INDUSTRIAL & SYSTEMS ENGINEERING
UNIVERSITY of WASHINGTON
College of Engineering

Recommended non-ISE courses for Graduate Students

Advanced Probability and Stochastic Processes:

EE 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 EE 416.

EE 506 Fundamentals of Wireless Communication (4)
Reviews fundamentals of wireless communications including signal and noise theory, modulation techniques, fading channels, error analysis, synchronization, and coding. Prerequisite: EE 505.

EE 507 Communication Theory II (3)
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: EE 506.

EE 508 Stochastic Processes in Engineering (3)
Non-measure theoretic introduction to stochastic processes. Topics include Poisson processes, renewal processes, Markov and semi-Markov processes, Brownian motion, and martingales, with applications to problems in queuing, supply chain management, signal processing, control, and communications. Prerequisite: EE 505. Offered: jointly with IND E 508.

EE 595 Advanced Topics in Communication Theory (1-5, max. 16)
Extension of E E 507, E E 508, E E 518, E E 519, E E 520. Material differs each year, covering such topics as: detection theory, decision theory, game theory, adaptive communication systems, nonlinear random processes.

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 491 Introduction to Stochastic Processes (3) NW
Random walks, Markov chains, branching processes, Poisson process, point processes, birth and death processes, queuing theory, stationary processes. Prerequisite: minimum grade of 2.0 in MATH 396 or STAT 396. Offered: jointly with MATH 491.

STAT 492 Stochastic Calculus for Option Pricing (3) NW
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: either MATH 394 or STAT 394; either MATH 395 or STAT 395. Offered: jointly with MATH 492.

STAT 516 Stochastic Modeling of Scientific Data (3-)
Covers discrete-time Markov chain theory; inference for discrete-time Markov chains; Monte Carlo methods; missing data; hidden Markov models; and Gaussian Markov random fields. Prerequisite: either STAT 342 or STAT 396.

STAT 517 Stochastic Modeling of Scientific Data (-3)
Covers Markov random fields; continuous-time Markov chains; birth-death and branching processes; and point processes and cluster models. Procedures for inference for these stochastic processes, including Likelihood methods and estimating equations. Prerequisite: STAT 516.

STAT 518 Stochastic Modeling Project (3)
Student in-depth analyses, oral presentations, and discussion of selected research articles focusing on stochastic modeling of, and inference for, scientific data. Prerequisite: STAT 517 and permission of instructor.

Global Health:

G H 511 Problems in Global Health ([0-4]-, max. 4)
Explores social, political, economic, environmental determinants of developing countries' health; traces development of societal responses to problems. Includes: origins of primary healthcare; 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 (3)
General review of the fundamentals of traffic engineering, including their relationship to transportation operations management and planning, with emphasis on calculations and procedures in the Highway Capacity Manual; field surveys and data analysis. Prerequisite: CEE 327.

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.

CEE 581 Travel Demand Forecasting (4)
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 Transportation Energy and Sustainability (3)
Addresses technical and policy options for making transportation more sustainable, considering economic, environmental, and equity impacts. Topics include transportation demand management; vehicle technologies; alternative fuels; dynamics of technology change; and roles of state, federal, and international policy. Prepares students to think broadly, analyze systematically, and communicate effectively in this area.

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.

CEE 588 Energy Infrastructure and the Environment (3)
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.

CEE 589 Transit Systems Planning (3)
Planning, operational methods for urban public transportation. Review of technological, operating characteristics of vehicles and systems; financing, management, institutional aspects. Paratransit. Short-range planning, operational strategies, revenue-fare structures. Service monitoring. Mode

choice, transit demand relating to service. Computer-aided methods for planning, design of transit systems.

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. Prerequisite: CEE 327.

Information Systems:

IS 451 Business Data Analytics (4)
Introduction to business data analytics concepts and techniques, including association rules, classification, cluster analysis, decision trees, logistic regression, text mining, and web analytics. Real-world applications in information systems, supply chain management, and others. Prerequisite: I S 300, OPMGT301.

IMT 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 587 Principles of Information Project Management (4)
Introduces project management principles within information-related business contexts. Provides knowledge that managers need to implement information systems on time and within budget. Concentrates on methods and issues in organizing, planning, and controlling projects, and their use of computer-based project management tools.

INFO 445 Advanced Database Design, Management, and Maintenance (5)
Advanced perspectives on DBMS theory, architecture, and implementation. Conceptual, logical, physical modeling. Index structures, query optimization and performance tuning, relational algebra, transaction processing, and concurrency control. Operational databases, decision support systems, and data warehousing. Projects in database implementation and integration. Social implications of large distributed database systems. Prerequisite: INFO 340.

Optimization:

EE 578 Convex Optimization (4)
Basics of convex analysis: Convex sets, functions, and optimization problems. Optimization theory: Least-squares, linear, quadratic, geometric and semidefinite programming. Convex modeling. Duality theory. Optimality and KKT conditions. Applications in signal processing, statistics, machine learning, control communications, and design of engineering systems. Prerequisite: AA 510, CHEM E 510, E E 510 or M E 510. Offered: jointly with AA 578/ME 578.

MATH 407 Linear Optimization (3) NW
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: minimum grade of 2.0 in either MATH 136, MATH 308, or AMATH 352.

MATH 408 Nonlinear Optimization (3) NW
Maximization and minimization of nonlinear functions, constrained and unconstrained; nonlinear programming problems and methods. Lagrange multipliers; Kuhn-Tucker conditions, convexity. Quadratic programming. Prerequisite: minimum grade of 2.0 in MATH 407 or MATH 464; minimum grade of 2.0 in either MATH 327 or MATH 334.

MATH 409 Discrete Optimization (3) NW
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: minimum grade of 2.0 in MATH 407.

MATH 514 Networks and Combinatorial Optimization (3)
Mathematical foundations of combinatorial and network optimization with an emphasis on structure and algorithms with proofs. Topics include combinatorial and geometric methods for optimization of network flows, matching, traveling salesmen problem, cuts, and stable sets on graphs. Special emphasis on connections to linear and integer programming, duality theory, total unimodularity, and matroids. Prerequisite: either MATH 308 or AMATH 352 any additional 400-level mathematics course. Offered: jointly with AMATH 514.

MATH 515 Fundamentals of Optimization (5)
Maximization and minimization of functions of finitely many variables subject to constraints. Basic problem types and examples of applications; linear, convex, smooth, and nonsmooth programming. Optimality conditions. Saddlepoints and dual problems. Penalties, decomposition. Overview of computational approaches. Prerequisite: linear algebra and advanced calculus. Offered: jointly with AMATH 515/IND E 515.

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. Offered: jointly with AMATH 516.

MATH 518 Theory of Optimal Control (3)
Trajectories from ordinary differential equations with control variables. Controllability, optimality, maximum principle. Relaxation and existence of solutions. Techniques of nonsmooth analysis. Prerequisite: real analysis on the level of MATH 426; background in optimization corresponding to MATH 515. Offered: jointly with AMATH 518.

Statistics:

BIOST 517 Applied Biostatistics I (4)
Introduction to the analysis of biomedical data. Descriptive and inferential statistical analysis for discrete, continuous, and right-censored random variables. Analytic methods based on elementary parametric and non-parametric models for one sample; two sample (independent and paired), stratified sample, and simple regression problems.

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.

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.

STAT 423 Applied Regression and Analysis of Variance (4) NW
Regression analysis. Problems in interpreting regression coefficients. Estimation, including two-stage least squares. Guided regression: building linear models, selecting carriers. Regression residuals. Analysis of variance. Nonparametric regression. Factorial designs, response surface methods. Prerequisite: either STAT 342, STAT 421, or STAT 481/ECON 481.

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 390/STAT 390, ECON 481/STAT 481, STAT 509/CS&SS 509/ECON 580 or equivalent; MATH 308 or equivalent.

STAT 504 Applied Regression (4)
Least squares estimation. Hypothesis testing. Interpretation of regression coefficients. Categorical independent variables. Interactions. Assumption violations: outliers, residuals, robust regression; nonlinearity, transformations, ACE, CART; nonconstant variance. Variable selection and model averaging. Prerequisite: either STAT 342, STAT 390/MATH 390, STAT 421, STAT 481/ECON 481, STAT 509/CS&SS 509/ECON 580, or SOC 425. Offered: jointly with CS&SS 504.

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 Econometrics I: Introduction to Mathematical Statistics (4)
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. Prerequisite: STAT 311/ECON 311; either MATH 136 or MATH 126 with either MATH 308 or MATH 309. (Credit allowed for only one of STAT 390, STAT 481, and ECON 580.) Offered: jointly with CS&SS 509/ECON 580.

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. Decision theory. Prerequisite: STAT 395 and STAT 421, STAT 423, STAT 504, or BIOST 512 (concurrent registration permitted for these three).

STAT 513 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. Decision theory. Prerequisite: STAT 512.

STAT 519 Time Series Analysis (3)
Descriptive techniques. Stationary and nonstationary processes, including ARIMA processes. Estimation of process mean and autocovariance function. Fitting ARIMA models to data. Statistical tests for white noise. Forecasting. State space models and the Kalman filter. Robust time series analysis. Regression analysis with correlated errors. Statistical properties of long memory processes. Prerequisite: STAT 513.

STAT 527 Nonparametric Regression and Classification (3)
Covers techniques for smoothing and classification including spline models, kernel methods, generalized additive models, and the averaging of multiple models. Describes measures of predictive performance, along with methods for balancing bias and variance. Prerequisite: either STAT 502 and STAT 504 or BIOST 514 and BIOST 515. Offered: jointly with BIOST 527.

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 423, 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.

STAT 535 Statistical Learning: Modeling, Prediction, and Computing (3)
Covers statistical learning over discrete multivariate domains, exemplified by graphical probability models. Emphasizes the algorithmic and computational aspects of these models. Includes additional topics in probability and statistics of discrete structures, general purpose discrete optimization algorithms like dynamic programming and minimum spanning tree, and applications to data analysis. Prerequisite: experience with programming in a high level language.

STAT 538 Statistical Learning: Modeling, Prediction, and Computing (3)
Reviews optimization and convex optimization in its relation to statistics. Covers the basics of unconstrained and constrained convex optimization, basics of clustering and classification, entropy, KL divergence and exponential family models, duality, modern learning algorithms like boosting, support vector machines, and variational approximations in inference. Prerequisite: experience with programming in a high level language.

STAT 539 Statistical Learning: Modeling, Prediction and Computing (3) Supervised, applied project in statistical modeling, prediction, and computing. Prerequisite: STAT 535; STAT 538; computer programming at intermediate level.

STAT 547 Options and Derivatives (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 permission of instructor.

STAT 564 Bayesian Statistics for the Social Sciences (4)
Statistical methods based on the idea of probability as a measure of uncertainty. Topics covered include subjective notion of probability, Bayes' Theorem, prior and posterior distributions, and data analysis techniques for statistical models. Prerequisite: SOC 504, SOC 505, SOC 506 or equivalent. Offered: jointly with CS&SS 564.

STAT 566 Causal 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. Offered: jointly with CS&SS 566.

STAT 567 Statistical Analysis of Social Networks (4)
Statistical and mathematical descriptions of social networks. Topics include graphical and matrix representations of social networks, sampling methods, statistical analysis of network data, and applications. Prerequisite: SOC 504, SOC 505, SOC 506, or equivalent. Offered: jointly with CS&SS 567.

Machine Learning/Artificial Intelligence:

CSE 546 Machine Learning (4)
Explores methods for designing systems that learn from data and improve with experience. Supervised learning and predictive modeling; decision trees, rule induction, nearest neighbors, Bayesian methods, neural networks, support vector machines, and model ensembles. Unsupervised learning and clustering. Prerequisite: either CSE 312, STAT 341, STAT 391 or equivalent.

CSE 547 Machine Learning for Big Data (4)
Covers machine learning and statistical techniques for analyzing datasets of massive size and dimensionality. Representations include regularized linear models, graphical models, matrix factorization, sparsity, clustering, and latent factor models. Algorithms include sketching, random projections, hashing, fast nearest-neighbors, large-scale online learning, and parallel learning (Map-Reduce, GraphLab). Prerequisite: either STAT 535 or CSE 546. Offered: jointly with STAT 548.

EE 562 Artificial Intelligence for Engineers (3)
Covers main areas of artificial intelligence (AI) without need for extensive prerequisites. Programming languages for AI; problem solving; representations; control strategies; searching strategies; predicate calculus; rule-based deduction; goal-directed planning; knowledge-based systems. Prerequisite: CSE 373.

Other:

CFRM 557 Financial Software Development and Integration with C++ (4)
Practical introduction to C++ programming for financial applications. Focuses on developing basic object oriented programming skills in C++ to implement computational finance solutions. Also includes integrating C++ applications with R, MATLAB, SQL, and VBA.

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.

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 Web 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.

ME 588 Dynamics and Vibrations (3)
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.

PPM 512 Data Analysis Practicum (4)
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.