Recommended non-ISE courses for Graduate Students

Advanced Probability and Stochastic Processes:

STAT 491 Introduction to Stochastic Processes (3)
Random walks, Markov chains, branching processes, Poisson process, point processes, birth and death processes, queuing theory, stationary processes. Prerequisite: either 2.0 in MATH395 or STAT 395. Offered: jointly with MATH 491; A.

STAT 492 Stochastic Calculus for Option Pricing (3)
Introductory stochastic calculus mathematical foundation for pricing options and derivatives. Basic stochastic analysis tools, including stochastic integrals, stochastic differential equations, Ito’s formula, theorems of Girsanov and Feynman-Kac, Black-Scholes option pricing, American and exotic options, bond options. Prerequisite: MATH 394/STAT 394, MATH 395/STAT 395. Offered: jointly with MATH 492.

MATH 521 Advanced Probability (3)
Measure theory and integration, independence, laws of large numbers, Fourier analysis of distributions, central limit problem and infinitely divisible laws, conditional expectations, martingales. Prerequisite: either MATH 426 or MATH 576. Offered: jointly with STAT 521.

MATH 522 Advanced Probability (3)
Measure theory and integration, independence, laws of large numbers, Fourier analysis of distributions, central limit problem and infinitely divisible laws, conditional expectations, martingales. Prerequisite: either MATH 426 or MATH 576. Offered: jointly with STAT 522.

MATH 523 Advanced Probability (3)
Measure theory and integration, independence, laws of large numbers, Fourier analysis of distributions, central limit problem and infinitely divisible laws, conditional expectations, martingales. Prerequisite: either MATH 426 or MATH 576. Offered: jointly with STAT 523.

STAT 516 Stochastic Modeling of Scientific Data (4)
Markovian and semi-Markovian models, point processes, cluster models, queuing models, likelihood methods, estimating equations. Prerequisite: STAT 511 or STAT 396. Offered: A.

STAT 517 Stochastic Modeling of Scientific Data (4)
Markovian and semi-Markovian models, point processes, cluster models, queuing models, likelihood methods, estimating equations. Prerequisite: STAT 516. Offered: W.

STAT 518 Stochastic Modeling Project (4)
Supervised, applied project based on stochastic modeling of scientific data. Prerequisite: STAT 517. Offered: Sp.

E E 505 Probability and Random Processes (4)
Foundations for the engineering analysis of random processes: set theoretic fundamentals, basic axioms of probability models, conditional probabilities and independence, discrete and continuous random variables, multiple random variables, sequences of random variables, limit theorems, models of stochastic processes, noise, stationarity and ergodicity, Gaussian processes, power spectral densities. Prerequisite: graduate standing and understanding of probability at the level of E E 416.

E E 506 Communication Theory I (3) Ricey
Review of stochastic processes. Communication system models. Channel noise and capacity. Optimum detection,
modulation and coding, convolutional coders and decoders. Typical channels, random and fading channels. Waveform communication, optimum filters. Prerequisite: E E 505 or equivalent.

**E E 507 Communication Theory II (3) Ritcey**

**E E 508 Stochastic Processes (3) Ritcey**

**E E 595 Advanced Topics in Communication Theory (1-5, max. 5)**
Extension of 507, 508, 518, 519, 520. Material differs each year, covering such topics as: detection theory, decision theory, game theory, adaptive communication systems, nonlinear random processes. Prerequisite: permission of instructor.

**Education:**

**MATH 498 Special Topics in Mathematics (1-5, max. 15)**
Reading and lecture course intended for special needs of advanced students. Offered: AWSpS.

**MATH 503 Special Topics in Teaching and Learning Mathematics (2-3, max. 15)**
Selected Topics dealing with issues in the teaching and learning of mathematics.

**EDPSY 586 Qualitative Methods of Educational Research (5) Knapp**
Survey of various qualitative research methods from a variety of disciplinary perspectives (anthropology, sociology, applied linguistics, cognitive psychology, policy analysis, and evaluation) with intensive experience in collection, analysis, and reporting of data. Prerequisite: second-year doctoral standing and one course in statistics, and permission of instructor. Offered: jointly with EDC&I 578; A.

**EDPSY 591 Methods of Educational Research (3)**
Introduction to educational research. Primary focus on hypothesis development, experimental design, use of controls, data analysis and interpretation. Prerequisite: EDPSY 490. Offered: AWSp.

**Global Health:**

**GH 511 Problems in International Health (4)**
Explores social, political, economic, environmental determinants of developing countries' health; traces development of societal responses to problems. Includes: origins of primary health care; child survival; traditional systems; population; water; sanitation; international agencies; impact of economic policies. Case study formulating pharmaceutical policy in a developing country.

**Transportation and Logistics:**

**CEE 410 Traffic Engineering Fundamentals and Surveys (3)**
General review of the fundamentals of traffic engineering, including their relationship to transportation operations management and planning, with special emphasis on traffic engineering field surveys and data analysis. Prerequisite: CEE 320. Offered: A.

**CEE 557 Air Resources Management (3)**
Technical, administrative, and legal aspects of air conservation. Topics include urban and regional scale air quality measurement and modeling systems, receptor modeling based on chemical fingerprinting of sources and current case
studies involving engineering analysis, air-quality modeling, and regulatory aspects at local, state, and federal governmental levels. Offered: A.

CEE 581 Travel Demand Forecasting (4) Rutherford
Application of mathematical models to forecast urban travel behavior. Introduces emerging methods, land use models, travel demand models, including trip generation, trip distribution, mode choice, and network assignment. Discusses validation and ethics.

CEE 582 Intelligent Transportation Systems (3)
Application of modern computer and communication technologies to transportation systems. Benefits to public agencies, commercial companies, and travelers. Coordination between private and public sectors. Intelligent Transportation System's (ITS) social, organizational, and operational changes.

CEE 583 Airport Engineering (3)
Definitions and terminology relating to airport engineering. Characteristics of aircraft, air traffic control, and resulting impact upon design process. Airport capacity, configuration, and planning associated with terminal design. Emphasis on geometric and structural design of pavements and airside. Design projects relating to airport engineering required. Prerequisite: permission of instructor.

CEE 585 Analytical Methods in Transportation II (3)
Applications of advanced econometric methods to transportation issues. Topics include, but not limited to, systems of equations, duration models, limited dependent variable approaches, and count models. Hands-on modeling, with numerous data sets, available for application. Collaborative projects. Prerequisite: CEE 584 or permission of instructor.

CEE 587 Global Trade, Transportation, and Logistics Management (4)
Provides an overview of trade, transportation, and logistics activities. Develops an understanding of the physical and information flows in supply chains, and the economic drivers of supply chain choices. Includes methods to analyze and improve logistics and transportation systems, including applications of policy, technology, and infrastructure. Offered: Sp.

CEE 588 Energy Infrastructure and the Environment (3) Larson, Mahoney
Focuses on energy infrastructure, including site selection, permitting, design, construction, and maintenance. Includes electrical production facilities as well as transmission, focusing on permitting and construction of renewable energy facilities. Covers renewable energy infrastructure, emphasizing wind, solar, and geothermal. Offered: A.

CEE 589 Transit Systems Planning (3)

CEE 590 Traffic Systems Operations (3)
Operational planning, management of arterial and freeway traffic systems. Review of transportation system management strategies to achieve more efficient use of existing infrastructure, including improved and innovative traffic control systems and demand management policies, measures of effectiveness, impact assessment, traveler response. Introduction to use of relevant computer models and packages.

Information Systems:

IS 451 Data Mining for Business Intelligence (4)
Introduces data mining concepts and techniques, including associations rules, decision trees, cluster analysis, classification, logistic regression, text mining, and web analytics. Includes real-work applicants in information systems, supply chain management, and marketing. Prerequisite: IS 300; OPMGT 301. Offered: AWSp.
IMT / INSC 586 Information Dynamics I (4)
Introduction to the concepts and methods of information feedback, systems thinking, soft systems methodology (SSM), and "soft operations research," as well as the quantitative modeling of complex dynamic systems by means of differential and integral equations (system dynamics). Offered: jointly with INSC 586.

IMT / INSC 587 Information Dynamics II (4)
Advanced concepts and methods of information feedback, systems thinking, soft systems methodology (SSM), and "soft operations research," as well as the quantitative modeling of complex dynamic systems by means of differential and integral equations (system dynamics), including model building, testing, and validating.
Prerequisite: IMT 586.

INFO 445 Advanced Database Design, Management, and Maintenance (5)

Optimization:

MATH 407 Linear Optimization (3)
Maximization and minimization of linear functions subject to constraints consisting of linear equations and inequalities; linear programming and mathematical modeling. Simplex method, elementary games and duality.
Prerequisite: either 2.0 in MATH 136, 2.0 in MATH 308, 2.0 in MATH 318, or 2.0 in AMATH 352. Offered: AWS.

MATH 408 Nonlinear Optimization (3)
Maximization and minimization of nonlinear functions, constrained and unconstrained; nonlinear programming problems and methods. Lagrange multipliers; Kuhn-Tucker conditions, convexity. Quadratic programming.
Prerequisite: either 2.0 in MATH 308 or 2.0 in MATH 318; 2.0 in MATH 327 or 2.0 in MATH 334. Offered: W.

MATH 409 Discrete Optimization (3)
Maximization and minimization problems in graphs and networks (shortest paths, minimum spanning trees, maximum flows, minimum cost flows); transportation and trans-shipment problems, NP-completeness. Prerequisite: 2.0 in MATH 407. Offered: Sp.

MATH 514 Networks and Combinatorial Optimization (3)
Networks and directed graphs. Paths and trees. Feasible and optimal flows and potentials. Transportation problems, matching and assignment problems. Algorithms and applications. Prerequisite: MATH 308 or AMATH 352 and MATH 324. Offered: jointly with AMATH 514.

MATH 515 Fundamentals of Optimization (5)

MATH 516 Numerical Optimization (3)
Methods of solving optimization problems in finitely many variables, with or without constraints. Steepest descent, quasi-Newton methods. Quadratic programming and complementarity. Exact penalty methods, multiplier methods. Sequential quadratic programming. Cutting planes and nonsmooth optimization. Prerequisite: MATH 515. Offered: jointly with AMATH 516.

MATH 517 Optimization Under Uncertainty (3)
Sequential optimization problems involving random variables. Dynamic programming, stochastic programming. Control of uncertain dynamic systems in finite, discrete time. Risk, feedback, adaptivity. Problems with imperfect
state information. Applications such as to optimal stopping, inventory control, resource management. Prerequisite: MATH 308, MATH 324 and an introduction to basic concepts of probability, such as MATH 390 or MATH 394, MATH 395. Offered: jointly with AMATH 517.

Statistics:

ECON 484 Econometrics and Data Science (5) NW
Advanced continuation of ECON 482 and ECON 483. Traditional topics: structural modeling, non-linear and logistic regression, the LASSO, and non-traditional topics: regression and classification trees, bagging, boosting, and random forests. Computer based, uses the R language, emphasizing interpretation, not formal proofs. Prerequisite: ECON 482; MATH 126; recommended: ECON 483.

STAT 421 Applied Statistics and Experimental Design (4) NW
Computer-aided data analyses using comparisons between batches, analysis of variance and regression. Evaluation of assumptions, data transformation, reliability of statistical measures (jackknife, bootstrap). Fisher-Gosset controversy. Prerequisite: either STAT 342 or STAT 481/ECON 481; recommended: MATH 308. Offered: A.

STAT 423 Applied Regression and Analysis of Variance (4) NW

STAT 502 Design and Analysis of Experiments (4)
Design of experiments covering concepts such as randomization, blocking, and confounding. Analysis of experiments using randomization tests, analysis of variance, and analysis of covariance. Prerequisite: either STAT 342, MATH/STAT 390, ECON/STAT 481, ECON 580 or equivalent; MATH 308 or equivalent. Offered: A.

STAT 504 Applied Regression (4)

STAT 506 Applied Probability and Statistics (4)
Discrete and continuous random variables, independence and conditional probability, central limit theorem, elementary statistical estimation and inference, linear regression. Emphasis on physical applications. Prerequisite: some advanced calculus and linear algebra. Offered: jointly with AMATH 506.

STAT 509 Introduction to Mathematical Statistics: Econometrics I (5) NW
Examines methods, tools, and theory of mathematical statistics. Covers, probability densities, transformations, moment generating functions, conditional expectation. Bayesian analysis with conjugate priors, hypothesis tests, the Neyman-Pearson Lemma. Likelihood ratio tests, confidence intervals, maximum likelihood estimation. Central limit theorem, Slutsky Theorems, and the delta-method. (Credit allowed for only one of STAT 390, STAT 481, and ECON 580.) Prerequisite: STAT 311/ECON 311; either MATH 136 or MATH 126 with either MATH 308 or MATH 309; recommended: MATH 324. Offered: jointly with CS&SS 509/ECON 580; A.

STAT 512 Statistical Inference (4)
Review of random variables; transformations, conditional expectation, moment generating functions, convergence, limit theorems, estimation; Cramer-Rao lower bound, maximum likelihood estimation, sufficiency, ancillarity, completeness. Rao-Blackwell theorem. Hypothesis testing: Neyman-Pearson lemma, monotone likelihood ratio, likelihood-ratio tests, large-sample theory. Contingency tables, confidence intervals, invariance. Introduction to decision theory. Prerequisite: STAT 395 and STAT 421, STAT 423, STAT 504, or BIOST 512 (concurrent registration permitted for these three). Offered: A.
STAT 513 Statistical Inference (4)

STAT 529 Sample Survey Techniques (3)
Design and implementation of selection and estimation procedures. Emphasis on human populations. Simple, stratified, and cluster sampling; multistage and two-phase procedures; optimal allocation of resources; estimation theory; replicated designs; variance estimation; national samples and census materials. Prerequisite: either STAT 421, STAT 504, QMETH 500, BIOST 511, or BIOST 517, or equivalent; or permission of instructor. Offered: jointly with BIOST 529/CS&SS 529.

STAT 534 Statistical Computing (3)
Introduction to scientific computing. Includes programming tools, modern programming methodologies, (modularization, object oriented design), design of data structures and algorithms, numerical computing and graphics. Uses C++ for several substantial scientific programming projects. Prerequisite: experience with programming in a high level language. Offered: jointly with BIOST 534; Sp.

STAT 547 Derivatives: Theory, Statistics and Computing (4)
Covers theory, computation, and statistics of options and derivatives pricing, including options on stocks, stock indices, futures, currencies, and interest rate derivatives. Prerequisite: STAT 506 or equivalent, or permission of instructor. Recommended: ECON 424.

STAT/CS&SS 566 Casual Modeling (4)
Construction of causal hypotheses. Theories of causation, counterfactuals, intervention vs. passive observation. Contexts for causal inference: randomized experiments; sequential randomization; partial compliance; natural experiments, passive observation. Path diagrams, conditional independence, and d-separation. Model equivalence and causal under-determination. Prerequisite: course in statistics, SOC 504, SOC 505, SOC 506, or equivalent.

Other:

CFRM 557 Financial Software Development & Integration with C++ (4)
This course is a practical introduction to C++ programming for financial applications. The course will focus on developing basic object oriented programming skills in C++ to implement computational finance solutions. Course coverage will also include integrating C++ applications with R and Excel.

AMATH 581 Scientific Computing (5)
Project-oriented computational approach to solving problems arising in the physical/engineering sciences, finance/economics, medical, social, and biological sciences. Problems requiring use of advanced MATLAB routines and toolboxes. Covers graphical techniques for data presentation and communication of scientific results. Prerequisite: either a course in numerical analysis or permission of instructor.

AMATH 582 Computational Methods for Data Analysis (5)
Exploratory and objective data analysis methods applied to the physical, engineering, and biological sciences. Brief review of statistical methods and their computational implementation for studying time series analysis, spectral analysis, filtering methods, principal component analysis, orthogonal mode decomposition, and image processing and compression. Prerequisite: either MATLAB and linear algebra or permission of instructor. Offered: W.

E E 552 Power Systems Dynamics and Control (4)
Advanced computer modeling and analysis of power systems. Application of modern systems and control theories. Prerequisite: E E 351 and E E 455.
HCDE 532 Wed Design Studio (2)
Provides an overview of basic principles and practices of professional web site design and programming. Students gain hands-on experience with designing and building a successful website using industry standard techniques. For students planning to take HCDE 535 or HCDE 537 without previous programming experience.

M E 588 Dynamics and Vibrations (3) Shen
Variational techniques, Hamilton's principle, Lagrange's equations applied to dynamics of particles and rigid bodies. Vibration analysis of multi-degree-of-freedom and continuous systems. Prerequisite: graduate standing in engineering or permission of instructor. Offered: A.

PPM 512 Data Analysis Practicum (4) Long
Develops the methodological capacity to undertake independent research. Includes reading, critiquing, and replicating portions of selected empirical papers from a range of scholarly areas. Provides opportunities to deal with issues of research design, data limitations, measurement, model specification, and interpretation. Offered: A.