












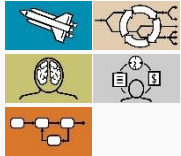
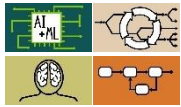




KEY

 Aerospace	 Environment & Sustainability	 Systems Security
 Artificial Intelligence & Machine Learning	 Human Factors & Sociotechnical Systems	 Transportation & Urban Design
 Data Analysis	 Management	 Virtual Reality / Augmented Reality
 Decision Support & Lifecycle	 Radiation and Health	
 Energy	 Systems Modeling	

SYSE

Title	Course	Prereqs	Description	Interest Categories
Foundations of Systems Engineering	SYSE 501**		Introductory overview of the SE perspective to set the conceptual and practical framework of the SE graduate programs. Covers foundational components, concept development stages, and the process steps of the engineering development stage. Several issues related to post-development and special topics areas are presented. Finishing this course with at least a B+ allows you to bypass the INCOSE knowledge exam for ASEP or CSEP certification.	
Systems Thinking for the Real World	SYSE 505		Application of systems thinking language, tools, and framework for solving real-world complex issues.	
Control Engineering for Systems Engineers	SYSE 511	MATH 369 & CBE 430 or ECE 411 or MECH 417 (Linear Algebra & Control Systems) or instructor permission	Challenge-driven overview of the diversity of control paradigms for modern, dynamic engineering systems for realizing desired system behaviors. Topics include linear, nonlinear, optimal, robust, decentralized, and hierarchical control methods. Examples from aero-actuation, space, energy, thermal, chemical, and financial systems are presented.	
Systems Sensing and Imaging Analysis	SYSE 512	STAT 301/303/315 or equivalent	Sensing, sampling, filtering, transducing, and transmission of information to transform physical data to the digital domain. Subsequent processing of image and digital data, restoration, analysis and classification to problems in inspection, authentication, color science, biometrics, and signal/image characterization. Previously ENGR 681A2; credit may not be earned for both.	


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<p>Overview of Systems Engineering Processes</p>	<p>SYSE 530**</p>	<p>STAT 301/303/315 or equivalent</p>	<p>Helps students develop a conceptual understanding of the SE life-cycle process and familiarity with analysis techniques used in that process. Introduces concepts of reliability and robustness, and rigorous tools for analysis and design with them in mind. Utilizes real-world experience and case studies of working with a system through all phases of the system design process. Model-Based Systems Engineering is introduced using the magic grid method to enhance complex system design and analysis.</p>	
<p>Dynamics of Complex Systems</p>	<p>SYSE 532</p>	<p>Any one of: SYSE 501, SYSE 505, SYSE 530, ENGR 502, or ENGR 531 (can be concurrent)</p>	<p>This course deals with understanding the higher-level behavior and issues that emerge from interaction between components in complex socio-technical systems. The course emphasizes system thinking, dynamic cause and effect relationships, and the higher-level emergent behavior that results from the interaction of many smaller effects that are individually well understood, but more difficult to grasp at a higher level.</p>	
<p>Human Systems Integration</p>	<p>SYSE 534</p>		<p>Evaluation of human capabilities and limitations when designing and evaluating complex systems in order to enhance safety, efficiency, usability, and reduce life cycle costs.</p>	
<p>Space Mission Analysis and Design</p>	<p>SYSE 536</p>	<p>SYSE 501</p>	<p>Appropriate for engineers, scientists, and technical managers designing or evolving the best mission possible with a limited set of resources including limited time. Designed for both students and professionals in space systems-related fields including defense, commercial, civil and exploration</p>	
<p>Engineering Data Design and Visualization</p>	<p>SYSE 541</p>	<p>STAT 301/303/315 or equivalent</p>	<p>Data design, aggregation and filtering, intuitive data exploration, effective communication of patterns, summaries, and findings, and methods of archiving for engineers.</p>	
<p>AR/VR Environmental Realism for SE</p>	<p>SYSE 544</p>	<p>STAT 301/303/315 or equivalent or MECH 231 (Engineering Experimentation)</p>	<p>Systems approaches to create environmental realism in augmented reality/virtual reality (AR/VR) applications, with examples in manufacturing, agriculture, space flight, and healthcare. Topics include test, measurement, and qualification of the environments of interest, functional/quantifiable verification of replication, and systems engineering practice-inspired means of designing/specifying the content of the AR/VR applications.</p>	
<p>AR/VR Systems Development</p>	<p>SYSE 545</p>	<p>STAT 301/303/315 or MECH 231 (Engineering Experimentation); SYSE 544 recommended</p>	<p>A systems-based approach to utilizing Social Virtual and Augmented Reality as platforms for designing and implementing AR/VR learning experiences.</p>	
<p>Security Engineering for SE</p>	<p>SYSE 548</p>	<p>SYSE 530 or SYSE 567</p>	<p>Secure design concepts, leveraging modern case studies of offensive approaches used by attackers. Topics include threat analysis, usability, protocols, cryptography, access control, economics, multilevel security, locks, monitoring, security printing, nuclear command, biometrics, side channels, networks, and information warfare.</p>	






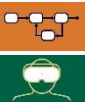
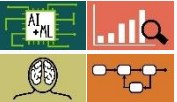
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Secure Vehicle and Industrial Networking	SYSE 549	CS 163 or CS 164 (Intro to Programming) or equivalent	Theoretical and practical applications of secure communications in automotive and industrial networked systems. Within the context of the OSI seven-level layer networking model, coverage will include physical connections, encoding, message framing, media access control, error detection, cryptography and application security.	
Sustainable Systems Engineering	SYSE 551 (Prev. 580A9)	One of: SYSE 501, SYSE 505, SYSE 530, or SYSE 532 (can be concurrent)	Foundational concepts for sustainable systems engineering, including methodologies for analyzing multiple interlinked systems and their synergies with a sustainability lens. Application of systems thinking, dynamic lifecycle analysis, systems of systems assessment, and resiliency and adaptability in the SE lifecycle.	
Humanitarian Engineering	SYSE 552 (prev. 581A3)		Engineering skills in the context of solutions for developing communities, with emphasis placed on a systems approach. Methods and implementation used in humanitarian engineering, including relevant community development methodologies, appropriate design, development strategy, sustainable community guidelines, emergency response, and design for vulnerable communities.	
Transitions in Energy Systems	SYSE 555	STAT 301/303/315 or equivalent	Synthesizes foundational ideas from across various components of the global energy complex, some of which are technical-, scientific-, business-, or policy-oriented. Study and investigate the technical, operational, environmental, economic, social, and political transitions that are underway in the energy sector that impact the design, development, and deployment of energy systems of the future.	
Systems Engineering Architecture	SYSE 567	SYSE 501 or SYSE 530 (can be concurrent) or instructor approval	Introduction to formal system architecture methods using the Systems Modeling Language (SysML) and Model-Based Systems Engineering (MBSE) with detailed examples. Students will apply the methodology to build architecture models of systems of their choice. Topics include Service-Oriented Architecture (SOA), real-time systems, secure systems, and networked enterprise architecture. ***If requesting prereq override*** must present evidence of experience with core competencies in key SE concepts that will be captured in a rigorous, model-based approach; ex: requirements, structural/functional decomposition, V-model, "ilities", etc.	
Cybersecurity Awareness for Systems Engineers	SYSE 569	SYSE 501 (can be concurrent)	Cybersecurity principles, practices, technologies, design approaches, and terminology. Incorporation of cybersecurity principles into effective systems designs. This course is directed to System Engineers and other technical personnel with a need to integrate cybersecurity into a balanced system design.	
Analytics in Systems Engineering	SYSE 571	STAT 301/303/315 or equivalent	Topics include: machine learning for analytics; systems engineering and meta-algorithms; prototyping software for getting to know your data-R, Python, Arduino; applications; 1st, 2nd, 3rd order meta-algorithms for future patterns for intelligent systems.	


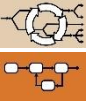

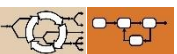

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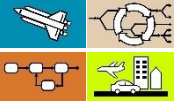
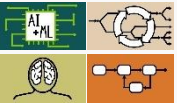
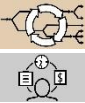



Cost Optimization for Systems Engineers	SYSE 573	ENGR 502 & ENGR 531 (or instructor permission)	Techniques and strategies to respond to requirements, design decisions, and development decisions, while optimizing for cost at the organizational, program, and project level.	
AI-Augmented Systems Engineering	SYSE 580A6	SYSE 501	Artificial intelligence (AI) approaches, such as machine learning, neural networks, and data science techniques that support human engineers in the system engineering effort. Topics include the conceptual architecture, challenges, and ethical debates that are relevant to employing AI as an assistant SE engineer and applying this knowledge to specific applications in the SE domain.	
Nuclear Systems Engineering	SYSE 580A7	CBE 332 or MECH 344 (Heat & Mass Transfer)	Foundational topics in nuclear reactor physics, design, and operation. Designed for non-nuclear engineers, the focus is on developing a critical understanding of nuclear reactors as a system.	
Modeling Methane Emissions from Oil and Gas	SYSE 580A8	CS 163 or CS 164 (Intro to Programming) & STAT 301 or equivalent	A SE approach to modeling and analysis of emissions from oil and gas facilities using a variety of approaches and tools, including dispersion models, Monte Carlo methods, and mechanistic models. Model predictions and uncertainties will be examined considering relevant emissions data.	
Systems Modeling Language and Tools	SYSE 580B1	MATH 160 (Calculus I) or equivalent	Applies to ME and MS degrees only. Build effective and efficient system engineering models by developing the skills needed to deploy the Systems Modeling Language (SysML). Learn essential syntax for all nine SysML diagrams, while building a cohesive model that communicates systems engineering information. The use of modern software packages enables project-based learning through the development of models of industrial applications.	
Systems Modeling for Digital Twins	SYSE 580B2	SYSE 501	Systems engineering principles to develop Digital Twin models. Analyze closed-loop control, sensor integration, predictive analytics, and system verification/validation (V&V). Develop a system lifecycle model for a complex system using data from physical assets to virtual objects using Virtual Reality or other suitable simulation approach for visualization.	
Network-Based Complex Systems Engineering	SYSE 580B3	STAT 301/303/315 or MATH 160 (Calc I) or MATH/DSCI 369 (Linear Algebra) or CS 345 (ML Foundations)	Integrates network-based models and deep learning to solve complex systems engineering problems. Analyzes system architecture through graph metrics, motifs, and probabilistic models. Creates predictive frameworks using Artificial Neural Networks (ANN) and Graph Neural Networks (GNN) to support the design and analysis of large-scale complex systems.	











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Wicked Problems and Systems Engineering	SYSE 580B4	Any 3-credit graduate-level course completed or instructor permission	Wicked problems are large-scale, have no clear definition or solution, and require interdisciplinary systems approaches. Core SE toolkits such as concept of operations and the Verification and Validation lifecycle are applied to wicked problems (WPs). Ethics and human interactions are exemplified through multi-cultural perspectives. Socio-technical-political interactions and using AI in WPs are covered. Class examples are primarily environmental but are extended to other major wicked systems.	
Systems Requirements Engineering	SYSE 602	SYSE 501 & SYSE 530	Introduction to the rigorous requirements process within SE, including system requirements analysis, requirements decomposition, allocation, tracking, verification, and validation.	
Introduction to Systems Test and Evaluation	SYSE 603	ENGR 502 & ENGR 531	Test and evaluation of systems at both the component and systems levels to provide insights into how systems succeed or fail based on test methodologies.	
Advanced Model-Based Systems Engineering	SYSE 667	SYSE 567	This course continues SYSE 567 by diving deeper into formal system architecting topics, modern tools, and research techniques for system architecture and model-based systems engineering (MBSE).	
Research Methods in Systems Engineering	SYSE 701		Can apply to master's degrees but not DEng. Introduction to the systems engineering research field. Students will learn about the academic research process, norms, and techniques, with emphasis on the PhD program and expectations. <u>PhD students are recommended to take this course as close to starting SYSE 799A credits as possible, instead of early in their program.</u>	
Leadership/Innovation in Systems Engineering	SYSE 710		Only admitted DEng students eligible to enroll. Background in technical leadership skill sets, systems engineering skill sets, and intellectual toolkit to develop a successful applied and translational research project/practicum.	
Ethics in Systems Engineering	SYSE 711	SYSE 501	A 1-credit brief course covering ethical principles and their application to systems engineering. May apply to either the DEng Professional or Technical Elective. May not apply to the SE PhD.	

ENGR

Title	Course	Prereqs	Description	Interest Categories
Engineering Project and Program Management	ENGR 502**		Engineering program management fundamentals, program planning and control strategies, risk assessment, work breakdown structures and costing options.	
Engineering Optimization: Method/Application	ENGR 510	MATH 229 & MATH 261 (Matrices/Linear Equations & Calculus III) or equivalent – review provided during the course	Introductory optimization course for all engineers covers linear programming, simplex algorithm, nonlinear optimization, interior-point and penalty approaches, derivative-free methods, genetic algorithms, and optimization of systems. A broad range of examples is shown, including problems in transportation, scheduling, machine learning, mechanics, and aerospace.	
Intelligent Decision Support Systems	ENGR 520	Skills in basic quantitative reasoning and programming	This course provides an introduction to engineering decision support systems, normative vs. descriptive approaches in decision analysis. Basic concepts include multiobjective analysis, multicriteria decision making.	
Intellectual Property and Invention Systems	ENGR 525		Focused on the appropriate application of “patterns for patenting” together with intuition, inspiration, and cross-disciplinary connecting. De-mystify “inventing” as applied to science, engineering and technology. Credit not allowed for both 525 and 423.	
Engineering Risk & Reliability Analysis	ENGR 531**	STAT 301/303/315 or equivalent	Successful engineering project management includes estimation and proactive risk identification and development of mitigation techniques. System uncertainty is reduced when project risks are identified, quantified, and mitigation strategies implemented. Tools, techniques, and methodologies used by successful project managers will be examined.	
Spaceflight and Biological Systems	ENGR 533		Starting with an understanding of the different components of gravity, explore spaceflight’s direct and indirect impact on all major biological systems, culminating with a consideration of how spaceflight can be made more sustainable.	
Modeling Human Systems Behavior	ENGR 535	STAT 301/303/315 or equivalent	An introduction to human systems modeling and the rigor and application of theory and quantitative methods to understand and characterize human behavior, with specific applications to engineering systems and decision making.	

Title	Course	Prereqs	Description	Interest Categories
Spaceflight Experimentation and Commerce	ENGR 537		Advanced experimentation in spaceflight, including commercialization, intellectual property generation, cybersecurity, and analytics associated with space experimentation. Considers fundamental differences in performing experimentation in space (loss of gravity, loss of convection and buoyancy, radiation, etc.) and various motivators for spaceflight research including commercial aspects and benefits to earth-bound citizens. Specifics of analysis, security, and experiment lifecycle are covered.	  
Design & Analysis of Engineering Experiments	ENGR 540	STAT 301/303/315 or equivalent	Strategies to acquire meaningful data from engineered experiments and create useful models from these data. Techniques include comparative tests, analysis of variance, factorial designs, Latin squares, regression, response surfaces, stochastic processes and system model identification.	 
AR/VR Biometrics and Sensing for Training	ENGR 546		Application of biometrics and sensor engineering with augmented reality/virtual reality technologies to develop integrated training for dangerous environments. Training applications include spaceflight, wind turbine upkeep, and hazardous waste site cleanup.	 
AI-Augmented Engineering Management	ENGR 580A7		Generative artificial intelligence (Gen AI) systems and associated applications in the context of engineering management. Topics include artificial intelligence system structure, prompt engineering, along with comparisons between human and Gen AI system output. Organizational integration of Gen AI systems along with their impacts on strategic management, decision-making, ethics, and sustainability.	  

MECH

Title	Subject	Prereqs	Description	Interest Categories
Simulation Modeling and Experimentation	MECH 513	STAT 301/303/315 or equivalent	Fundamental concepts of integrated modeling, simulation, and experimentation as a component of the systems engineering process. Practical processes for improving the defensibility, cost and capabilities of your simulations. Emphases on verification and validation of computational models, on quantification and propagation of uncertainty, on multi-disciplinary analysis and optimization, and on synthesis and decision making. Tools: MATLAB, Excel, ModelCenter, Simulink and SimEvents	