-0) Cr. 3. S.
Prereq: STAT 301 or STAT 326 or STAT 401
Statistical methods for the analysis of categorical data: graphical
summaries, estimation and inference for proportions, sample size
determination, chi-square tests, measures of relative risk, odds and
association, analysis of paired data and measures of agreement, logistic
regression models, log-linear models.

STAT 479: Computer Processing of Statistical Data
(3-0) Cr. 3. F.
Prereq: STAT 301 or STAT 326 or STAT 401
Structure, content and programming aspects of the Statistical Analysis
System (SAS) software package. Advanced techniques in the use of SAS
for data analysis including statistical graphics, regression diagnostics,
and complex analysis of variance models. The SAS graphical interfaces
Enterprise Guide and Enterprise Miner will be introduced.

STAT 480: Statistical Computing Applications
(3-0) Cr. 3. S.
Prereq: STAT 301 or STAT 326 or STAT 401
Modern statistical computing. Data management; spreadsheets,
verifying data accuracy, transferring data between software packages.
Data and graphical analysis with statistical software packages.
Algorithmic programming concepts and applications. Simulation.
Software reliability.

STAT 490: Independent Study
Cr. arr. Repeatable, maximum of 9 credits.
Prereq: 10 credits in statistics
No more than 9 credits in Stat 490 may be counted toward graduation.

STAT 490H: Independent Study: Honors
Cr. arr. Repeatable, maximum of 9 credits.
Prereq: 10 credits in statistics
No more than 9 credits in Stat 490 may be counted toward graduation.

STAT 495: Applied Statistics for Industry I
(3-0) Cr. 3. Alt. F., offered even-numbered years.
Prereq: STAT 101 or STAT 104 or STAT 105 or STAT 201 or STAT 226; MATH
166 (or MATH 166H)
Graduate students without an equivalent course should consult the
department. Statistical thinking applied to industrial processes.
Assessing, monitoring and improving processes using statistical
methods. Analytic/ enumerative studies; graphical displays of data;
fundamentals of six sigma; process monitoring; control charts; capability
analysis.

STAT 496: Applied Statistics for Industry II
(3-0) Cr. 3. Alt. S., offered odd-numbered years.
Prereq: STAT 495
Statistical design and analysis of industrial experiments. Concepts of
control, randomization and replication. Simple and multiple regression;
factorial and fractional factorial experiments; application of ideas of six
sigma; reliability; analysis of lifetime data.

Courses primarily for graduate students, open to qualified
undergraduates:
STAT 500: Statistical Methods I  
(3-2) Cr. 4. F.  
Prereq: STAT 447 or current enrollment in STAT 542; knowledge of matrix algebra.  
Analysis of data from designed experiments and observational studies. Randomization-based inference; inference on group means; nonparametric bootstrap; pairing/blocking and other uses of restricted randomization. Use of linear models to analyze data; least squares estimation; estimability; sampling distributions of estimators; general linear tests; inference for parameters and contrasts. Model assessment and diagnostics; remedial measures; alternative approaches based on ranks.

STAT 501: Multivariate Statistical Methods  
(3-0) Cr. 3. S.  
Prereq: STAT 500 or STAT 402; STAT 447 or STAT 542; STAT 579 or equivalent; knowledge of matrix algebra.  
Statistical methods for analyzing and displaying multivariate data; the multivariate normal distribution; inference in multivariate populations, simultaneous analysis of multiple responses, multivariate analysis of variance; summarizing high dimensional data with principal components, factor analysis, canonical correlations, classification methods, clustering, multidimensional scaling; introduction to basic nonparametric multivariate methods. Statistical software: SAS or R.

STAT 502: Applied Modern Multivariate Statistical Learning  
(3-0) Cr. 3. Alt. S., offered even-numbered years.  
Prereq: STAT 500, STAT 542, STAT 579.  
A Statistics-MS-level introduction to Modern Multivariate Statistical Learning. Theory-based methods for modern data mining and machine learning, inference and prediction. Variance-bias trade-offs and choice of predictors; linear methods of prediction; basis expansions; smoothing, regularization, kernel smoothing methods; neural networks and radial basis function networks; bootstrapping, model averaging, and stacking; linear and quadratic methods of classification; support vector machines; trees and random forests; boosting; prototype methods; unsupervised learning including clustering, principal components, and multi-dimensional scaling; kernel mechanics. Substantial use of R packages implementing these methods.

STAT 503: Exploratory Methods and Data Mining  
(2-2) Cr. 3. Alt. S., offered odd-numbered years.  
Prereq: STAT 301 or STAT 326 or STAT 401; STAT 341 or STAT 447 or STAT 542; STAT 480 or STAT 579.  
Approaches to finding the unexpected in data; exploratory data analysis; pattern recognition; dimension reduction; supervised and unsupervised classification; interactive and dynamic graphical methods; computer-intensive statistical techniques for large or high dimensional data and visual inference. Emphasis is on problem solving, topical problems, and learning how so-called black-box methods actually work.

STAT 505: Environmental Statistics  
(3-0) Cr. 3. Alt. S., offered even-numbered years.  
Prereq: STAT 341 or STAT 447; STAT 401.  
Statistical methods and models for environmental applications. Emphasis on environmental toxicology. Analysis of data with below detection-limit values. Dose-response curve modeling, including overdispersion and estimation of safe doses. Trend analysis; analysis of autocorrelated data. Equivalence testing.

STAT 506: Statistical Methods for Spatial Data  
(3-0) Cr. 3. Alt. S., offered odd-numbered years.  
Prereq: STAT 447 or STAT 542.  
The analysis of spatial data; geostatistical methods and spatial prediction; discrete index random fields and Markov random field models; models for spatial point processes.

STAT 510: Statistical Methods II  
(3-0) Cr. 3. S.  
Prereq: STAT 500, STAT 447 or credit/enrollment in STAT 543.  
Model selection and collinearity in linear regression. Likelihood analysis for general models and models with non-normal random components; linear model results in the context of likelihood; linear mixed models and their application; estimation, inference, and prediction. Computational issues in iterative algorithms; expectation- maximization algorithm and its use in mixed models. Case studies of applications including problem formulation, exploratory analysis, model development, estimation and inference, and model assessment.

STAT 512: Design of Experiments  
(3-0) Cr. 3. F.  
Prereq: STAT 511.  
Basic techniques of experimental design developed in the context of the general linear model; completely randomized, randomized complete block, and Latin Square designs; factorial experiments, confounding, fractional replication; split-plot and incomplete block designs.
STAT 513: Response Surface Methodology
(3-0) Cr. 3. Alt. S., offered even-numbered years.
Prereq: STAT 402 or STAT 512, knowledge of elementary matrix theory and matrix formulation of regression
Analysis techniques for locating optimum and near-optimum operating conditions: standard experimental designs for first- and second-order response surface models; design performance criteria; use of data transformations; mixture experiments; optimization for multiple-response problems. Requires use of statistical software with matrix functions.

STAT 515: Theory and Applications of Nonlinear Models
(3-0) Cr. 3. Alt. F., offered odd-numbered years.
Prereq: STAT 447 or STAT 543; STAT 510
Construction of nonlinear statistical models; random and systematic model components, additive error nonlinear regression with constant and non-constant error variances, generalized linear models, transform both sides models. Iterative algorithms for estimation and asymptotic inference. Basic random parameter models, beta-binomial and gamma-Poisson mixtures. Requires use of instructor-supplied and student-written R functions.

STAT 516: Statistical Design and Analysis of Gene Expression Experiments
(3-0) Cr. 3. S.
Prereq: STAT 500; STAT 447 or STAT 542
Introduction to high-throughput technologies for gene expression studies (especially RNA-sequencing technology): the role of blocking, randomization, and biological and technical replication in the design of gene expression experiments; normalization methods; methods for identifying differentially expressed genes including mixed linear model analysis, generalized linear model analysis, generalized linear mixed model analysis, quasi-likelihood methods, empirical Bayes analysis, and resampling based approaches; procedures for controlling false discovery rate for multiple testing; clustering and classification problems for gene expression data; testing gene categories; emphasis on current research topics for statistical analysis of high dimensional gene expression data.

STAT 520: Statistical Methods III
(3-0) Cr. 3. F.
Prereq: STAT 510, STAT 447 or STAT 543
Nonlinear regression; generalized least squares; asymptotic inference. Generalized linear models; exponential dispersion families; maximum likelihood and inference. Designing Monte Carlo studies; bootstrap; cross-validation. Fundamentals of Bayesian analysis; data models, priors and posteriors; posterior prediction; credible intervals; Bayes Factors; types of priors; simulation of posteriors; introduction to hierarchical models and Markov Chain Monte Carlo methods.

STAT 521: Theory and Applications of Sample Surveys
(3-0) Cr. 3. S.
Prereq: STAT 401; STAT 447 or STAT 542

STAT 522: Advanced Applied Survey Sampling
(3-0) Cr. 3. Alt. F., offered odd-numbered years.
Prereq: STAT 521 or both STAT 421 and STAT 447
Advanced topics in survey sampling and methodology: clustering and stratification in practice, adjustments and imputation for missing data, variance estimation in complex surveys, methods of panel and/or longitudinal surveys, procedures to increase response rates, and computing. Examples are taken from large, well-known surveys in various subject areas. Prior exposure to mathematical statistics, probability, and at least one course in survey sampling theory is assumed.

STAT 531: Quality Control and Engineering Statistics
(Cross-listed with I E). (3-0) Cr. 3. Alt. S., offered odd-numbered years.
Prereq: STAT 401; STAT 342 or STAT 447
Statistical methods and theory applicable to problems of industrial process monitoring and improvement. Statistical issues in industrial measurement; Shewhart, CUSUM, and other control charts; feedback control; process characterization studies; estimation of product and process characteristics; acceptance sampling, continuous sampling and sequential sampling; economic and decision theoretic arguments in industrial statistics.

STAT 533: Reliability
(Cross-listed with I E). (3-0) Cr. 3. Alt. S., offered even-numbered years.
Prereq: STAT 342 or STAT 432 or STAT 447
Probabilistic modeling and inference in engineering reliability; lifetime models, product limit estimator, probability plotting, maximum likelihood estimation for censored data, Bayesian methods in reliability, system reliability models, competing risk analysis, acceleration models and analysis of accelerated test data; analysis of recurrence data; planning studies to obtain reliability data.
STAT 534: Ecological Statistics
(3-0) Cr. 3. Alt. F., offered odd-numbered years.
Prereq: STAT 447 or STAT 542
Statistical methods for non-standard problems, illustrated using questions and data from ecological field studies. Estimation of abundance and survival from mark-recapture studies, deterministic and stochastic matrix models of population trends, integral projection models, and hierarchical modeling, especially of population dynamics. Additional topics vary based on student interest.

STAT 536: Statistical Genetics
(Cross-listed with GDCB). (3-0) Cr. 3. Alt. F., offered even-numbered years.
Prereq: STAT 401, STAT 447; GEN 320 or BIOL 313
Statistical models and methods for genetics covering models of population processes: selection, mutation, migration, population structure, and linkage disequilibrium, and inference techniques: genetic mapping, linkage analysis, and quantitative trait analysis. Applications include genetic map construction, gene mapping, genome-wide association studies (GWAS), inference about population structure, phylogenetic tree construction, and forensic and paternity identification.

STAT 542: Theory of Probability and Statistics I
(4-0) Cr. 4. F.
Prereq: MATH 414.

STAT 543: Theory of Probability and Statistics II
(3-0) Cr. 3. S.
Prereq: STAT 542.

STAT 544: Bayesian Statistics
(3-0) Cr. 3. S.
Prereq: STAT 543
Specification of probability models; subjective, conjugate, and noninformative prior distributions; hierarchical models; analytical and computational techniques for obtaining posterior distributions; model checking, model selection, diagnostics; comparison of Bayesian and traditional methods.

STAT 546: Nonparametric Methods in Statistics
(3-0) Cr. 3. Alt. F., offered even-numbered years.
Prereq: STAT 510, STAT 542
Overview of parametric versus nonparametric methods of inference; introduction to rank-based tests and/or nonparametric smoothing methods for estimating density and regression functions; smoothing parameter selection; applications to semiparametric models and goodness-of-fit tests of a parametric model.

STAT 547: Functional Data Analysis
(3-0) Cr. 3. Alt. S., offered odd-numbered years.
Prereq: STAT 543, STAT 511
Theory and methods for analyzing functional data, which are high dimensional data resulted from discrete, error-contaminated measurements on smooth curves and images. The topics include kernel and spline smoothing, basis expansion, semiparametric regression, functional analysis of variance, covariance modeling and estimation, functional principal component analysis, functional generalization linear models, joint modeling, dimension reduction, classification and clustering functional data.

STAT 551: Time Series Analysis
(3-0) Cr. 3. F.
Prereq: STAT 447 or STAT 542
Concepts of trend and dependence in time series data; stationarity and basic model structures for dealing with temporal dependence; moving average and autoregressive error structures; analysis in the time domain and the frequency domain; parameter estimation, prediction and forecasting; identification of appropriate model structure for actual data and model assessment techniques. Possible extended topics include dynamic models and linear filters.

STAT 554: Introduction to Stochastic Processes
(Cross-listed with MATH). (3-0) Cr. 3. F.
Prereq: STAT 542
Markov chains on discrete spaces in discrete and continuous time (random walks, Poisson processes, birth and death processes) and their long-term behavior. Optional topics may include branching processes, renewal theory, introduction to Brownian motion.
STAT 557: Statistical Methods for Counts and Proportions  
(3-0) Cr. 3. F.  
Prereq: STAT 500 or STAT 401; STAT 543 or STAT 447  
Statistical methods for analyzing simple random samples when outcomes are counts or proportions; measures of association and relative risk, chi-squared tests, loglinear models, logistic regression and other generalized linear models, tree-based methods. Extensions to longitudinal studies and complex designs, models with fixed and random effects. Use of statistical software: SAS, S-Plus or R.

STAT 565: Methods in Biostatistics and Epidemiology  
(Cross-listed with TOX). (3-0) Cr. 3. Alt. F., offered odd-numbered years.  
Prereq: STAT 500 or STAT 401; STAT 543 or STAT 447  
Statistical methods commonly used in epidemiology and human and animal health studies. Overview of cohort studies, case-control studies and randomized clinical trials. Topics include inference procedures for disease risk factors, analysis of time-to-event and survival data, analysis of longitudinal studies of disease progression and health status, approaches to handling missing data, and meta-analysis. Examples will come from recent studies of physical and mental health, nutrition and disease progression in human and animal populations. Use of statistical software: SAS or R.

STAT 568: Bioinformatics II (Statistical Bioinformatics)  
(Cross-listed with BCB, COM S, GDCB). (3-0) Cr. 3. S.  
Prereq: BCB 567 or (BIOL 315 and STAT 430), credit or enrollment in GEN 409  
Statistical models for sequence data, including applications in genome annotation, motif discovery, variant discovery, molecular phylogeny, gene expression analysis, and metagenomics. Statistical topics include model building, inference, hypothesis testing, and simple experimental design, including for big data/complex models.

STAT 570: Bioinformatics IV (Systems Biology)  
(Cross-listed with BCB, COM S, CPR E, GDCB). (3-0) Cr. 3. S.  
Prereq: BCB 567 or COM S 311, COM S 228, GEN 409, STAT 430  

STAT 579: An Introduction to R  
(0-2) Cr. 1. F.  
Prereq: Enrollment in STAT 500  
An introduction to the logic of programming, numerical algorithms, and graphics. The R statistical programming environment will be used to demonstrate how data can be stored, manipulated, plotted, and analyzed using both built-in functions and user extensions. Concepts of modularization, looping, vectorization, conditional execution, and function construction will be emphasized.

STAT 580: Statistical Computing  
(3-0) Cr. 3. S.  
Prereq: STAT 579; STAT 447 or STAT 542  
Introduction to scientific computing for statistics using tools and concepts in R: programming tools, modern programming methodologies, modularization, design of statistical algorithms. Introduction to C programming for efficiency; interfacing R with C. Building statistical libraries. Use of algorithms in modern subroutine packages, optimization and integration. Implementation of simulation methods; inversion of probability integral transform, rejection sampling, importance sampling. Monte Carlo integration.

STAT 590: Special Topics  
Cr. arr. Repeatable.

STAT 590A: Special Topics: Theory  
Cr. arr. Repeatable.

STAT 590B: Special Topics: Methods  
Cr. arr. Repeatable.

STAT 590C: Special Topics: Design of Experiments  
Cr. arr. Repeatable.

STAT 590D: Special Topics: Sample Surveys  
Cr. arr. Repeatable.

STAT 590E: Special Topics: Statistics Education  
Cr. arr. Repeatable.

STAT 590F: Special Topics: Statistical Computing and Graphics  
Cr. arr. Repeatable. F.

STAT 598: Cooperative Education  
Cr. R. F.S.SS.  
Prereq: Permission of the department chair  
Off-campus work periods for graduate students in a field of statistics.

STAT 599: Creative Component  
Cr. arr.

Courses for graduate students:
STAT 601: Advanced Statistical Methods  
(3-0) Cr. 3. S.  
Prereq: STAT 520, STAT 543 and MATH 414 or enrollment in STAT 641  
Methods of constructing complex models including adding parameters to existing structures, incorporating stochastic processes and latent variables. Use of modified likelihood functions; quasi-likelihoods; profiles; composite likelihoods. Asymptotic normality as a basis of inference; Godambe information. Sample reuse; block bootstrap; resampling with dependence. Simulation for model assessment. Issues in Bayesian analysis.

STAT 602: Modern Multivariate Statistical Learning  
(3-0) Cr. 3. Alt. S., offered odd-numbered years.  
Prereq: STAT 520, STAT 543, STAT 579  
Statistical theory and methods for modern data mining and machine learning, inference, and prediction. Variance-bias trade-offs and choice of predictors; linear methods of prediction; basis expansions; smoothing, regularization, and reproducing kernel Hilbert spaces; kernel smoothing methods; neural networks and radial basis function networks; bootstrapping, model averaging, and stacking; linear and quadratic methods of classification; support vector machines; trees and random forests; boosting; prototype methods; unsupervised learning including clustering, principal components, and multi-dimensional scaling; kernel mechanics.

STAT 606: Advanced Spatial Statistics  
(3-0) Cr. 3. Alt. S., offered odd-numbered years.  
Prereq: STAT 506, STAT 642  
Consideration of advanced topics in spatial statistics, including areas of current research. Topics may include construction of nonstationary covariance structures including intrinsic random functions, examination of edge effects, general formulation of Markov random field models, spatial subsampling, use of pseudo-likelihood and empirical likelihood concepts in spatial analysis, the applicability of asymptotic frameworks for inference, and a discussion of appropriate measures for point processes.

STAT 611: Theory and Applications of Linear Models  
(3-0) Cr. 3. F.  
Prereq: STAT 510; STAT 542 or STAT 447; a course in matrix algebra  
Matrix preliminaries, estimability, theory of least squares and of best linear unbiased estimation, analysis of variance and covariance, distribution of quadratic forms, extension of theory to mixed and random models, inference for variance components.

STAT 612: Advanced Design of Experiments  
(3-0) Cr. 3. Alt. S., offered even-numbered years.  
Prereq: STAT 512  
General theory of factorial experiments. Design optimality criteria, approximate design and general equivalence theory. Computational approaches to constructing optimal designs for linear models, and extensions to nonlinear models. Advanced topics of current interest in the design of experiments, including one or more of: distance based design criteria and construction of spatial process models, screening design strategies for high-dimensional problems, and design problems associated with computational experiments.

STAT 615: Advanced Bayesian Methods  
(3-0) Cr. 3. Alt. S., offered even-numbered years.  
Prereq: STAT 544 and STAT 601  

STAT 621: Advanced Theory of Survey Statistics  
(3-0) Cr. 3. Alt. F., offered odd-numbered years.  
Prereq: STAT 521  
Advanced topics of current interest in the design of surveys and analysis of survey data, including: asymptotic theory for design and model-based estimators, use of auxiliary information in estimation, variance estimation techniques, small area estimation, non-response modeling and imputation.

STAT 641: Foundations of Probability Theory  
(Cross-listed with MATH). (3-0) Cr. 3. F.  
Prereq: MATH 414 or MATH 501 or equivalent course.  
STAT 642: Advanced Probability Theory
(Cross-listed with MATH). (3-0) Cr. 3. S.
Prereq: STAT 641, or STAT 543 and MATH 515.

STAT 643: Advanced Theory of Statistical Inference
(3-0) Cr. 3. F.
Prereq: STAT 543, STAT 642

STAT 644: Advanced Bayesian Theory
(3-0) Cr. 3. Alt. F., offered even-numbered years.
Prereq: STAT 544 and STAT 642
Exchangeability, parametric models, consistency and asymptotic normality of posterior distributions, posterior robustness, selection of priors using formal rules, improper priors and posterior propriety. Bayes factors, model selection, MCMC theory, irreducibility. Harris recurrence, regeneration, minorization, drift, ergodicity, limit theorems, techniques for speeding up convergence of certain MCMC algorithms.

STAT 645: Advanced Stochastic Processes
(Cross-listed with MATH). (3-0) Cr. 3. S.

STAT 647: Advanced Multivariate Analysis
(3-0) Cr. 3. Alt. F., offered even-numbered years.
Prereq: STAT 543, knowledge of matrix algebra
Multivariate normal distribution, estimation of the mean vector and the covariance matrix, multiple and partial correlation, Hotelling's T2 statistic, Wishart distribution, multivariate regression, principle components, discriminant analysis, high dimensional data analysis, latent variables.

STAT 648: Seminar on Theory of Statistics and Probability
Cr. arr. F.
Prereq: STAT 543.
Seminar topics change with each offering.

STAT 651: Advanced Time Series
(3-0) Cr. 3. Alt. S., offered even-numbered years.
Prereq: STAT 551, STAT 642

STAT 680: Advanced Statistical Computing
(3-0) Cr. 3. F.
Prereq: STAT 543 and STAT 580

STAT 690: Advanced Special Topics
Cr. arr. Repeatable.
Prereq: Permission of instructor

STAT 690A: Advanced Special Topics: Theory
Cr. arr. Repeatable.
Prereq: Permission of instructor

STAT 690B: Advanced Special Topics: Methods
Cr. arr. Repeatable.
Prereq: Permission of instructor

STAT 690C: Advanced Special Topics: Design of Experiments
Cr. arr. Repeatable.
Prereq: Permission of instructor

STAT 690D: Advanced Special Topics: Sample Surveys
Cr. arr. Repeatable.
Prereq: Permission of instructor

STAT 690E: Advanced Special Topics: Statistical Computing
Cr. arr. Repeatable.
Prereq: Permission of instructor

STAT 690F: Advanced Special Topics: Graphics
Cr. arr. Repeatable.
Prereq: Permission of instructor
STAT 699: Research
Cr. arr. Repeatable.