ECONOMICS AND STATISTICS

The Economics-Statistics major provides the student with a grounding in economic theory comparable to that provided by the general economics major; and also exposes the student to rigorous and extensive training in Statistics. Students choose between two tracks of the major. The Computational Track consists of coursework in applied statistical methods. It is recommended for students preparing to apply statistical methods in the social sciences. The Theoretical Track consists of calculus-based probability, and the theory of statistical inference. It also provides some practical training in data analysis.

Available to students of the Class of 2021 and later.

Department Administrator: Robert O'Connor

Chair: Rajiv Sethi (Ann Whitney Olin Professor)
Professors: Elizabeth Ananat, André Burgstaller, Alan Dye, Daniel Hamermesh (Distinguished Scholar), Sharon Harrison, Shaw-Hwa Lo (Statistics), Lalith Munasinghe, David Weiman (Alena Wels Hirschorn '58 Professor)
Associate Professors: Yang Feng (Statistics), Jingchen Liu (Statistics), Randall Reback, Ashley Timmer (Adjunct)
Assistant Professors: Belinda Archibong, Biwei Chen (Term), Martina Jasova, Elizabeth Kopko (Adjunct), Peter Orbanz (Statistics), Sonia Pereira (Term), Anja Tolonen, Homa Zarghamee

Lecturers in Statistics: Banu Baydil, Ronald Neath, David Rios, Joyce Robbins, Gabriel Young

Computational Track

The Economics-Statistics, Computational Track requires a minimum of 16 courses (52 minimum credits).

10 courses in Economics, Mathematics

<table>
<thead>
<tr>
<th>Course</th>
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<tbody>
<tr>
<td>ECON BC1003</td>
<td>Introduction to Economic Reasoning</td>
</tr>
<tr>
<td>MATH UN1102</td>
<td>Calculus II</td>
</tr>
<tr>
<td>MATH UN201</td>
<td>Calculus III</td>
</tr>
<tr>
<td>MATH UN2010</td>
<td>Linear Algebra</td>
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<tr>
<td>ECON BC3033</td>
<td>Intermediate Macroeconomic Theory</td>
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<td>ECON BC3035</td>
<td>Intermediate Microeconomic Theory</td>
</tr>
<tr>
<td>ECON BC3041</td>
<td>Theoretical Foundations of Political Economy</td>
</tr>
<tr>
<td>Two Upper-level Electives in Economics</td>
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<tr>
<td>ECON BC3063</td>
<td>SENIOR SEMINAR</td>
</tr>
</tbody>
</table>

6 courses in Statistics

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<tr>
<td>STAT UN1201</td>
<td>Calculus-Based Introduction to Statistics</td>
</tr>
<tr>
<td>ECON BC3018</td>
<td>ECONOMETRICS</td>
</tr>
<tr>
<td>STAT GU4203</td>
<td>PROBABILITY THEORY</td>
</tr>
<tr>
<td>STAT GU4204</td>
<td>Statistical Inference</td>
</tr>
<tr>
<td>STAT GU4205</td>
<td>Linear Regression Models</td>
</tr>
<tr>
<td>One Elective in Statistics at the 3000+ level (or a Computer Science Elective such as COMS W1004, W1005, W1007, or STAT UN2102)</td>
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</tbody>
</table>

Theoretical Track

The Economics-Statistics, Theoretical Track requires a minimum of 16 courses (52 minimum credits).

10 courses in Economics, Mathematics which are the same as in the Computational Track above, plus

6 courses in Statistics which differs from the Computational Track somewhat:

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Economics, Mathematics

ECON BC1003 Introduction to Economic Reasoning. 3 points.

Covers basic elements of microeconomic and macroeconomic reasoning at an introductory level. Topics include Individual Constraints and Preferences, Production by Firms, Market Transactions, Competition, The Distribution of Income, Technological Progress and Growth, Unemployment and Inflation, the Role of Government in the Economy.

Note: Students cannot get credit for ECON BC1003 if they have taken the Columbia introductory course ECON W105 Principles of Economics.

MATH UN1102 Calculus II. 3 points.

Prerequisites: MATH V1101 or the equivalent. Methods of integration, applications of the integral, Taylor's theorem, infinite series. (SC)

MATH UN1201 Calculus III. 3 points.

Prerequisites: MATH V1101 or the equivalent. Vectors in dimensions 2 and 3, complex numbers and the complex exponential function with applications to differential equations, Cramer's rule, vector-valued functions of one variable, scalar-valued functions of several variables, partial derivatives, gradients, surfaces, optimization, the method of Lagrange multipliers. (SC)

MATH UN2010 Linear Algebra. 3 points.

Prerequisites: MATH V1201, or the equivalent. Matrices, vector spaces, linear transformations, eigenvalues and eigenvectors, canonical forms, applications. (SC)
ECON BC3033 Intermediate Macroeconomic Theory. 4 points.
Prerequisites: An introductory course in economics and a functioning knowledge of high school algebra and analytical geometry or permission of the instructor.
Systematic exposition of current macroeconomic theories of unemployment, inflation, and international financial adjustments.

ECON BC3035 Intermediate Microeconomic Theory. 4 points.
Prerequisites: An introductory course in microeconomics or a combined macro/micro principles course (ECON BC1003 or ECON W1105, or the equivalent) and one semester of calculus or ECON BC1007, or permission of the instructor.
Preferences and demand; production, cost, and supply; behavior of markets in partial equilibrium; resource allocation in general equilibrium; pricing of goods and services under alternative market structures; implications of individual decision-making for labor supply; income distribution, welfare, and public policy. Emphasis on problem solving.

ECON BC3041 Theoretical Foundations of Political Economy. 3 points.
Prerequisites: An introductory course in economics or permission of the instructor.
Intellectual origins of the main schools of thought in political economy. Study of the founding texts in classical political economy, Marxian economics, neoclassicism, and Keynesianism.

ECON BC3063 SENIOR SEMINAR. 4.00 points.
Prerequisites: Permission of the instructor and the completion of all courses (except for the senior requirement) required for the economics track, political economy track, or economics and mathematics majors. Exceptions to these prerequisites may be granted by the chair of the department only. Seminar sections are limited to 15 students. A topic in economic theory or policy of the instructors choice. See department for current topics and for senior requirement preference forms

Statistics, Computer Science

STAT UN1201 Calculus-Based Introduction to Statistics. 3 points.
Prerequisites: one semester of calculus.
Designed for students who desire a strong grounding in statistical concepts with a greater degree of mathematical rigor than in STAT W1111. Random variables, probability distributions, pdf, cdf, mean, variance, correlation, conditional distribution, conditional mean and conditional variance, law of iterated expectations, normal, chi-square, F and t distributions, law of large numbers, central limit theorem, parameter estimation, unbiasedness, consistency, efficiency, hypothesis testing, p-value, confidence intervals, maximum likelihood estimation. Serves as the pre-requisite for ECON W3412.

STAT UN3105 Applied Statistical Methods. 3 points.
Prerequisites: At least one, and preferably both, of STAT UN2103 and UN2104 are strongly recommended. Students without programming experience in R might find STAT UN2102 very helpful. This course is intended to give students practical experience with statistical methods beyond linear regression and categorical data analysis. The focus will be on understanding the uses and limitations of models, not the mathematical foundations for the methods. Topics that may be covered include random and mixed-effects models, classical non-parametric techniques, the statistical theory causality, sample survey design, multi-level models, generalized linear regression, generalized estimating equations and over-dispersion, survival analysis including the Kaplan-Meier estimator, log-rank statistics, and the Cox proportional hazards regression model. Power calculations and proposal and report writing will be discussed.

STAT UN3106 APPLIED MACHINE LEARNING. 3.00 points.
Prerequisites: STAT UN2103. Students without programming experience in R might find STAT UN2102 very helpful. This course is a machine learning class from an application perspective. We will cover topics including data-based prediction, classification, specific classification methods (such as logistic regression and random forests), and basics of neural networks. Programming in homeworks will require R.
STAT GU4203 PROBABILITY THEORY. 3 points.
Prerequisites: At least one semester, and preferably two, of calculus. An introductory course (STAT UN1201, preferably) is strongly recommended. A calculus-based introduction to probability theory. A quick review of multivariate calculus is provided. Topics covered include random variables, conditional probability, expectation, independence, Bayes’ rule, important distributions, joint distributions, moment generating functions, central limit theorem, laws of large numbers and Markov’s inequality.

STAT GU4204 Statistical Inference. 3 points.
Prerequisites: STAT GU4203. At least one semester of calculus is required; two or three semesters are strongly recommended. Calculus-based introduction to the theory of statistics. Useful distributions, law of large numbers and central limit theorem, point estimation, hypothesis testing, confidence intervals maximum likelihood, likelihood ratio tests, nonparametric procedures, theory of least squares and analysis of variance.

STAT GU4205 Linear Regression Models. 3 points.
CC/GS: Partial Fulfillment of Science Requirement
Prerequisites: STAT GU4204 or the equivalent, and a course in linear algebra. Theory and practice of regression analysis. Simple and multiple regression, testing, estimation, prediction, and confidence procedures, modeling, regression diagnostics and plots, polynomial regression, collinearity and confounding, model selection, geometry of least squares. Extensive use of the computer to analyse data.

STAT GU4206 Statistical Computing and Introduction to Data Science. 3 points.
Prerequisites: STAT GU4204 and GU4205 or the equivalent. Introduction to programming in the R statistical package: functions, objects, data structures, flow control, input and output, debugging, logical design, and abstraction. Writing code for numerical and graphical statistical analyses. Writing maintainable code and testing, stochastic simulations, parallelizing data analyses, and working with large data sets. Examples from data science will be used for demonstration.

COMS W1004 Introduction to Computer Science and Programming in Java. 3 points.
Lect: 3.
A general introduction to computer science for science and engineering students interested in majoring in computer science or engineering. Covers fundamental concepts of computer science, algorithmic problem-solving capabilities, and introductory Java programming skills. Assumes no prior programming background. Columbia University students may receive credit for only one of the following two courses: 1004 or 1005.

COMS W1005 Introduction to Computer Science and Programming in MATLAB. 3 points.
CC/GS: Partial Fulfillment of Science Requirement
A general introduction to computer science concepts, algorithmic problem-solving capabilities, and programming skills in MATLAB. Assumes no prior programming background. Columbia University students may receive credit for only one of the following two courses: W1004 or W1005.