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

Computational Track

A major in Economics-Statistics, Computational Track must complete the following 16 courses or their equivalents:

10 courses in Economics, Mathematics

- ECON BC1003 Introduction to Economic Reasoning
- MATH UN1102 CALCULUS II
- MATH UN1201 Calculus III
- MATH UN2010 LINEAR ALGEBRA
- ECON BC3033 Intermediate Macroeconomic Theory
- ECON BC3035 Intermediate Microeconomic Theory
- ECON BC3041 Theoretical Foundations of Political Economy

Two Upper-level Electives in Economics

ECON BC3063 SENIOR SEMINAR

6 courses in Statistics

- STAT UN1201 Calculus-Based Introduction to Statistics
- ECON BC3018 ECONOMETRICS
- STAT GU4203 PROBABILITY THEORY
- STAT GU4204 Statistical Inference
- STAT GU4205 Linear Regression Models

One of the following two courses:

- STAT UN3105 Applied Statistical Methods
- STAT UN3106 Applied Data Mining

One Upper-level Elective in Statistics (STAT UN3106, GU4203, GU4204, GU4205, GU4206, or a Computer Science Elective)

Theoretical Track

A major in Economics-Statistics, Theoretical Track must complete the following 16 courses or their equivalents:

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:

- STAT UN1201 Calculus-Based Introduction to Statistics
- ECON BC3018 ECONOMETRICS
- STAT GU4203 PROBABILITY THEORY
- STAT GU4204 Statistical Inference
- STAT GU4205 Linear Regression Models

One Elective in Statistics at the 3000+ level (or a Computer Science Elective such as COMS W1004, W1005, W1007, or STAT UN2102)

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 W1105 Principles of Economics.

Fall 2021: ECON BC1003

<table>
<thead>
<tr>
<th>Course Number</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
</tr>
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<tr>
<td>ECON 1003</td>
<td>001/00345</td>
<td>T Th 10:10am - 11:25am</td>
<td>Belinda Archibong</td>
<td>3</td>
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<td>ECON 1003</td>
<td>002/00223</td>
<td>M W 1:10pm - 2:25pm</td>
<td>Rajiv Sethi</td>
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Spring 2022: ECON BC1003

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<tr>
<th>Course Number</th>
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<th>Times/Location</th>
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<td>T Th 2:40pm - 3:55pm</td>
<td>Homa Zarghamee</td>
<td>3</td>
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<tr>
<td>ECON 1003</td>
<td>002/00270</td>
<td>T Th 11:40am - 12:55pm</td>
<td>Sonia Pereira</td>
<td>3</td>
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</table>
MATH UN1102 CALCULUS II. 3.00 points.
Prerequisites: MATH UN1101 or the equivalent.
Prerequisites: MATH UN1101 or the equivalent. Methods of integration, applications of the integral, Taylor's theorem, infinite series. (SC)

Fall 2021: MATH UN1102

<table>
<thead>
<tr>
<th>Course Number</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
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<tr>
<td>MATH 1102</td>
<td>001/10631</td>
<td>M W 1:10pm - 2:25pm 407 Mathematics Building</td>
<td>Gerhardt Hinkle</td>
<td>3.00</td>
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<tr>
<td>MATH 1102</td>
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<td>Yash Uday Deshmukh</td>
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<tr>
<td>MATH 1102</td>
<td>003/10634</td>
<td>M W 4:10pm - 5:25pm 312 Mathematics Building</td>
<td>Francesco Lin</td>
<td>3.00</td>
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<tr>
<td>MATH 1102</td>
<td>004/10635</td>
<td>T Th 10:10am - 11:25am 203 Mathematics Building</td>
<td>Dobrind Marchev</td>
<td>3.00</td>
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</tr>
<tr>
<td>MATH 1102</td>
<td>005/10636</td>
<td>T Th 11:40am - 12:55pm 614 Schermerhorn Hall</td>
<td>Yu-sheng Lee</td>
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<tr>
<td>MATH 1102</td>
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<td>Elliott Stein</td>
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Spring 2022: MATH UN1102

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<th>Course Number</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
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<tr>
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<td>Panagiota Daskalopoulos</td>
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<tr>
<td>MATH 1102</td>
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<tr>
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<tr>
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<td>George Dragomir</td>
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<td>MATH 1102</td>
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<td>T Th 2:40pm - 3:55pm Room TBA</td>
<td>George Dragomir</td>
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<td>0/116</td>
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</table>

MATH UN1201 Calculus III. 3 points.
Prerequisites: MATH UN1101 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)

Fall 2021: MATH UN1201

<table>
<thead>
<tr>
<th>Course Number</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
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<tbody>
<tr>
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<td>M W 10:10am - 11:25am 312 Mathematics Building</td>
<td>Konstantin Aleshkin</td>
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<td>Stephen Miller</td>
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Spring 2022: MATH UN1201

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<th>Course Number</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
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<tr>
<td>MATH 1201</td>
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<td>Kyle Hayden</td>
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<td>Kyle Hayden</td>
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<tr>
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<tr>
<td>MATH 1201</td>
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<td>T Th 2:40pm - 3:55pm Room TBA</td>
<td>Stephen Miller</td>
<td>3.00</td>
<td>0/110</td>
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</table>
MATH UN2010 LINEAR ALGEBRA. 3.00 points.
Prerequisites: MATH UN1201 or the equivalent.
Prerequisites: MATH UN1201 or the equivalent. Matrices, vector spaces, linear transformations, eigenvalues and eigenvectors, canonical forms, applications. (SC)

Fall 2021: MATH UN2010
Course Number Section/Call Number Times/Location Instructor Points Enrollment
MATH 2010 001/00173 T Th 8:40am - 9:55am 328 Milbank Hall David Bayer 3.00 29/50
MATH 2010 002/00174 T Th 10:10am - 11:25am 328 Milbank Hall David Bayer 3.00 40/50
MATH 2010 003/10679 M W 10:10am - 11:25am 207 Mathematics Building Marco Castronovo 3.00 38/100
MATH 2010 004/10693 M W 11:40am - 12:55pm 312 Mathematics Building Marco Castronovo 3.00 50/100
MATH 2010 005/10698 T Th 4:10pm - 5:25pm 520 Mathematics Building Henry Pinkham 3.00 13/49

Spring 2022: MATH UN2010
Course Number Section/Call Number Times/Location Instructor Points Enrollment
MATH 2010 001/11856 M W 10:10am - 11:25am Room TBA Amadou Bah 3.00 0/110
MATH 2010 002/11857 M W 11:40am - 12:55pm Room TBA Amadou Bah 3.00 0/110
MATH 2010 003/11858 T Th 1:10pm - 2:25pm Room TBA 0. FACULTY 3.00 0/116
MATH 2010 004/11859 T Th 4:10pm - 5:25pm Room TBA Henry Pinkham 3.00 0/49
MATH 2010 005/11860 T Th 6:10pm - 7:25p Room TBA Elliott Stein 3.00 0/49

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.

Fall 2021: ECON BC3035
Course Number Section/Call Number Times/Location Instructor Points Enrollment
ECON 3035 001/00233 T Th 4:10pm - 5:25pm L103 Diana Center Elizabeth Ananat 4 24/60
ECON 3035 002/00348 T Th 2:40pm - 3:55pm 203 Diana Center Lalith Munasinghe 4 14/50

Spring 2022: ECON BC3035
Course Number Section/Call Number Times/Location Instructor Points Enrollment
ECON 3035 001/00366 M W 2:40pm - 3:55pm Room TBA Lalith Munasinghe 4 0/45

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.

Fall 2021: ECON BC3041
Course Number Section/Call Number Times/Location Instructor Points Enrollment
ECON 3041 001/00234 T Th 6:10pm - 7:25pm L103 Diana Center Sonia Pereira 3 35/35
ECON 3041 002/00235 T Th 4:10pm - 5:25pm 328 Milbank Hall Sonia Pereira 3 37/35

Spring 2022: ECON BC3041
Course Number Section/Call Number Times/Location Instructor Points Enrollment
ECON 3041 001/00330 M W 1:10pm - 2:25pm Room TBA Sonia Pereira 3 0/40
ECON 3041 002/00332 M W 2:40pm - 3:55pm Room TBA David Weiman 3 0/40

ECON 3033 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.

Fall 2021: ECON BC3033
Course Number Section/Call Number Times/Location Instructor Points Enrollment
ECON 3033 001/00232 M W 10:10am - 11:25am Room TBA Martina Jasova 4 76/75

Spring 2022: ECON BC3033
Course Number Section/Call Number Times/Location Instructor Points Enrollment
ECON 3033 001/00358 T Th 6:10pm - 7:25pm Room TBA Elham Saeidinezhad 4 0/50
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.

Statistics, Computer Science

STAT UN2102 Applied Statistical Computing. 3 points.
Corequisites: An introductory course in statistic (STAT UN1101 is recommended).
This course is an introduction to R programming. After learning basic programming component, such as defining variables and vectors, and learning different data structures in R, students will, via project-based assignments, study more advanced topics, such as recursion, conditionals, modular programming, and data visualization. Students will also learn the fundamental concepts in computational complexity, and will practice writing reports based on their statistical analyses.

Statistics, Computer Science

STAT UN2104 Applied Categorical Data Analysis. 3 points.
Prerequisites: STAT UN2103 is strongly recommended. Students without programming experience in R might find STAT UN2102 very helpful.
This course covers statistical models and methods for analyzing and drawing inferences for problems involving categorical data. The goals are familiarity and understanding of a substantial and integrated body of statistical methods that are used for such problems, experience in analyzing data using these methods, and proficiency in communicating the results of such methods, and the ability to critically evaluate the use of such methods. Topics include binomial proportions, two-way and three-way contingency tables, logistic regression, log-linear models for large multi-way contingency tables, graphical methods. The statistical package R will be used.
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.

Fall 2021: STAT UN3105
Course Number Section/Call Number Times/Location Instructor Points Enrollment
STAT 3105 001/13040 T Th 11:40am - 12:55pm 517 Hamilton Hall Xiaofei Shi 3 47/86

STAT UN3106 Applied Data Mining. 3 points.
Prerequisites: STAT UN2103. Students without programming experience in R might find STAT UN2102 very helpful. This course will be taught as a machine learning class. 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; students without programming experience in R might find STAT UN2102 helpful.

Spring 2022: STAT UN3106
Course Number Section/Call Number Times/Location Instructor Points Enrollment
STAT 3106 001/13800 T Th 2:40pm - 3:55pm Room TBA Wayne Lee 3 0/55

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.

Fall 2021: STAT GU4203
Course Number Section/Call Number Times/Location Instructor Points Enrollment
STAT 4203 001/13044 M W 10:10am - 11:25am 903 School Of Social Work Shaw-Hwa Lo 3 8/60

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.

Fall 2021: STAT GU4204
Course Number Section/Call Number Times/Location Instructor Points Enrollment
STAT 4204 001/13047 M W 6:10pm - 7:25pm 501 Schermerhorn Hall Irene Hueter 3 36/86

Spring 2022: STAT GU4204
Course Number Section/Call Number Times/Location Instructor Points Enrollment
STAT 4204 002/13048 M W 6:10pm - 7:25pm 501 Schermerhorn Hall Irene Hueter 3 12/50

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, and analysis of variance. Extensive use of the computer to analyse data.

Fall 2021: STAT GU4205
Course Number Section/Call Number Times/Location Instructor Points Enrollment
STAT 4205 001/13049 M W 6:10pm - 7:25pm 717 Hamilton Hall Gabriel Young 3 27/30

STAT 4205 002/13050 M W 8:40am - 9:55am 312 Mathematics Building Ronald Neath 3 24/25

STAT 4205 003/13051 M W 1:10pm - 2:25pm 329 Pupin Laboratories Xiaofei Shi 3 14/25

STAT 4205 004/13052 M W 8:40am - 9:55am 301 Pupin Laboratories Haiyuan Wang 3 10/15

STAT 4205 005/13053 M W 8:40am - 9:55am 402 Chandler Yuqi Gu 3 8/15

Spring 2022: STAT GU4205
Course Number Section/Call Number Times/Location Instructor Points Enrollment
STAT 4205 001/13984 M W 7:10pm - 8:25pm Room TBA Irene Hueter 3 0/35
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, paralleling 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.