

Suggested Electives for Systems Engineering Graduate Degrees

If your S.E. degree has an elective requirement, the following courses may be used. For courses not on this list, please check with the Systems Engineering Program to see if it may count as an elective. **It is the student's responsibility to ensure they meet all current prerequisites for electives listed at the time of registration or to contact the instructor to request permission to enroll.**

Note: The 42-credit PhD program does not permit electives. Courses with shaded backgrounds may not be used as electives toward the 72-credit PhD.

Course Number	On-Campus?	Online?	Title	Credits	Prerequisite	Catalog Description
AREC 540/ECON 540	X		Economics of Natural Resources	3	AREC 340 / ECON340, MATH 141	Public natural resources policy, effect on resource use in private sector, optimal pricing of minerals, timber and fisheries, and public project analysis.
AREC 541/ECON 541	X		Environmental Economics	3		Economics of environmental policy; partial equilibrium and general equilibrium model; pollution; natural environments; population and economic growth.
BUS 500	X	X	Business Systems and Processes	2		Introduction to core concepts from Business Process Management (BPM) and Operations Management (OM).
BUS 601	X	X	Quantitative Business Analysis	2	BUS 500, may be taken concurrently.	Uses and management of information; decision tools and concepts; quality control.
BUS 616	X	X	Financial Reporting and Analysis	2	BUS 614 or BUS 615	Tools and techniques for analysis of financial reports of public companies.
BUS 620	X	X	Leadership and Teams	2	BUS 500, may be taken concurrently or BUS 601 to 665	Ethical leadership and team dynamics; basic models of motivation utilized by leaders
BUS 625	X	X	Organizational Communication	2		Improving understanding and application of managerial communication skills and negotiation tools and their implications for effective management.
BUS 626	X	X	Managing Human Capital	2	BUS 500, may be taken concurrently.	Management of human capital for competitive advantage and superior results.
BUS 630	X	X	Information Management	2	(BUS 500 or BUS 601 to 665) and (BUS 614 or BUS 615)	Role and value of information in business functions; risks and rewards of enterprise information; fundamentals of information storage and retrieval.
BUS 635	X	X	Business Economics for the Current Market	2	(BUS 601) and (BUS 614 or BUS 615)	Application of economic principles to current business problems within context of global marketplace.
BUS 650	X	X	Supply Chain Management	2	BUS 500, may be taken concurrently.	Value-driven supply chain principles, design and management of supply chains, and supply chain management software and applications.
BUS 655	X	X	Marketing Management	2	BUS 500, may be taken concurrently.	Examines processes of customer value creation (e.g. product development, communications, distribution) and value capture (e.g. pricing).
BUS 660	X	X	Ethical, Legal, and Regulatory Issues	2	BUS 500 or BUS 601 to 665	Legal, regulatory, societal and ethical issues encountered by business professionals; analytical skills for making judgments.
CIS 600	X	X	Information Technology and Project Management	3		Strategic role in and management of information technology and software development projects.
CIS 601/MGT 601	X	X	Enterprise Computing and Systems Integration	3		Integrated extended enterprise planning and execution systems concepts including ERP, CRM, SCM, MRP II, business processes, front/back office systems.

CIS 610	X	X	Software Development Methodology	3		Methods for all phases of software development focusing upon the establishment of economical software that is reliable and cross platform.
CIS 611	X	X	Object-Oriented Systems	3	CIS 610	Object-oriented and web-based software; object model describing classes; relationships to other objects, attributes, and operations.
CIVE 504	X		Wind Engineering	3		Influence of wind on humanity. Applications to structures, air pollution, wind energy, agricultural aerodynamics, snow movement, human comfort.
CIVE 514	X		Hydraulic Structures/ Systems	3	CIVE 401	Analysis and design of hydraulic structures which make up components of water resource systems.
CIVE 520	X	X	Physical Hydrology	3	CIVE 322/ENVE 322	Hydrologic, atmospheric processes in the water cycle; linear systems, hydrologic response; geomorphologic description of hydrologic processes, response.
CIVE 522	X	X	Engineering Hydrology	3	CIVE 520	Hydrologic design under uncertainty; conventional and remote sensing; design flows and storms; river routing; reservoir design; watershed models.
CIVE 546	X	X	Water Resource Systems Analysis	3	CIVE 322/ENVE 322 or concurrent registration; ENGR 510/MATH 510 or concurrent registration	Applications of systems analysis and optimization techniques in water resources planning and management.
CIVE 574	X	X	Civil Engineering Project Management	3		Principles of civil engineering project management including proposals, contracts, scheduling, quality assurance, budgeting, and risk management.
CS 518	X		Distributed Software System Development	4	CS 414; CS 451. Must register for lecture and laboratory.	Principles of developing distributed systems; middleware technologies and techniques for building complex distributed component-based systems.
CS 533	X	X	Database Management Systems	4	CS 430. Must register for lecture and laboratory.	Theory and implementation of concurrency control, recovery, and query processing as it applies to centralized and distributed systems.
CS 545	X	X	Machine Learning	4	CS 440. Must register for lecture and laboratory.	Computational methods that allow computers to learn; neural networks, decision trees, genetic algorithms, bagging and boosting.
CS 556	X	X	Computer Security	3	CS 451. Must register for lecture and laboratory.	Topics in computer security: concepts, threats, risks, access control models, trusted systems, cryptography, authentication

CS 557	X	X	Advanced Networking	3	CS 457	LAN/WAN technologies, congestion/flow control, traffic analysis, intra-/inter- domain routing, multicast, overlays, P2P systems and quality of service.
ECE 508	X	X	Introduction to Power System Markets	3	ECE 461	Deregulated electrical power systems, system security, investments in generation and transmission, ancillary services, and nodal pricing.
ECE 509	X	X	Signal Processing for Power Systems	3	ECE 312; ECE 461	Signal processing tools for analyzing power systems, voltage frequency, magnitude variations, unbalance, waveform distortion.
ECE 510	X	X	Wide-Area Monitoring for Power Systems	3	ECE 312 & ECE 461 both with C or better	WAMS for modern power grid including signal processing, communications and networking techniques in WAMS/WAMS applications.
ECE 512	X	X	Digital Signal Processing	3	ECE 312 with grade of C- or better	Discrete time signals and systems, digital filter design and implementation, fast algorithms, quantization effects.
ECE 513	X	X	Digital Image Processing	3	ECE 303/STAT 303with grade of C- or better; ECE 312 with grade of C- or better	Image acquisition and display systems, image enhancement, restoration and encoding, image analysis; real-life applications.
ECE 514	X		Applications of Random Processes	3	ECE 303/STAT 303with grade of C- or better; ECE 312 with grade of C- or better	Bit-error rates, signal-to-noise power ration, signal detection, signal estimation, Wiener filter, application.
ECE 520	X		Optimization Methods-Control and Communication	3	MATH 229; MATH 317	Linear and nonlinear optimization theory and methods; applications in systems, control, and communication.
ECE 524	X		Wireless Telecommunications	3	ECE 421	Physical layer design, including channel modeling, receiver design and performance, and multiple access techniques.
ECE 549	X	X	Radar Systems and Design	3	ECE 444	Fundamental ideas of radar operation and basic design of various radar types including current topics.
ECE 561	X	X	Hardware/Software Design of Embedded Systems	4	CS 270 or CS 470 or ECE 251 or ECE 452	Embedded systems design including system level modeling, design space exploration, hardware-software partitioning, high level synthesis.
ECE 562	X		Power Electronics	3	EE 332 with grade of C- or better	Switch mode and resonant converters, control using switch averaged dynamic models, modeling of all circuit components including sources, loads, and switches.
ECE 563	X		Power Electronics II	3	ECE 562	Electrical energy, processing circuits, lightweight power management, and power conversion circuits emphasizing small signal transfer functions.

ECE 566	X	X	Grid Integration of Wind Energy Systems	3	ECE 461 and ECE 462 or ECE 565.	Aspects of integration of wind energy conversion systems (WECS) to electric power transmission grids.
ECE 568	X	X	Electrical Energy Generation Systems	3		Energy systems: renewable and traditional. Physics and operation of energy devices; solar-photovoltaic, wind energy, gas, coal and nuclear plants.
ECE 611	X	X	Nonlinear Control Systems	3	ECE 412	Controller analysis and design for nonlinear systems.
ECE 612	X	X	Robust Control Systems	3	ECE 411	Introduction to modern robust control theory techniques for analysis and design of large- scale uncertain multivariable systems.
ECE 614	X		Principles of Digital Communications	3	ECE 514	Information theory, optimal receiver design, waveform coding, error correcting coding.
ECE 652	X		Estimation and Filtering Theory	3	ECE 411 or ECE 412; ECE 514 or STAT 525	Linear and Nonlinear parameter and state estimation methods; Optimal Kalman state estimation and applications.
ECE655	X		Multi-dimensional Digital Signal Processing	3	ECE 512	Multidimensional signals and systems, 2-D transforms, stability methods, design and implementations, spectral factorization, and image modeling.
ECE 656	X		Neural Networks and Adaptive Systems	3	ECE 512	Various adaptation rules, neural network paradigms, learning, stability and convergence, applications in signal/image processing and control.
ECE 658/CS 658	X	X	Internet Engineering	3	ECE 456 or CS 457.	Link technologies, multiple access, hardware and software for internetworks routing, switching flow control, multicast, performance, and applications. Credit not allowed for both ECE 658 and CS 658. Must register for lecture and laboratory.
ENGR 501	X	X	Foundations of Systems Engineering	3		Functional components of systems engineering, application of systems engineering to practical problems, system life-cycle process
ENGR 502	X	X	Engineering Project and Program Management	3		Engineering program management fundamentals, program planning and control strategies, risk assessment, work breakdown structures and costing options.
ENGR 510	X	X	Engineering Optimization: Method/Application	3	MATH 261 and MATH 229	Optimization methods; linear programming, network flows, integer programming, interior point methods, quadratic programming, engineering applications.
ENGR 520	X	X	Engineering Decision Support/Expert Systems	3	ENGR 510 or MATH 510	Decision support systems for complex engineering problems; multicriteria decision making and optimization; hybrid knowledge-based/algorithmic methods.
ENGR 530	X	X	Overview of Systems Engineering Processes	3	ECE 303 or STAT 303 or STAT 315	Systems engineering life-cycle process and analysis techniques. Reliability and robustness.
ENGR 531	X	X	Engineering Risk Analysis	3	ECE 303 or STAT 303 or STAT 315	Estimation and risk identification, development of mitigation techniques
ENGR 532/ECE 532	X	X	Dynamics of Complex Engineering Systems	3	ENGR 501, may be concurrent	Higher-level behavior and issues that emerge from interaction between components in complex socio-technical systems.

ENGR 565/ECE 565	X	X	Electrical Power Engineering	3	ECE 332 and ECE 342	Analysis of power systems in terms of current, voltage, and active/reactive power; introduction of computer-aided tools for power systems.
ENGR 567		X	Systems Engineering Architecture	3	ENGR 501	Observation/classification of systems architecture. Systems architecture principles and critical evaluation through design studies.
MATH 519	X		Complex Variables I	3	MATH 317	Analytic functions, complex integration theory, singularities, elementary functions, and mapping.
MATH 520	X		Nonlinear Programming	3	MATH 510/ ENGR 510	Theoretical, computational, practical aspects of nonlinear programming (NLP); unconstrained, constrained NLP; quadratic programming; large-scale NLP.
MATH 525	X		Optimal Control	3	MATH 340 or MATH 345	Theory and application of optimal control and optimal estimation theory; continuous and discrete time systems; Pontryagin maximum principle.
MATH 530	X		Mathematics for Scientists and Engineers	4	MATH 340 or MATH 345	Proof-oriented linear algebra, ordinary and partial differential equations.
MATH 531	X		Discrete Models of Physical Systems	3	MATH 340 or MATH 345	Discrete models for physical systems; systems of ordinary differential equations, applied linear algebra; introduction to finite elements.
MATH 532	X		Mathematical Modeling of Large Data Sets	3	MATH 369 or MATH 530; preparedness to do programming in a standard language.	Mathematical theory and algorithms for modeling large data sets. Application to real world problems. Emphasis on geometric ideas.
MATH 540	X		Dynamical Systems	3	MATH 369; MATH 417	Linear and nonlinear systems, orbits, phase space, flows of vector fields, stability, bifurcation theory, chaos, strange attractors and applications.
MATH 545	X		Partial Differential Equations I	3	MATH 340 or MATH 345 or MATH 530	Second order linear PDEs, elliptic and parabolic equations, equations of math physics, separation of variables, Fourier series.
MATH 546	X		Partial Differential Equations II	3	MATH 545	Distribution theory, Green's functions, Sobolev spaces, elliptic and parabolic equations.
MATH 550	X		Difference Methods – Partial Differential Equations	3	MATH 530 or MATH 545	Explicit, implicit methods for second order equations, higher-dimensional problems, stability analysis, method of characteristics.
MATH 560	X		Linear Algebra	3	MATH 369	Finite dimensional vector spaces, inner products, dual spaces, transformations, projections, adjoints, norms, eigenvalues, eigenvectors.

MATH 561	X		Numerical Analysis I	4	CS 156 or CS 160 or CS 253 or MATH 151; MATH 560	Numerical linear algebra, solving nonlinear systems, least squares, and minimization.
MATH 633	X		Industrial and Applied Mathematics	3	MATH 530 or MATH 560 or MATH 561; preparedness to do Programming in a standard language.	Team solution of problems arising in industrial and applied mathematics. Problem formulation, solution proposal, implementation and analysis.
MATH 640	X		Ordinary Differential Equations I	3	MATH 340 or MATH 345 or MATH 530; MATH 369; MATH 517	Existence and uniqueness, continuation, continuous dependence, linear systems, and stability.
MATH 641	X		Ordinary Differential Equations II	3	MATH 640	Topics selected from nonlinear boundary value problems, periodic phenomena, differential operators, and others.
MATH 645	X		Advanced Partial Differential Equations I	3	MATH 546	Abstract methods for linear partial differential equations.
MATH 646	X		Advanced Partial Differential Equations II	3	MATH 645	Problems in nonlinear partial differential equations.
MATH 651	X		Numerical Analysis II	4	CS 156 or CS 160 or CS 253 or MATH 151; MATH 340 or MATH 345 or MATH 369 or MATH 530	Interpolation, approximation, quadrature, initial and boundary value problems.
MECH 502	X	X	Advanced/Additive Manufacturing Engineering	3	MECH 202; MECH 331	Materials, controls, and mechanics applied to additive manufacturing; rapid prototyping; direct digital manufacturing.
MECH 511	X	X	Engineering Decision Making Under Uncertainty	3	MECH 410; STAT 315	Systems engineering and engineering economic methodologies for evaluating interdependent capital expenditure proposals under incomplete information
MECH 512	X	X	Reliability Engineering	3	MECH 513; STAT 315	Models to predict time to failure of mechanical or electronic devices, reliability data analysis and case studies.
MECH 513	X	X	Simulation Modeling and Experimentation	3	STAT 315	Logic/analytic modeling in simulations. Event and transient entity-based simulation languages. Simulation design, experimentation and analysis.
MECH 524	X		Principles of Dynamics	3	MECH 324	Kinematics and dynamics of rigid body motion; Lagrangian and Hamiltonian formulations of mechanics; applications to engineering problems.
MECH 536	X		Materials Applications in Renewable Energy	3	MECH 331	Materials science applied to renewable energy, transmission and storage; study of solar cells, fuel cells, Li-ion batteries and related technologies. Required field trips.
MECH 551	X		Physical Gas Dynamics I	3	MECH 342	Characteristics of real gases in reacting and nonequilibrium systems; equilibrium air; statistical mechanics, chemical thermodynamics.

MECH 558	X		Combustion	3	MECH 342	Combustion processes: explosions, detonations, flame propagation, ignition, generation of pollutants in moving and stationary energy conversion systems.
MECH 561	X		Space Propulsion and Mission Analysis	4	MATH 340	Analysis of space flight missions and propulsion systems.
MECH 563	X		Air Pollution Control	3	MECH 337	Abatement of emissions from mobile and stationary sources; monitoring, dispersion, air quality standards, electrostatic precipitation, energy consumption.
MECH 575	X		Solar and Alternative Energies	3	MECH 337; MECH 342; MECH 344	Solar radiation, flat-plate collectors, energy storage, space heating and cooling, power generation, applications, simulation.
MECH 644	X		Conduction Heat Transfer	3	MECH 344	Linear and nonlinear, isotropic and nonisotropic conduction; analytical, numerical techniques, inverse methods.
MECH 645	X		Radiation Heat Transfer	3	MECH 344	Radiation fundamentals; properties; spectral, directional variations; transfer between surfaces; participating media; numerical Monte Carlo methods.
MECH 646	X		Convection Heat Transfer	3	MECH 344	Fundamentals; conservation, constitutive equations; second law; forced, free convection; internal, external flows; laminar, turbulent flows.
MECH 676	X		Building Energy Design	4	MECH 575. Must register for lecture and laboratory	Design of space heating and cooling systems. Solar thermal electric power systems, industrial and agricultural process heat.
MGT 600	X		Manufacturing Process and Systems Design	3	BUS 620 and BUS 625	Strategic understanding of alternate manufacturing processes and systems design support needed to manage those processes.
NR 503	X		Remote Sensing of Natural Resources	4	Must register for lecture and laboratory.	Interpretation and analysis of photographic, multispectral scanner, and radar data; sensor systems; applications to resource management.
NR 504	X		Computer Analysis of Remote Sensing Data	4	NR 323 or NR 503	Computer-aided analysis techniques for extracting resource information from aerial and satellite remote sensing data.
NR 505	X		Concepts in GIS	4	STAT 301 or STAT 511. Must register for lecture and laboratory.	Concepts of geographic information systems and spatial data analysis.
NR 512	X		Spatial Statistical Modeling – Natural Resources	3	STAT 301; NR 322; NR 323. Must register for lecture and laboratory.	Statistical techniques used to model natural and environmental resources; GIS, remote sensing, and spatial statistics.

NR 523/STAT 523	X		Quantitative Spatial Analysis	3	STAT 301 or STAT 307/ERHS 307. Credit not allowed for both NR 523 and STAT 523.	Techniques in spatial analysis: point pattern analysis, spatial autocorrelation, trend surface and spectral analysis.
PH 641	X		Electro magnetism I	3	PH 351; PH 572	Electrostatics in a vacuum and a medium, general solution of Laplace's equation, Green's functions, magnetostatics in a vacuum and a medium.
PH 642	X		Electro magnetism II	3	PH 641	Maxwell's equations, electromagnetic waves, radiation by accelerated charges, special relativity, Lagrangian formulation of electromagnetism.
PH 672/ECE 672	X		Principles of Semiconductors	3	PH 531 or ECE 471.	Electronic properties of semiconductors; band structure, statistics, transport properties, photoelectronic properties, potential barriers, interfaces. Credit not allowed for both PH 672 and ECE 672.
POLS 670	X		Politics of Environment and Sustainability	3	Written consent of instructor.	Domestic, international, and comparative dimensions of environment and natural resource politics and policy.
POLS 709	X		Environmental Politics in the U.S.	3	POLS 500 or POLS 501; POLS 670	Selected primary materials on governmental performance, groups, and mass public in American environmental politics.
POLS 729	X		Political Theory and the Environment	3	POLS 520; POLS 670	Political thought applied to questions of the environment.
POLS 739	X		International Environmental Politics	3	POLS 530; POLS 670	Theories and methodologies used in analyzing international environmental politics and policy.
POLS 749	X		Comparative Environmental Politics	3	POLS 540 or POLS541; POLS 670	Application of comparative political theory to analysis of environmental politics.
POLS 759	X		Environmental Policy and Administration	3	POLS 670	Effects of regulation, intergovernmental relations, and resource availability on federal environmental programs in U.S.
STAT 500	X	X	Statistical Computer Packages	1	STAT 340 and STAT 350	Comparison, evaluation, and use of computer packages for univariate and multivariate statistical analyses.
STAT 501	X		Statistical Science	1		Overview of statistics: theory; use in agriculture, business, environment, engineering; modeling; computing; statisticians as researchers/consultants.
STAT 511		X	Design and Data Analysis for Researchers I	4	STAT 301 or STAT 307 or ERHS 307 or STAT 311 or STAT 315	Statistical methods for experimenters and researchers emphasizing design and analysis of experiments.
STAT 512	X	X	Design and Data Analysis for Researchers II	4	STAT 511	Statistical methods for experimenters and researchers emphasizing design and analysis of experiments.



STAT 520	X		Introduction to Probability Theory	4	MATH 229; MATH261; MATH 317	Probability, random variables, distributions, expectations, generating functions, limit theorems, convergence, random processes.
STAT 523/NR 523	X		Quantitative Spatial Analysis	3	STAT 301 or STAT307/ERHS 307	Techniques in spatial analysis: point pattern analysis, spatial autocorrelation
STAT 525	X		Analysis of Time Series I	3	STAT 430	Trend and seasonality, stationary processes, Hilbert space techniques, spectral distribution function, fitting ARIMA models, linear prediction
STAT 530	X		Mathematical Statistics	3	STAT 520	Sampling distributions, estimates, testing, confidence intervals, exact and asymptotic theories of maximum likelihood and distribution-free methods.
STAT 540	X		Data Analysis and Regression	3	Six credits of upper-division statistics courses.	Introduction to multiple regression and data analysis with emphasis on graphics and computing.
STAT 547/CIVE547	X		Statistics for Environmental Monitoring	3	STAT 301	Applications of statistics in environmental pollution studies involving air, water, or soil monitoring; sampling designs; trend analysis; censored data.
STAT 605	X	X	Theory of Sampling Techniques	3	STAT 301 or STAT 307 /ERHS 307 or STAT 311 or STAT 315; STAT 430	Survey designs; simple random, stratified, cluster samples; theory of estimation; optimization techniques for minimum variance or costs.
STAT 640	X		Design and Linear Modeling I	4	MATH 369; STAT 540	Introduction to linear models; experimental design; fixed, random, and mixed models.
STAT 645	X		Categorical Data Analysis and GLIM	3	Concurrent registration in STAT 640	Generalized linear models, binary and polytomous data, log linear models, quasilielihood, survival data models
STAT 650	X	X	Design and Linear Modeling II	3	STAT 640	Mixed factorials; response surface methodology; Taguchi methods; variance components.