## Fall 2020 Course Descriptions as of 04/05/2020 08:14 PM

Information in Browse Course Catalog is subject to change. Information is term specific. Please refer to the appropriate term when searching for course content. Key to Course Descriptions may be found at: **http://rcs.registrar.arizona.edu/course_descriptions_key**.

**Systems & Industrial Engr (SIE)**

**SIE 199: Independent Study** (1 - 5 units)
**Description:** Qualified students working on an individual basis with professors who have agreed to supervise such work.
**Grading basis:** Alternative Grading: S, P, F
**Career:** Undergraduate
**Course Components:** Independent Study Required
**Repeatable:** Course can be repeated a maximum of 99 times.
**Course typically offered:**
Main Campus: Fall, Spring, Summer

**SIE 250: Introduction to Systems & Industrial Engineering** (3 units)
**Description:** System modeling; the elementary constructs and principles of system models including discrete time, discrete-state system theory; finite state machines; modeling components, system coupling, and system experiments (simulation). System design including requirements, life-cycle, performance measures and cost measures, tradeoffs, alternative design concepts, testing plan, and documentation. Applications and case studies from engineering.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Course typically offered:**
Main Campus: Fall
Distance Campus: Fall

**Enrollment requirement:** MATH 129

**-SA** represents a Student Abroad & Student Exchange offering
**-CC** represents a Correspondence Course offering
**May Be Offered** Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

**SIE 265: Engineering Management I** (3 units)
**Description:** Fundamentals of economic analysis and the time value of money for engineers. Construction of financial models in EXCEL including Income, Cash Flow, and Balance Sheet. Estimation of required capital and project acceptance criteria.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Equivalent to:** ENGR 265
**Also offered as:** ENGR 265
**Course typically offered:**
Main Campus: Fall, Spring
Distance Campus: Fall, Spring

**Enrollment requirement:** MATH 122B or MATH 124 or MATH 125

**SIE 270: Mathematical Foundations of Systems and Industrial Engineering** (3 units)
**Description:** Basics of data structures, transformations, computer methods, their implementation in MATLAB, and their applications in solving engineering problems.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Course typically offered:**
Main Campus: Spring
Distance Campus: Spring

**Enrollment requirement:** (ECE 175 or CSC 127A or CSC 110) and MATH 129 and PHYS 141.

**SIE 277: Object-Oriented Modeling and Design** (3 units)
**Description:** Modeling and design of complex systems using all views of the Unified Modeling Language (UML). Most effort will be in the problem domain (defining the problem). Some effort will be in the solution domain (producing hardware or software).
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Course typically offered:**
Main Campus: Fall
Distance Campus: Fall

**Enrollment requirement:** ECE 175 or CSC 127A or CSC 110.

**SIE 295S: Systems and Industrial Engineering Sophomore Colloquium** (1 unit)
**Description:** A colloquium designed to help students understand what SIE's do. Students will interact with speakers and take tours to local companies. The course helps students select course options within the SIE programs and helps focus on possible SIE applications areas.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Colloquium Required
**Course typically offered:**
Main Campus: Spring
Distance Campus: Fall

**Enrollment requirement:** Major: Systems Engineering, Industrial Engineering, or Engineering Management. SIE 250 or SIE 265.

**SIE 299: Independent Study** (1 - 5 units)
**Description:** Qualified students working on an individual basis with professors who have agreed to supervise such work.
**Grading basis:** Alternative Grading: S, P, F
**Career:** Undergraduate
**Course Components:** Independent Study Required
**Repeatable:** Course can be repeated a maximum of 99 times.
**Course typically offered:**
Main Campus: Fall, Spring, Summer

**SIE 299H: Honors Independent Study** (1 - 3 units)
**Description:** Qualified students working on an individual basis with professors who have agreed to supervise such work.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Independent Study Required
**Repeatable:** Course can be repeated a maximum of 99 times.
**Course typically offered:**
Main Campus: Fall, Spring, Summer

**Enrollment requirement:** Student must be active in the Honors College.
**Honors Course:** Honors Course
**Honors Course:** Honors Course

**SIE 305: Introduction to Engineering Probability and Statistics** (3 units)
**Description:** Axioms of probability, discrete and continuous distributions, sampling distributions. Engineering applications of statistical estimation, hypothesis testing, confidence intervals.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Course typically offered:**
Main Campus: Fall, Spring, Summer
Distance Campus: Fall, Spring, Summer

**Recommendations and additional information:** MATH 129.
**Enrollment requirement:** Students must have Advanced Standing in the College of Engineering AND completion of MATH 129 to enroll in course.

**SIE 321: Probabilistic Models in Operations Research** (3 units)
**Description:** Probability, Markov chains, Poisson processes, queuing models, reliability models.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Course typically offered:**
Main Campus: Spring
Distance Campus: Spring

**Recommendations and additional information:** SIE 305.
**Enrollment requirement:** Adv Stdg: Engineering. SIE 305.

**SIE 330L: Engineering Experiment Design Lab** (1 unit)
**Description:** Application of statistical software to analyze observational and planned experiments using multiple linear regression, control charts and other data summarization methods.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Laboratory Required
**Course typically offered:**
Main Campus: Spring
Distance Campus: Spring

**Recommendations and additional information:** SIE 305; Concurrent registration, SIE 330R.
**Enrollment requirement:** Adv Stdg: Engineering.

**SIE 330R: Engineering Experiment Design** (3 units)
**Description:** Design and analysis of observational and factorial experiments employing numerical and graphical methods. Topics include control charts, probability plots, multiple regression analysis, confidence and prediction intervals and significance tests.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Course typically offered:**
Main Campus: Spring
Distance Campus: Spring

**Recommendations and additional information:** SIE 305.
**Enrollment requirement:** Adv Stdg: Engineering. SIE 305.

**SIE 340: Deterministic Operations Research** (3 units)
**Description:** Linear programming models, solution techniques, sensitivity analysis and duality.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Course typically offered:**
Main Campus: Fall, Summer
Distance Campus: Fall, Summer

**Enrollment requirement:** Adv Stdg: Engineering. SIE 270.

**SIE 367: Engineering Management II** (3 units)
**Description:** Strategic, tactical and operational planning; innovation and technological cycles; the elements of entrepreneurship, and human relations topics for technical managers.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Equivalent to:** ENGR 467
**Also offered as:** ENGR 367
**Course typically offered:**
Main Campus: Spring

**Enrollment requirement:** Adv Stdg: Engineering. SIE 265.

**SIE 370: Embedded Computer Systems** (4 units)
**Description:** Boolean algebra, combinational and sequential logic circuits, finite state machines, simple computer architecture, assembly language programming, and real-time computer control. The computer is used as an example of systems engineering design; it is analyzed as a system, not as a collection of components. There is a lab associated with this course.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Laboratory Required
Lecture Required
**Course typically offered:**
Main Campus: Spring
Distance Campus: Spring

**Enrollment requirement:** Adv Stdg: Engineering. PHYS 241.

**SIE 375: Software Integration Tools for Decision Modeling** (3 units)
**Description:** Use and integration of software tools for decision making including VB/VBA, Excel, Mat lab, CPLEX. Software integration techniques such as TCP/IP sockets and client/server techniques.
**Grading basis:** Student Option ABCDE/PF
**Career:** Undergraduate
**Course Components:** Laboratory May Be Offered
Lecture Required
**Course typically offered:**
Main Campus: Spring

**Recommendations and additional information:** SIE 305, SIE 340.
**Enrollment requirement:** Adv Stdg: Engineering.

**SIE 377: Software for Engineers** (3 units)
**Description:** Rapid prototyping of decision support systems using Visual Basic for Applications (VBA) and Excel. Use of VBA, Excel, and external packages to solve optimization problems, to perform simulations, and to perform forecasting. Rapid design and implementation of decision support systems for financial, supply chain, and facility location problems.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Equivalent to:** CSC 342, MIS 342
**Course typically offered:**
Main Campus: Fall

**Enrollment requirement:** Adv Stdg: Engineering. ECE 175 or CSC 127A or CSC 110.

**SIE 383: Integrated Manufacturing Systems** (3 units)
**Description:** Introduction to the integrated manufacturing enterprise and automation. Topics include computer-aided design, process planning, computer numerical control machining, machine vision, application of robots and automation.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Course typically offered:**
Main Campus: Spring

**Recommendations and additional information:** CHEM 103A, PHYS 141, CAD Drawing experience.
**Enrollment requirement:** Adv Stdg: Engineering.

**SIE 399: Independent Study** (1 - 5 units)
**Description:** Qualified students working on an individual basis with professors who have agreed to supervise such work.
**Grading basis:** Alternative Grading: S, P, F
**Career:** Undergraduate
**Course Components:** Independent Study Required
**Repeatable:** Course can be repeated a maximum of 99 times.
**Course typically offered:**
Main Campus: Fall, Spring, Summer

**Enrollment requirement:** Adv Stdg: Engineering.

**SIE 399H: Honors Independent Study** (1 - 3 units)
**Description:** Qualified students working on an individual basis with professors who have agreed to supervise such work.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Independent Study Required
**Repeatable:** Course can be repeated a maximum of 99 times.
**Course typically offered:**
Main Campus: Fall, Spring, Summer

**Enrollment requirement:** Adv Stdg: Engineering. Honors active.
**Honors Course:** Honors Course
**Honors Course:** Honors Course

**SIE 406: Quality Engineering** (3 units)
**Description:** Quality, improvement and control methods with applications in design, development, manufacturing, delivery and service. Topics include modern quality management philosophies, engineering/statistical methods (including process control, control charts, process capability studies, loss functions, experimentation for improvement) and TQM topics (customer driven quality, teaming, Malcolm Baldridge and ISO 9000).
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Equivalent to:** AME 406
**Co-convened with:** SIE 506
**Course typically offered:**
Main Campus: Spring
Distance Campus: Spring

**Enrollment requirement:** Adv Stdg: Engineering. SIE 305.

**SIE 408: Reliability Engineering** (3 units)
**Description:** This is a three-credit course configured for well-qualified seniors, graduate students, and engineering professionals and practitioners. It is concerned with determining the probability that a component or system, whether simple or complex, will function as intended. The scope of this course includes: (1) Root cause analysis of critical failures, (2) reliability models of components and systems, (3) development of statistical methods for estimating the reliability of a product, (4) use of software tools to perform model development and analysis, and (5) methodologies to influence system designs.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Co-convened with:** SIE 508
**Course typically offered:**
Main Campus: Fall
Distance Campus: Fall

**Enrollment requirement:** Adv Stdg: Engineering. SIE 305.

**SIE 410A: Human Factors & Ergonomics in Design** (3 units)
**Description:** Consideration of human characteristics in the requirements for design of systems, organizations, facilities and products to enable human-centered design which considers human abilities, limitations and acceptance.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Course typically offered:**
Main Campus: Fall
Distance Campus: Fall

**Enrollment requirement:** Adv Stdg: Engineering. Completed or enrolled in SIE 305.

**SIE 411: Human-Machine Interaction** (3 units)
**Description:** Students (both onsite and distance learning) who take this course will get familiar with the basic concepts, methods, principles and skills in designing and evaluating various human-machine interfaces. Machine here is generally defined as any physical systems that can be operated by human operators. This course is composed of a systematic introduction of major principles and methods in human-machine interaction, including: 1) Fundamental concepts and principles of human-machine interaction; 2) User interface design, prototyping and interface analysis methods; 3) Quantitative and qualitative user modeling and interface evaluation methods. 4) Special topics in HMI: ecological and adaptive human-machine interface, speech and handwriting UIs in HMI, engineering aesthetics in HMI, as well as human-machine interaction in transportation.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Co-convened with:** SIE 511
**Course typically offered:**
Main Campus: Fall, Spring

**Enrollment requirement:** Advanced Standing: Engineering and SIE 305 and (ECE 175 or CSC 110) or consent of instructor.

**SIE 414: Law for Engineers and Scientists** (3 units)
**Description:** Topics covered in this course include patents, trade secrets, trademarks, copyrights, product liability contracts, business entities, employment relations and other legal matters important to engineers and scientists.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Equivalent to:** CHE 454, ENGR 454
**Also offered as:** ENGR 414
**Co-convened with:** SIE 554
**Course typically offered:**
Main Campus: Spring
Distance Campus: Spring

**Enrollment requirement:** Adv Stdg: Engineering.

**SIE 415: Technical Sales and Marketing** (3 units)
**Description:** Principles of the engineering sales process in technology-oriented enterprises; selling strategy, needs analysis, proposals, technical communications, electronic media, time management and ethics; practical application of concepts through study of real-world examples.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Co-convened with:** SIE 515
**Course typically offered:**
Main Campus: Fall, Spring
Distance Campus: Fall, Spring

**Enrollment requirement:** Adv Stdg: Engineering.

**SIE 422: Engineering Decision Making Under Uncertainty** (3 units)
**Description:** Application of principles of probability and statistics to the design and control of engineering systems in a random or uncertain environment. Emphasis is placed on Bayesian decision analysis.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Co-convened with:** SIE 522
**Course typically offered:**
Main Campus: Fall
Distance Campus: Fall

**Enrollment requirement:** Adv Stdg: Engineering. SIE 305.

**SIE 430: Engineering Statistics** (3 units)
**Description:** Statistical methodology of estimation, testing hypotheses, goodness-of-fit, nonparametric methods and decision theory as it relates to engineering practice. Significant emphasis on the underlying statistical modeling and assumptions.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Co-convened with:** SIE 530
**Course typically offered:**
Main Campus: Fall
Distance Campus: Fall

**Enrollment requirement:** Adv Stdg: Engineering. SIE 305.

**SIE 431: Simulation Modeling and Analysis** (3 units)
**Description:** Discrete event simulation, model development, statistical design and analysis of simulation experiments, variance reduction, random variate generation, Monte Carlo simulation.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Co-convened with:** SIE 531
**Course typically offered:**
Main Campus: Fall, Spring
Distance Campus: Fall, Spring

**Recommendations and additional information:** SIE 305.
**Enrollment requirement:** Adv Stdg: Engineering. SIE 305.

**SIE 432: Sports Analytics** (3 units)
**Description:** This course provides fundamental analytical skills necessary to analyze data and make decisions using sports examples. These skills include critical thinking, statistical analysis, computer programming, and data visualization which are generally applicable to other areas of engineering and business.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Also offered as:** ENGR 432
**Co-convened with:** SIE 532
**Course typically offered:**
Main Campus: Fall, Summer
Distance Campus: Fall, Summer

**Field trip:** none
**Enrollment requirement:** Adv Stdg: Engineering and SIE 305 or equivalent or instructor permission.

**SIE 433: Fundamentals of Data Science for Engineers** (3 units)
**Description:** This course will provide senior undergraduate and graduate students from a diverse engineering disciplines with fundamental concepts, principles and tools to extract and generalize knowledge from data. Students will acquire an integrated set of skills spanning data processing, statistics and machine learning, along with a good understanding of the synthesis of these skills and their applications to solving problem. The course is composed of a systematic introduction of the fundamental topics of data science study, including: (1) principles of data processing and representation, (2) theoretical basis and advances in data science, (3) modeling and algorithms, and (4) evaluation mechanisms. The emphasis in the treatment of these topics will be given to the breadth, rather than the depth. Real-world engineering problems and data will be used as examples to illustrate and demonstrate the advantages and disadvantages of different algorithms and compare their effectiveness as well as efficiency, and help students to understand and identify the circumstances under which the algorithms are most appropriate.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Co-convened with:** SIE 533
**Course typically offered:**
Main Campus: Fall
Online Campus: Fall
Distance Campus: Fall

**Recommendations and additional information:** SIE 305, equivalent courses or consent of instructor.
**Field trip:** N/A

**SIE 440: Survey of Optimization Methods** (3 units)
**Description:** Survey of methods including network flows, integer programming, nonlinear programming, and dynamic programming. Model development and solution algorithms are covered.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Co-convened with:** SIE 540
**Course typically offered:**
Main Campus: Spring
Distance Campus: Spring

**Enrollment requirement:** Adv Stdg: Engineering. SIE 340.

**SIE 443: Game Theory** (3 units)
**Description:** Principles of game theory. Historical context, Nash equilibrium, normal form and extensive forms. Stackelberg equilibrium, subgame perfect equilibrium. Cooperative games: core, bargaining, MCDM, social choice, Bayesian games. Examples from engineering, economics, military, national security, and environmental protection.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Co-convened with:** SIE 543
**Course typically offered:**
Main Campus: Fall

**Enrollment requirement:** Adv Stdg: Engineering.

**SIE 452: Space Systems Engineering** (3 units)
**Description:** Fundamentals of space systems engineering; The system engineering process for space missions; Model-based design for spacecrafts and space flight systems; Elements of mission analysis and design; Elements of analysis and design for spacecraft subsystems (structure and mechanisms, thermal control; attitude control and orbit determination; command and data handling; propulsion; communication; power); The course will involve preliminary design of a full space system (spacecraft, lander, rover) to accomplish specific mission goals and objectives (e.g. scientific); The course will include lectures on special topics that are specific to the targeted space system design project developed during the semester.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Discussion May Be Offered
Lecture Required
**Co-convened with:** SIE 552
**Course typically offered:**
Main Campus: Spring

**Enrollment requirement:** Adv Stdg: Engineering.

**SIE 453: Deterministic Control Systems** (3 units)
**Description:** The analysis and synthesis of deterministic linear control systems, with emphasis on design using both frequency-domain and state-variable approaches.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Recommendations and additional information:** SIE 350.
**Enrollment requirement:** Adv Stdg: Engineering.

**SIE 454A: The Systems Engineering Process** (3 units)
**Description:** Process and tools for systems engineering of large-scale, complex systems: requirements, performance measures, concept exploration, multi-criteria tradeoff studies, life cycle models, system modeling, etc.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Co-convened with:** SIE 554A
**Course typically offered:**
Main Campus: Fall
Distance Campus: Fall

**Enrollment requirement:** Adv Stdg: Engineering.

**SIE 455: Sensor Systems Engineering** (3 units)
**Description:** The primary purpose of this course is to provide students with a system level understanding of sensor development. The student will see the development of remote sensing techniques beginning with high level requirements through concept of operations, architecture development, subsystem modeling and culminating in integration, validation and verification. The student will be exposed to key design parameters for radar and Electro Optical sensing systems that drive both system cost and performance. Advanced multi-sensor systems and adaptive signal processing will also be discussed.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Co-convened with:** SIE 555
**Course typically offered:**
Main Campus: Spring

**SIE 456: Fundamental of Guidance for Aerospace Systems** (3 units)
**Description:** The main objective of the course is to introduce the students with the fundamental principles behind the development of guidance laws for aerospace systems. More specifically, the course will introduce basic and more advanced guidance concepts for aerospace vehicles and discuss their practical implementation on missiles, planetary landers, reentry and launch vehicles. The first part of the course is focused on the intercept guidance problem and its application to guided missile systems. The basic ideas behind the proportional navigation are introduced together with a detailed analysis of the PN law on both time and frequency domain. The guidance law design is viewed from a control theory standpoint and design methods using both time domain and frequency domain are introduced. Special emphasis is placed on non-linear control design techniques including sliding control mode and Lyapunov-based approach for a robust design and improvement of targeting performance. In the second part of the course, the optimal control theory is introduced as main tool to design guidance algorithms for planetary landers. More specifically, the design of guidance laws for powered descent landing on planetary bodies is discussed. Both numerical and analytical methods to determine targeting reference trajectories are presented together with real-time guidance algorithms that close the loop on the planned path. The third part of the course will be focused on a) guidance algorithms for hypersonic reentry vehicles and b) ascent guidance for Launch Vehicles (LV). In this contest, guidance algorithms available to control the bank angle for low lift-to-drag ratio capsules will be discussed together with powered exoatmospheric guidance algorithms for LV orbit targeting. Particular emphasis will be given to the practical implementation of the guidance algorithms.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Co-convened with:** SIE 556
**Course typically offered:**
Main Campus: Fall

**Enrollment requirement:** Adv Stdg: Engineering.

**SIE 457: Project Management** (3 units)
**Description:** Foundations, principles, methods and tools for effective design and management of projects in technology-based organizations. This course focuses on the scope, time, cost, performance and quality concerns of engineering projects characterized by risk and uncertainty. Initiating, planning, executing, monitoring, controlling and closing process are addressed. Students design and complete a project from concept through completion. Project management software is utilized.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Also offered as:** ENTR 457
**Co-convened with:** SIE 557
**Course typically offered:**
Main Campus: Fall
Distance Campus: Fall

**Enrollment requirement:** Adv Stdg: Engineering or Adv Stdg: Entrepreneurship.

**SIE 458: Model Based Systems Engineering** (3 units)
**Description:** An introduction to model-based systems engineering (MBSE), which is the formalized application of modeling to support system requirements, design, analysis, verification and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases. The course emphasizes practical use of the Systems Modeling Language (SysML) and MBSE methods.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Co-convened with:** SIE 558
**Course typically offered:**
Main Campus: Fall
Online Campus: Fall
Distance Campus: Fall

**Recommendations and additional information:** SIE 454A or permission of instructor.
**Enrollment requirement:** Adv Stdg: Engineering.

**SIE 462: Production Systems Analysis** (3 units)
**Description:** Production systems, quantitative methods for forecasting, aggregate planning, inventory control, materials requirement planning, production scheduling, manpower planning and facility design.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Co-convened with:** SIE 562
**Course typically offered:**
Main Campus: Spring
Distance Campus: Spring

**Recommendations and additional information:** SIE 305. SIE 340 or consent of advisor.
**Enrollment requirement:** Adv Stdg: Engineering. SIE 305 and SIE 340.

**SIE 463: Facilities and Production Systems Design** (3 units)
**Description:** Case studies emphasizing aspects of production systems design such as facility location, facility layout, group technology, product and process design, material handling, and automated assembly. The student will be required to work in groups. Solutions will be presented using both written and oral reports.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Course typically offered:**
Main Campus: Fall

**Recommendations and additional information:** Concurrent registration, SIE 462.
**Enrollment requirement:** Adv Stdg: Engineering.

**SIE 464: Cost Estimation** (3 units)
**Description:** Focuses on principles of cost estimation and measurement systems with specific emphasis on parametric models. Approaches from the fields of hardware, software and systems engineering are applied to a variety of contexts (risk assessment, judgment & decision making, performance measurement, process improvement, adoption of new tools in organizations, etc.). Material is divided into five major sections: cost estimation fundamentals, parametric model development and calibration, advanced engineering economic principles, measurement systems, and policy issues.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Co-convened with:** SIE 564
**Course typically offered:**
Main Campus: Spring

**Enrollment requirement:** Adv Stdg: Engineering. SIE 305.

**SIE 465: Supply Chain Management** (3 units)
**Description:** Fundamentals of Supply Chain Management including inventory/logistics planning and management, warehouse operations, procurement, sourcing, contracts and collaboration.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Co-convened with:** SIE 565
**Course typically offered:**
Main Campus: Spring
Distance Campus: Spring

**Enrollment requirement:** Adv Stdg: Engineering. SIE 305 and SIE 340. Enrollment not allowed if you have previously taken MIS 477 or MIS 577 "Supply Chain & Logistics".

**SIE 466: Life Cycle Analysis for Sustainable Design and Engineering** (3 units)
**Description:** This course will provide senior undergraduate and graduate students the conceptual, methodological, and scientific bases to quantify and reduce the impact of engineering decisions on the environment, with a focus on applying life cycle analysis (LCA) to support the material choice, product/process design, and manufacturing/engineering decisions. Main topics covered include concept of life cycle thinking, computational structure of LCA, process and economic input-output based LCA, LCA software demonstration, LCA case studies, environmental product declaration, and recent development and advanced topics in LCA.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Co-convened with:**
**Course typically offered:**
Main Campus: Fall, Summer
Online Campus: Fall, Summer
Distance Campus: Fall, Summer

**Field trip:** None.

**SIE 471: Systems Cyber Security Engineering** (3 units)
**Description:** The purpose of this course is to introduce selected topics, issues, problems, and techniques in the area of System Cyber Security Engineering (SCSE), early in the development of a large system. Students will explore various techniques for eliminating security vulnerabilities, defining security specifications / plans, and incorporating countermeasures in order to achieve overall system assurance. SCSE is an element of system engineering that applies scientific and engineering principles to identify, evaluate, and contain or eliminate system vulnerabilities to known or postulated security threats in the operational environment. SCSE manages and balances system security risk across all protection domains spanning the entire system engineering life-cycle. The fundamental elements of cyber security will be explored including: human cyber engineering techniques, penetration testing, mobile and wireless vulnerabilities, network mapping and security tools, embedded system security, reverse engineering, software assurance and secure coding, cryptography, vulnerability analysis, and cyber forensics. After a fundamental understanding of the various cyber threats and technologies are understood, the course will expand upon the basic principles, and demonstrate how to develop a threat / vulnerability assessment on a representative system using threat modeling techniques (i.e. modeling threats for a financial banking system, autonomous automobile, or a power distribution system). With a cyber resilience focus, students will learn how to identify critical use cases or critical mission threads for the system under investigation, and how to decompose and map those elements to various architectural elements of the system for further analysis. Supply chain risk management (SCRM) will be employed to enumerate potential cyber threats that could be introduced to the system either unintentionally or maliciously throughout the supply chain. The course culminates with the conduct of a realistic Red Team / Blue Team simulation to demonstrate and explore both the attack and defend perspectives of a cyber threat. The Red Team will perform a vulnerability assessment of the prospective system, with the intention of attacking its vulnerabilities. The Blue Team will perform a vulnerability of the same system with the intention of defending it against cyber threats. A comparison will be made between the outcomes of both teams in order to better understand the overarching solutions to addressing the threats identified.Upon completion of the course, students will be proficient with various elements of cyber security and how to identify system vulnerabilities early on in the system engineering lifecycle. They will be exposed to various tools and processes to identify and protect a system against those vulnerabilities, and how to develop program protection plans to defend against and prevent malicious attacks on large complex systems.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Co-convened with:** SIE 571
**Course typically offered:**
Main Campus: Fall
Distance Campus: Fall

**Enrollment requirement:** Adv Stdg: Engineering.

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**-CC** represents a Correspondence Course offering
**May Be Offered** Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

**SIE 472: Information Security and Research (INSuRE)** (3 units)
**Description:** This course engages students in diverse and varied national cybersecurity/information systems security problems, under an existing and very successful umbrella program called 'INSuRE', that enables a collaboration across several universities, Cyber professionals and cross-disciplined Cyber related technologies. Led by Purdue University, and made possible by a grant from the NSA and NSF, INSuRE has fielded a multi-institutional cybersecurity research course in which small groups of undergraduate and graduate students work to solve unclassified problems proposed by NSA, other US government agencies, and/or private organizations and laboratories. Students will learn how to apply research techniques, think clearly about these issues, formulate and analyze potential solutions, and communicate their results with sponsors and other participating universities. Working in small groups under the mentorship of technical experts from government and industry, each student will formulate, carry out, and present original research on current cybersecurity / information assurance problems of interest to the nation. This course will be run in a synchronized distance fashion, coordinating activities with other INSuRE technical clients and sponsors, along with partnering universities which are all National Centers of Academic Excellence in Cyber Defense Research (CAE-R) (i.e. Purdue University, Carnegie Mellon University, University of California Davis and several others).
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Co-convened with:** SIE 572
**Course typically offered:**
Main Campus: Spring
Distance Campus: Spring

**Recommendations and additional information:** Background in computer science, computer engineering, information technology, or related technical field. One of the following is strongly recommended: SIE 471 / 571, ECE 478/578, ECE 509, or MIS 416/516
**Enrollment requirement:** Adv Stdg: Engineering.

**SIE 474: Information Analytics and Decision-Making in Engineering** (3 units)
**Description:** Recent advances in computational and information technology allow the collection and evaluation of vast volumes of data. This explosion in information has amplified the need to understand the value of information and how to use available information to make better decisions that in turn affect the environment. For example, consider the following questions:- How should a firm optimally experiment among different website designs before deciding on a single one, with the goal to maximize user traffic or revenue?- How should a company choose its bid for mining rights if it has access to exclusive probing data, in order to maximize its profit?- How should a buyer interpret online feedback and ratings before deciding on which product to buy? - How should a doctor decide which medical tests to perform on a patient to deliver the most effective care?The course will cover information valuation, decision-making, and information economics in non-strategic and strategic settings.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Co-convened with:** SIE 574
**Course typically offered:**
Main Campus: Fall
Distance Campus: Fall

**Recommendations and additional information:** Knowledge of basic distributions, conditional probabilities, and coding small programs for activities.
**Enrollment requirement:** Adv Stdg: Engineering. SIE 305.

**SIE 477: Introduction to Biomedical Informatics** (3 units)
**Description:** Driven by efforts to improve human health and healthcare systems, this course will cover relevant topics at the intersection of people, health information, and technology. Specifically, we will survey the field of biomedical informatics that studies the effective uses of biomedical data, information, and knowledge from individuals (patients), populations, biomolecules, and cellular processes, for scientific inquiry, problem solving, and decision making. We will explore foundations and methods from both biomedical and computing perspectives, including hands-on experiences with systems, tools, and technologies in the healthcare ecosystem.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Also offered as:** BME 477
**Course typically offered:**
Main Campus: Fall

**Home department:** Biomedical Engineering
**Enrollment requirement:** (ECE 175 or CSC 127A or CSC 110 or consent of instructor), and Engineering Advanced Standing.

**SIE 482: Lean Engineering** (3 units)
**Description:** Survey of lean and variability reduction principles as applied to manufacturing and non-manufacturing environments.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Course typically offered:**
Main Campus: Spring

**Recommendations and additional information:** SIE 305 or equivalent (probability & statistics)
**Enrollment requirement:** Adv Stdg: Engineering. SIE 305.

**SIE 483: Computer-Integrated Manufacturing (CIM) Systems** (3 units)
**Description:** Modern manufacturing systems with emphasis on information requirements and data management. Includes CAD, CAM, CAPP, real-time scheduling, networking, and system justification.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Co-convened with:** SIE 583
**Course typically offered:**
Main Campus: Fall

**Recommendations and additional information:** Familiar with CAD system, scientific programming language, and a database system.
**Enrollment requirement:** Adv Stdg: Engineering. SIE 383.

**SIE 484: Development of New Venture Plans** (4 units)
**Description:** Preparation and presentation of a comprehensive business plan. Integration of financial, operational, and marketing elements.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Equivalent to:** FIN 484, MAP 484, MGMT 484, SIE 484
**Also offered as:** ENTR 484
**Course typically offered:**
Main Campus: Spring

**Home department:** McGuire Center for Entrepreneurship
**Enrollment requirement:** Adv Stdg: Entrepreneurship.

**SIE 487: New Venture Development and Industry Analysis** (4 units)
**Description:** Integration of marketing, production and management functions. Pro forma statements. Development of venture capital.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Lecture Required
**Equivalent to:** MAP 487, MGMT 487, SIE 487
**Also offered as:** ENTR 487
**Course typically offered:**
Main Campus: Fall

**Home department:** McGuire Center for Entrepreneurship
**Student Engagement Activity:** Entrepreneurship
**Student Engagement Competency:** Innovation and Creativity

**SIE 492: Directed Research** (1 - 3 units)
**Description:** Individual or small group research under the guidance of faculty.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Independent Study Required
**Repeatable:** Course can be repeated for a maximum of 6 units.
**Course typically offered:**
Main Campus: Fall, Spring, Summer

**Enrollment requirement:** Adv Stdg: Engineering.

**SIE 493: Internship** (1 - 3 units)
**Description:** Specialized work on an individual basis, consisting of training and practice in actual service in a technical, business, or governmental establishment.
**Grading basis:** Alternative Grading: S, P, F
**Career:** Undergraduate
**Course Components:** Independent Study Required
**Repeatable:** Course can be repeated a maximum of 99 times.
**Course typically offered:**
Main Campus: Fall, Spring, Summer
Distance Campus: Fall, Spring, Summer

**Enrollment requirement:** Adv Stdg: Engineering.
**Student Engagement Activity:** Professional Development
**Student Engagement Competency:** Professionalism

**SIE 496: Special Topics in Systems and Industrial Engineering** (3 units)
**Description:** This course is designed to provide a flexible topics course across several domains in the field of Systems Engineering, Industrial Engineering, and Engineering Management. Students will develop and exchange scholarly information in a small group setting. Selected advanced topics in Systems and Industrial Engineering and Operations Research, such as 1) optimization, 2) stochastic systems, 3) systems engineering and design, 4) human cognition systems, and 5) informatics.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Seminar Required
**Repeatable:** Course can be repeated a maximum of 3 times.
**Course typically offered:**
Main Campus: Fall, Spring, Summer

**Recommendations and additional information:** Background in computer programming language recommended.
**Enrollment requirement:** Adv Stdg: Engineering. SIE 305.

**SIE 498A: Senior Design Projects I** (2 - 3 units)
**Description:** Teams of students will use material taught in the SIE curriculum to address a customer's needs and help a real-world client design or improve a system. Students will use a system design process, discover system requirements, identify project and technical risks, and develop a project plan and schedule. Students will communicate orally and in writing. A series of design reviews will monitor project goals, schedule, risk and progress. 498A should be taken in the student's penultimate or antepenultimate semester.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Independent Study Required
Lecture May Be Offered
**Course typically offered:**
Main Campus: Fall, Spring, Summer
Distance Campus: Fall, Spring, Summer

**Recommendations and additional information:** Senior Standing.
**Enrollment requirement:** Adv Stdg: Engineering.
**Student Engagement Activity:** Discovery
**Student Engagement Competency:** Innovation and Creativity

**SIE 498B: Senior Design Projects II** (3 units)
**Description:** Teams of students will use material taught in the SIE curriculum to address a customer's needs and help a real-world client design or improve a system. Students will use a system design process, discover system requirements, identify project and technical risks, and develop a project plan and schedule. Students will communicate orally and in writing. A series of design reviews will monitor project goals, schedule, risk and progress. Continuation of SIE-498A.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Independent Study Required
Lecture May Be Offered
**Course typically offered:**
Main Campus: Fall, Spring, Summer
Distance Campus: Fall, Spring, Summer

**Recommendations and additional information:** SIE 498A.
**Enrollment requirement:** Adv Stdg: Engineering.
**Student Engagement Activity:** Discovery
**Student Engagement Competency:** Innovation and Creativity

**SIE 498H: Honors Thesis** (3 units)
**Description:** An honors thesis is required of all the students graduating with honors. Students ordinarily sign up for this course as a two-semester sequence. The first semester the student performs research under the supervision of a faculty member; the second semester the student writes an honors thesis.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Independent Study Required
**Repeatable:** Course can be repeated for a maximum of 9 units.
**Course typically offered:**
Main Campus: Fall, Spring, Summer
Distance Campus: Fall, Spring, Summer

**Enrollment requirement:** Adv Stdg: Engineering. Honors active.
**Honors Course:** Honors Course
**Honors Course:** Honors Course
**Student Engagement Activity:** Discovery
**Student Engagement Competency:** Innovation and Creativity
**Writing Emphasis:** Writing Emphasis Course

**SIE 499: Independent Study** (1 - 3 units)
**Description:** Qualified students working on an individual basis with professors who have agreed to supervise such work.
**Grading basis:** Alternative Grading: S, P, F
**Career:** Undergraduate
**Course Components:** Independent Study Required
**Repeatable:** Course can be repeated a maximum of 99 times.
**Course typically offered:**
Main Campus: Fall, Spring, Summer
Distance Campus: Fall, Spring, Summer

**Enrollment requirement:** Adv Stdg: Engineering.

**SIE 499H: Honors Independent Study** (3 units)
**Description:** Qualified students working on an individual basis with professors who have agreed to supervise such work.
**Grading basis:** Regular Grades
**Career:** Undergraduate
**Course Components:** Independent Study Required
**Repeatable:** Course can be repeated a maximum of 99 times.
**Course typically offered:**
Main Campus: Fall, Spring, Summer
Distance Campus: Fall, Spring, Summer

**Enrollment requirement:** Adv Stdg: Engineering. Honors active.
**Honors Course:** Honors Course
**Honors Course:** Honors Course

**SIE 500A: Introduction to SIE Methods: Probability and Statistics** (1 unit)
**Description:** Axioms of probability, discrete and continuous distributions, sampling distributions. Applications of statistical estimation, hypothesis testing, confidence intervals.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Course typically offered:**
Main Campus: Fall, Spring
Online Campus: Fall, Spring
Distance Campus: Fall, Spring

**Recommendations and additional information:** MATH 129.

**SIE 500B: Introduction to SIE Methods: Stochastic Processes** (1 unit)
**Description:** Introduction to probabilistic models commonly used in systems and industrial engineering and related disciplines. Markov chains, Poisson processes, queuing models.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Course typically offered:**
Main Campus: Fall, Spring
Online Campus: Fall, Spring
Distance Campus: Fall, Spring

**SIE 500C: Introduction to SIE Methods: Linear Programming** (1 unit)
**Description:** Linear programming models, solution techniques, and duality.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Course typically offered:**
Main Campus: Fall, Spring
Online Campus: Fall, Spring
Distance Campus: Fall, Spring

**Recommendations and additional information:** SIE 270 and SIE 265, or ECON 210.

**SIE 503: Technical Leadership for Engineers** (1 unit)
**Description:** This course introduces the concepts of technical leadership in today's modern engineering profession. The increasing complexity of advanced technologies and systems requires a new generation of technical leaders who are creative, independent, and innovative to think, understand and solve complex problems from multiple engineering perspectives. This senior level course leverages the principles of systems engineering by applying a "systems thinking" approach to solving complex industrial problems in today's continuous challenging technical environments. This course examines the critical roles and functions of leadership and management for technical engineers. Topics include leadership by example, professional ethics, creating and developing effective teams, relationship building, influencing, and leading and managing change through creativity and innovation. This course also analyzes leadership attributes as a means to understand what makes a successful or failed leader. There will be assigned case studies that analyze these attributes.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Also offered as:** MNE 503
**Course typically offered:**
Main Campus: Fall

**Home department:** Mining & Geologicl Engineering

**SIE 506: Quality Engineering** (3 units)
**Description:** Quality, improvement and control methods with applications in design, development, manufacturing, delivery and service. Topics include modern quality management philosophies, engineering/statistical methods (including process control, control charts, process capability studies, loss functions, experimentation for improvement) and TQM topics (customer driven quality, teaming, Malcolm Baldridge and ISO 9000). Graduate-level requirements include additional readings and assignments/projects.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Equivalent to:** AME 506
**Co-convened with:** SIE 406
**Course typically offered:**
Main Campus: Spring
Online Campus: Spring
Distance Campus: Spring

**SIE 508: Reliability Engineering** (3 units)
**Description:** This is a three-credit course configured for well-qualified seniors, graduate students, and engineering professionals and practitioners. It is concerned with determining the probability that a component or system, whether simple or complex, will function as intended. The scope of this course includes: (1) Root cause analysis of critical failures, (2) reliability models of components and systems, (3) development of statistical methods for estimating the reliability of a product, (4) use of software tools to perform model development and analysis, and (5) methodologies to influence system designs. Graduate-level requirements include a term project that focuses on real-world implementations of the course material and/or original theoretical developments in the form of a technical paper. Project topics (e.g., system reliability optimization, physics-based reliability models, warranty data analysis) must be approved by the instructor.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Co-convened with:** SIE 408
**Course typically offered:**
Main Campus: Fall
Online Campus: Fall
Distance Campus: Fall

**Recommendations and additional information:** SIE 430 or 530.

**SIE 511: Human-Machine Interaction** (3 units)
**Description:** Students (both onsite and distance learning) who take this course will get familiar with the basic concepts, methods, principles and skills in designing and evaluating various human-machine interfaces. Machine here is generally defined as any physical systems that can be operated by human operators. This course is composed of a systematic introduction of major principles and methods in human-machine interaction, including: 1) Fundamental concepts and principles of human-machine interaction; 2) User interface design, prototyping and interface analysis methods; 3) Quantitative and qualitative user modeling and interface evaluation methods. 4) Special topics in HMI: ecological and adaptive human-machine interface, speech and handwriting UIs in HMI, engineering aesthetics in HMI, as well as human-machine interaction in transportation.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Co-convened with:** SIE 411
**Course typically offered:**
Main Campus: Fall
Online Campus: Fall
Distance Campus: Fall

**Recommendations and additional information:** Background in visual basic application in Excel or similar programming languages is recommended.

**SIE 512: Human Factors Engineering Research Methods** (3 units)
**Description:** Students (both onsite and distance learning) who take this course will become familiar with the start-of-art research methods in human factors engineering, including study design, research hypotheses generation, literature search and management in human factors, experimental design and human behavior data analysis in human factors, various human behavior measurement methods, and writing conference and journal papers in human factors.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Course typically offered:**
Main Campus: Spring

**Recommendations and additional information:** It is recommended (but not required) that students have taken SIE 411/511 Human Machine Interaction.

**SIE 514: Law for Engineers/Scientists** (3 units)
**Description:** Topics covered in this course include patents, trade secrets, trademarks, copyrights, product liability contracts, business entities, employment relations and other legal matters important to engineers and scientists. Graduate-level requirements include an in-depth research paper on a current topic.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Equivalent to:** CHE 554, ENGR 554
**Also offered as:** ENGR 514
**Co-convened with:** SIE 414
**Course typically offered:**
Main Campus: Spring
Online Campus: Spring
Distance Campus: Spring

**SIE 515: Technical Sales and Marketing** (3 units)
**Description:** Principles of the engineering sales process in technology-oriented enterprises; selling strategy, needs analysis, proposals, technical communications, electronic media, time management and ethics; practical application of concepts through study of real-world examples. Graduate-level requirements include a term paper on a course topic selected from a short list of topics, other graded components of the course and creation of a PowerPoint presentation to the class.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Co-convened with:** SIE 415
**Course typically offered:**
Main Campus: Fall, Spring
Online Campus: Fall, Spring
Distance Campus: Fall, Spring

**SIE 520: Stochastic Modeling I** (3 units)
**Description:** Modeling of stochastic processes from an applied viewpoint. Markov chains in discrete and continuous time, renewal theory, applications to engineering processes.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Course typically offered:**
Main Campus: Spring
Online Campus: Spring
Distance Campus: Spring

**Recommendations and additional information:** SIE 321.

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**-CC** represents a Correspondence Course offering
**May Be Offered** Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

**SIE 522: Engineering Decision Making Under Uncertainty** (3 units)
**Description:** Application of principles of probability and statistics to the design and control of engineering systems in a random or uncertain environment. Emphasis is placed on Bayesian decision analysis. Graduate-level requirements include a semester research project.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Co-convened with:** SIE 422
**Course typically offered:**
Main Campus: Fall
Online Campus: Fall
Distance Campus: Fall

**SIE 525: Queuing Theory** (3 units)
**Description:** Application of the theory of stochastic processes to queuing phenomena; introduction to semi-Markov processes; steady-state analysis of birth-death, Markovian, and general single- and multiple-channel queuing systems.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Course typically offered:**
Main Campus: Spring
Online Campus: Spring
Distance Campus: Spring

**SIE 530: Engineering Statistics** (3 units)
**Description:** Statistical methodology of estimation, testing hypotheses, goodness-of-fit, nonparametric methods and decision theory as it relates to engineering practice. Significant emphasis on the underlying statistical modeling and assumptions. Graduate-level requirements include additionally more difficult homework assignments.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Co-convened with:** SIE 430
**Course typically offered:**
Main Campus: Fall
Online Campus: Fall
Distance Campus: Fall

**SIE 531: Simulation Modeling and Analysis** (3 units)
**Description:** Discrete event simulation, model development, statistical design and analysis of simulation experiments, variance reduction, random variate generation, Monte Carlo simulation. Graduate-level requirements include a library research report.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Co-convened with:** SIE 431
**Course typically offered:**
Main Campus: Fall, Spring
Online Campus: Fall, Spring
Distance Campus: Fall, Spring

**SIE 532: Sports Analytics** (3 units)
**Description:** This course provides fundamental analytical skills necessary to analyze data and make decisions using sports examples. These skills include critical thinking, statistical analysis, computer programming, and data visualization which are generally applicable to other areas of engineering and business.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Also offered as:** ENGR 532
**Co-convened with:** SIE 432
**Course typically offered:**
Main Campus: Fall, Summer
Online Campus: Fall, Summer
Distance Campus: Fall, Summer

**Recommendations and additional information:** Statistics
**Field trip:** none

**SIE 533: Fundamentals of Data Science for Engineers** (3 units)
**Description:** This course will provide senior undergraduate and graduate students from a diverse engineering disciplines with fundamental concepts, principles and tools to extract and generalize knowledge from data. Students will acquire an integrated set of skills spanning data processing, statistics and machine learning, along with a good understanding of the synthesis of these skills and their applications to solving problem. The course is composed of a systematic introduction of the fundamental topics of data science study, including: (1) principles of data processing and representation, (2) theoretical basis and advances in data science, (3) modeling and algorithms, and (4) evaluation mechanisms. The emphasis in the treatment of these topics will be given to the breadth, rather than the depth. Real-world engineering problems and data will be used as examples to illustrate and demonstrate the advantages and disadvantages of different algorithms and compare their effectiveness as well as efficiency, and help students to understand and identify the circumstances under which the algorithms are most appropriate.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Co-convened with:** SIE 433
**Course typically offered:**
Main Campus: Fall
Online Campus: Fall
Distance Campus: Fall

**Recommendations and additional information:** SIE 530, equivalent courses such as SIE 500A taken in parallel or consent of instructor.
**Field trip:** N/A

**SIE 536: Experiment Design and Regression** (3 units)
**Description:** Planning and designing experiments with an emphasis on factorial layout. Includes analysis of experimental and observational data with multiple linear regression and analysis of variance.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Course typically offered:**
Main Campus: Spring
Online Campus: Spring
Distance Campus: Spring

**Recommendations and additional information:** SIE 530.

**SIE 537: Design & Analysis of Computer Simulation Experiments** (3 units)
**Description:** Methods for designing and analyzing experiments that are conducted using computer simulation models, rather than physical experiments. The course covers topics of design strategies for simulation experiments, metamodels, simulation-based optimization, sensitivity analysis, model validation, uncertainty quantification. This course focuses mainly on deterministic computer simulations commonly used in engineering design, analysis and optimization, but stochastic simulations (e.g., for queueing and inventory systems) will also be discussed.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Course typically offered:**
Main Campus: Spring
Online Campus: Spring
Distance Campus: Spring

**Recommendations and additional information:** SIE 530 or equivalent course in Statistics
**Field trip:** N/A

**SIE 540: Survey of Optimization Methods** (3 units)
**Description:** Survey of methods including network flows, integer programming, nonlinear programming, and dynamic programming. Model development and solution algorithms are covered. Graduate-level requirements include additional assigned readings and a project paper.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Co-convened with:** SIE 440
**Course typically offered:**
Main Campus: Spring
Online Campus: Spring
Distance Campus: Spring

**SIE 544: Linear Programming** (3 units)
**Description:** Linear and integer programming formulations, simplex method, geometry of the simplex method, sensitivity and duality, projective transformation methods.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Course typically offered:**
Main Campus: Fall
Online Campus: Fall
Distance Campus: Fall

**Recommendations and additional information:** SIE 340.

**SIE 545: Fundamentals of Optimization** (3 units)
**Description:** Unconstrained and constrained optimization problems from a numerical standpoint. Topics include variable metric methods, optimality conditions, quadratic programming, penalty and barrier function methods, interior point methods, successive quadratic programming methods.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Course typically offered:**
Main Campus: Fall
Online Campus: Fall
Distance Campus: Fall

**Recommendations and additional information:** SIE 340.

**SIE 546: Algorithms, Graphs, and Networks** (3 units)
**Description:** Model formulation and solution of problems on graphs and networks. Topics include heuristics and optimization algorithms on shortest paths, min-cost flow, matching and traveling salesman problems.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Course typically offered:**
Main Campus: Spring
Online Campus: Spring
Distance Campus: Spring

**Recommendations and additional information:** SIE 340. Credit allowed for only one of these courses: SIE 546, MIS 546.

**SIE 550: Theory of Linear Systems** (3 units)
**Description:** An intensive study of continuous and discrete linear systems from the state-space viewpoint, including criteria for observability, controllability, and minimal realizations; and optionally, aspects of optimal control, state feedback, and observer theory.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Course typically offered:**
Main Campus: Spring
Online Campus: Spring
Distance Campus: Spring

**Recommendations and additional information:** SIE 350.

**SIE 552: Space Systems Engineering** (3 units)
**Description:** Fundamentals of space systems engineering; The system engineering process for space missions; Model-based design for spacecrafts and space flight systems; Elements of mission analysis and design; Elements of analysis and design for spacecraft subsystems (structure and mechanisms, thermal control; attitude control and orbit determination; command and data handling; propulsion; communication; power); The course will involve preliminary design of a full space system (spacecraft, lander, rover) to accomplish specific mission goals and objectives (e.g. scientific); The course will include lectures on special topics that are specific to the targeted space system design project developed during the semester. Graduate-level requirements include in-depth analysis of spacecraft subsystems, e.g. design of algorithms for trajectory guidance and attitude control; study of navigation algorithms; Development of detailed thermal and vibration models; design and analysis of science payloads.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Discussion — May Be Offered
Lecture — Required
**Co-convened with:** SIE 452
**Course typically offered:**
Main Campus: Spring
Online Campus: Spring
Distance Campus: Spring

**Recommendations and additional information:** Graduate students in College of Engineering.

**SIE 554A: The Systems Engineering Process** (3 units)
**Description:** Process and tools for systems engineering of large-scale, complex systems: requirements, performance measures, concept exploration, multi-criteria tradeoff studies, life cycle models, system modeling, etc. Graduate-level requirements include extensive sensitivity analysis of their final projects.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture — Required
**Co-convened with:** SIE 454A
**Course typically offered:**
Main Campus: Fall
Online Campus: Fall
Distance Campus: Fall

**SIE 555: Sensor Systems Engineering** (3 units)
**Description:** Provide students with a system level understanding of sensor development. The student will see the development of remote sensing techniques beginning with high level requirements through concept of operations, architecture development, subsystem modeling and culminating in integration, validation and verification. The student will be exposed to key design parameters for radar and Electro Optical sensing systems that drive both system cost and performance. Advanced multi-sensor systems and adaptive signal processing will also be discussed.Graduates working in groups of 2 must accomplish the undergraduate part of the project and additionally create an algorithm in MATLAB that identifies an object as a person (pedestrian or on a bicycle), a car, and a truck. Graduate students will be required to present their Project results.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Co-convened with:** SIE 455
**Course typically offered:**
Main Campus: Spring

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**-CC** represents a Correspondence Course offering
**May Be Offered** Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

**SIE 556: Fundamental of Guidance for Aerospace Systems** (3 units)
**Description:** The main objective of the course is to introduce the students with the fundamental principles behind the development of guidance laws for aerospace systems. More specifically, the course will introduce basic and more advanced guidance concepts for aerospace vehicles and discuss their practical implementation on missiles, planetary landers, reentry and launch vehicles. The first part of the course is focused on the intercept guidance problem and its application to guided missile systems. The basic ideas behind the proportional navigation are introduced together with a detailed analysis of the PN law on both time and frequency domain. The guidance law design is viewed from a control theory standpoint and design methods using both time domain and frequency domain are introduced. Special emphasis is placed on non-linear control design techniques including sliding control mode and Lyapunov-based approach for a robust design and improvement of targeting performance. In the second part of the course, the optimal control theory is introduced as main tool to design guidance algorithms for planetary landers. More specifically, the design of guidance laws for powered descent landing on planetary bodies is discussed. Both numerical and analytical methods to determine targeting reference trajectories are presented together with real-time guidance algorithms that close the loop on the planned path. The third part of the course will be focused on a) guidance algorithms for hypersonic reentry vehicles and b) ascent guidance for Launch Vehicles (LV). In this contest, guidance algorithms available to control the bank angle for low lift-to-drag ratio capsules will be discussed together with powered exoatmospheric guidance algorithms for LV orbit targeting. Particular emphasis will be given to the practical implementation of the guidance algorithms. Graduate-level requirements include answering additional questions during the midterm as well as providing additional analysis and more extensive simulations at the final project stage.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Co-convened with:** SIE 456
**Course typically offered:**
Main Campus: Fall
Online Campus: Fall
Distance Campus: Fall

**-SA** represents a Student Abroad & Student Exchange offering
**-CC** represents a Correspondence Course offering
**May Be Offered** Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

**SIE 557: Project Management** (3 units)
**Description:** Foundations, principles, methods and tools for effective design and management of projects in technology-based organizations. This course focuses on the scope, time, cost, performance and quality concerns of engineering projects characterized by risk and uncertainty. Initiating, planning, executing, monitoring, controlling and closing process are addressed. Students design and complete a project from concept through completion. Project management software is utilized. Graduate-level requirements include completing a more complex project which will include more tasks and will be characterized by greater risk and uncertainty.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Also offered as:** ENTR 557
**Co-convened with:** SIE 457
**Course typically offered:**
Main Campus: Fall
Online Campus: Fall
Distance Campus: Fall

**Recommendations and additional information:** SIE 305.

**SIE 558: Model-Based Systems Engineering** (3 units)
**Description:** An introduction to model-based systems engineering (MBSE), which is the formalized application of modeling to support system requirements, design, analysis, verification and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases. The course emphasizes practical use of the Systems Modeling Language (SysML) and MBSE methods.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Co-convened with:** SIE 458
**Course typically offered:**
Main Campus: Fall
Online Campus: Fall
Distance Campus: Fall

**Recommendations and additional information:** Co-Requisite: SIE-454A/554A The Systems Engineering Process or consent of the instructor.

**SIE 561: Traffic Modeling & Simulation** (3 units)
**Description:** The course will cover various modeling and simulation approaches used in studying traffic dynamics and control in a transportation network. The model-based simulation tools discussed include dynamic macroscopic and microscopic traffic flow simulation and assignment models. Models will be analyzed for their performance in handling traffic dynamics, route choice behavior, and network representation.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Equivalent to:** CE 561
**Also offered as:** CE 561
**Course typically offered:**
Main Campus: Fall
Online Campus: Fall
Distance Campus: Fall

**SIE 562: Production Systems Analysis** (3 units)
**Description:** Production systems, quantitative methods for forecasting, aggregate planning, inventory control, materials requirement planning, production scheduling, manpower planning and facility design. Graduate level requirements include additional case studies/projects.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Co-convened with:** SIE 462
**Course typically offered:**
Main Campus: Spring
Online Campus: Spring
Distance Campus: Spring

**Enrollment requirement:** SIE 305 and SIE 340.

**SIE 563: Integrated Logistics and Distribution Systems** (3 units)
**Description:** Plan and design of efficient logistics and distribution systems. Topics include: supply chain management, integration of production/inventory/location/transportation decisions, shipment scheduling with incomplete and uncertain information, vehicle routing and scheduling, goods distribution networks with multiple transshipment, terminals and warehouses.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Course typically offered:**
Main Campus: Fall
Online Campus: Fall
Distance Campus: Fall

**Recommendations and additional information:** SIE 305 or SIE 321 or SIE 440/540.

**SIE 564: Cost Estimation** (3 units)
**Description:** Focuses on principles of cost estimation and measurement systems with specific emphasis on parametric models. Approaches from the fields of hardware, software and systems engineering are applied to a variety of contexts (risk assessment, judgment & decision making, performance measurement, process improvement, adoption of new tools in organizations, etc.). Material is divided into five major sections: cost estimation fundamentals, parametric model development and calibration, advanced engineering economic principles, measurement systems, and policy issues. The graduate-level requirements include a final paper.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Co-convened with:** SIE 464
**Course typically offered:**
Main Campus: Spring
Online Campus: Spring
Distance Campus: Spring

**SIE 565: Supply Chain Management** (3 units)
**Description:** Fundamentals of Supply Chain Management including inventory/logistics planning and management, warehouse operations, procurement, sourcing, contracts and collaboration. Graduate-level requirements include an additional semester research paper.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Co-convened with:** SIE 465
**Course typically offered:**
Main Campus: Spring
Online Campus: Spring
Distance Campus: Spring

**Enrollment requirement:** Enrollment not allowed if you have previously taken MIS 477 or MIS 577 "Supply Chain & Logistics".

**SIE 566: Life Cycle Analysis for Sustainable Design and Engineering** (3 units)
**Description:** This course will provide senior undergraduate and graduate students the conceptual, methodological, and scientific bases to quantify and reduce the impact of engineering decisions on the environment, with a focus on applying life cycle analysis (LCA) to support the material choice, product/process design, and manufacturing/engineering decisions. Main topics covered include concept of life cycle thinking, computational structure of LCA, process and economic input-output based LCA, LCA software demonstration, LCA case studies, environmental product declaration, and recent development and advanced topics in LCA.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Co-convened with:**
**Course typically offered:**
Main Campus: Fall, Summer
Online Campus: Fall, Summer
Distance Campus: Fall, Summer

**Field trip:** None.

**SIE 567: Financial Modeling for Innovation** (3 units)
**Description:** Financial modeling and simulation of new technology ventures. Topics include Pro Forma financial statements construction, time value of money, accounting, valuation, and technology ownership issues. Entrepreneurship issues related to forming a company will be discussed. This course is intended for graduate students in science or engineering with little or no prior background in engineering economics.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Equivalent to:** ENGR 567
**Course typically offered:**
Main Campus: Fall
Online Campus: Fall
Distance Campus: Fall

**SIE 570: Intelligent Control Systems and Applications** (3 units)
**Description:** Architectures and algorithms of intelligent control systems. Concepts, methods and tools for task organization, task coordinations, and task executions. Attention will be given to computer simulations and real-world applications.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Course typically offered:**
Main Campus: Fall
Online Campus: Fall
Distance Campus: Fall

**Recommendations and additional information:** SIE 350.

**-SA** represents a Student Abroad & Student Exchange offering
**-CC** represents a Correspondence Course offering
**May Be Offered** Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

**SIE 571: Systems Cyber Security Engineering** (3 units)
**Description:** The purpose of this course is to introduce selected topics, issues, problems, and techniques in the area of System Cyber Security Engineering (SCSE), early in the development of a large system. Students will explore various techniques for eliminating security vulnerabilities, defining security specifications / plans, and incorporating countermeasures in order to achieve overall system assurance. SCSE is an element of system engineering that applies scientific and engineering principles to identify, evaluate, and contain or eliminate system vulnerabilities to known or postulated security threats in the operational environment. SCSE manages and balances system security risk across all protection domains spanning the entire system engineering life-cycle. The fundamental elements of cyber security will be explored including: human cyber engineering techniques, penetration testing, mobile and wireless vulnerabilities, network mapping and security tools, embedded system security, reverse engineering, software assurance and secure coding, cryptography, vulnerability analysis, and cyber forensics. After a fundamental understanding of the various cyber threats and technologies are understood, the course will expand upon the basic principles, and demonstrate how to develop a threat / vulnerability assessment on a representative system using threat modeling techniques (i.e. modeling threats for a financial banking system, autonomous automobile, or a power distribution system). With a cyber resilience focus, students will learn how to identify critical use cases or critical mission threads for the system under investigation, and how to decompose and map those elements to various architectural elements of the system for further analysis. Supply chain risk management (SCRM) will be employed to enumerate potential cyber threats that could be introduced to the system either unintentionally or maliciously throughout the supply chain. The course culminates with the conduct of a realistic Red Team / Blue Team simulation to demonstrate and explore both the attack and defend perspectives of a cyber threat. The Red Team will perform a vulnerability assessment of the prospective system, with the intention of attacking its vulnerabilities. The Blue Team will perform a vulnerability of the same system with the intention of defending it against cyber threats. A comparison will be made between the outcomes of both teams in order to better understand the overarching solutions to addressing the threats identified.Upon completion of the course, students will be proficient with various elements of cyber security and how to identify system vulnerabilities early on in the system engineering lifecycle. They will be exposed to various tools and processes to identify and protect a system against those vulnerabilities, and how to develop program protection plans to defend against and prevent malicious attacks on large complex systems.Graduate students will be given an additional assignment to write a draft Program Protection Plan (PPP) for the system that the class performed the threat analysis for. Program protection planning employs a step-by-step analytical process to identify the critical technologies to be protected; analyze the threats; determine program vulnerabilities; assess the risks; and apply countermeasures. A PPP describes the analysis, decisions and plan to mitigate risks to any advanced technology and mission-critical system functionality.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Co-convened with:** SIE 471
**Course typically offered:**
Main Campus: Fall
Online Campus: Fall
Distance Campus: Fall

**-SA** represents a Student Abroad & Student Exchange offering
**-CC** represents a Correspondence Course offering
**May Be Offered** Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

**SIE 572: Information Security and Research (INSuRE)** (3 units)
**Description:** This course engages students in diverse and varied national cybersecurity/information systems security problems, under an existing and very successful umbrella program called 'INSuRE', that enables a collaboration across several universities, Cyber professionals and cross-disciplined Cyber related technologies. Led by Purdue University, and made possible by a grant from the NSA and NSF, INSuRE has fielded a multi-institutional cybersecurity research course in which small groups of undergraduate and graduate students work to solve unclassified problems proposed by NSA, other US government agencies, and/or private organizations and laboratories. Students will learn how to apply research techniques, think clearly about these issues, formulate and analyze potential solutions, and communicate their results with sponsors and other participating universities. Working in small groups under the mentorship of technical experts from government and industry, each student will formulate, carry out, and present original research on current cybersecurity / information assurance problems of interest to the nation. This course will be run in a synchronized distance fashion, coordinating activities with other INSuRE technical clients and sponsors, along with partnering universities which are all National Centers of Academic Excellence in Cyber Defense Research (CAE-R) (i.e. Purdue University, Carnegie Mellon University, University of California Davis and several others).
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Co-convened with:** SIE 472
**Course typically offered:**
Main Campus: Spring
Online Campus: Spring
Distance Campus: Spring

**Recommendations and additional information:** Background in computer science, computer engineering, information technology, or related technical field. One of the following is strongly recommended: SIE 471/571, ECE 478/578, ECE 509, or MIS 416/516

**-SA** represents a Student Abroad & Student Exchange offering
**-CC** represents a Correspondence Course offering
**May Be Offered** Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

**SIE 574: Information Analytics and Decision-Making in Engineering** (3 units)
**Description:** Recent advances in computational and information technology allow the collection and evaluation of vast volumes of data. This explosion in information has amplified the need to understand the value of information and how to use available information to make better decisions that in turn affect the environment. For example, consider the following questions:* How should a firm optimally experiment among different website designs before deciding on a single one, with the goal to maximize user traffic or revenue?* How should a company choose its bid for mining rights if it has access to exclusive probing data, in order to maximize its profit?* How should a buyer interpret online feedback and ratings before deciding on which product to buy? * How should a doctor decide which medical tests to perform on a patient to deliver the most effective care?The course will cover information valuation, decision-making, and information economics in non-strategic and strategic settings.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Co-convened with:** SIE 474
**Course typically offered:**
Main Campus: Fall
Online Campus: Fall
Distance Campus: Fall

**Recommendations and additional information:** Students should be comfortable with basic distributions, conditional probabilities, and coding small programs for activities.

**SIE 575: Bayesian Machine Learning and Optimal Learning I** (3 units)
**Description:** We consider optimization problems whose objective functions are unknown and hence have to be learned from data. Such problems are pervasive in science and industry, e.g., when- designing prototypes in engineering,- automated tuning of machine learning algorithms, e.g., in deep learning,- optimizing control policies in robotics,- developing pharmaceutical drugs, and many more.Bayesian optimization methods are popular in the machine learning community due to their high sample-efficiency and have become a key technique in the area of "automatic machine learning". We introduce a general framework in which to understand and formulate such optimal learning problems, and provide a survey of problems, methods, and theoretical results.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Course typically offered:**
Main Campus: Fall
Online Campus: Fall
Distance Campus: Fall

**SIE 577: Introduction to Biomedical Informatics** (3 units)
**Description:** Driven by efforts to improve human health and healthcare systems, this course will cover relevant topics at the intersection of people, information, and technology. Specifically, we will survey the field of biomedical informatics that studies the effective uses of biomedical data, information, and knowledge from molecules and cellular processes to individuals and populations, for scientific inquiry, problem solving, and decision making. We will explore foundations and methods from both biomedical and computing perspectives, including hands-on experiences with systems, tools, and technologies in the healthcare system. Graduate students will be required to submit an additional assignment or project.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Also offered as:** BME 577
**Course typically offered:**
Main Campus: Fall

**Home department:** Biomedical Engineering

**SIE 578: Artificial Intelligence for Health and Medicine** (3 units)
**Description:** The practice of modern medicine in a highly regulated, complex, sociotechnical enterprise is a testament to the future healthcare system where the balance between human intelligence and artificial expertise will be at stake. The goal of this course is to introduce the underlying concepts, methods, and the potential of intelligent systems in medicine. We will explore foundational methods in artificial intelligence (AI) with greater emphasis on machine learning and knowledge representation and reasoning, and apply them to specific areas in medicine and healthcare including, but not limited to, clinical risk stratification, phenotype and biomarker discovery, time series analysis of physiological data, disease progression modeling, and patient outcome prediction. As a research and project-based course, student(s) will have opportunities to identify and specialize in particular AI methods, clinical/healthcare applications, and relevant tools.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Also offered as:** BME 578
**Course typically offered:**
Main Campus: Spring

**Recommendations and additional information:** Course suitable for Majors: APPL, BME, ECE, MEE, CSC, SIE, STAT, IS, MIS., or obtain instructor consent. Basic foundation in linear algebra, discrete mathematics, probability & statistics, and data structures recommended for this course.
**Home department:** Biomedical Engineering

**SIE 583: Computer-Integrated Manufacturing (CIM) Systems** (3 units)
**Description:** Modern manufacturing systems with emphasis on information requirements and data management. Includes CAD, CAM, CAPP, real-time scheduling, networking, and system justification. Graduate-level requirements include selection of their own topics (not have them assigned by the instructor), and the topics must be on a more advanced level.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Co-convened with:** SIE 483
**Course typically offered:**
Main Campus: Fall

**SIE 593: Internship** (1 - 3 units)
**Description:** Specialized work on an individual basis, consisting of training and practice in actual service in a technical, business, or governmental establishment.
**Grading basis:** Alternative Grading: S, P, F
**Career:** Graduate
**Course Components:** Independent Study Required

**SIE 596: Special Topics in Systems and Industrial Engineering** (3 units)
**Description:** This course is designed to provide a flexible topics course across several domains in the field of Systems Engineering, Industrial Engineering, and Engineering Management. Students will develop and exchange scholarly information in a small group setting. Selected advanced topics in Systems and Industrial Engineering and Operations Research, such as 1) optimization, 2) stochastic systems, 3) systems engineering and design, 4) human cognition systems, and 5) informatics.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Seminar Required
**Repeatable:** Course can be repeated a maximum of 3 times.
**Course typically offered:**
Main Campus: Fall, Spring, Summer

**SIE 599: Independent Study** (1 - 5 units)
**Description:** Qualified students working on an individual basis with professors who have agreed to supervise such work. Graduate students doing independent work which cannot be classified as actual research will register for credit under course number 599, 699, or 799.
**Grading basis:** Alternative Grading: S, P, F
**Career:** Graduate
**Course Components:** Independent Study Required
**Repeatable:** Course can be repeated a maximum of 99 times.
**Course typically offered:**
Main Campus: Fall, Spring, Summer
Online Campus: Fall, Spring, Summer
Distance Campus: Fall, Spring, Summer

**SIE 606: Advanced Quality Engineering** (3 units)
**Description:** Advanced techniques for statistical quality assurance, including multivariate statistical inference, multiple regression, multivariate control charting, principal components analysis, factor analysis, multivariate statistical analysis for process fault diagnosis, and select papers from the recent literature.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Course typically offered:**
Main Campus: Spring
Online Campus: Spring
Distance Campus: Spring

**Recommendations and additional information:** SIE 530, SIE 506.

**SIE 608: Advanced Reliability Engineering** (3 units)
**Description:** This is a three-credit course for well-qualified graduate students who have taken graduate-level statistics courses. The course provides a comprehensive introduction to the statistical principles and methods for reliability data analysis. This course will cover parametric, nonparametric, and semiparametric methods for modeling degradation data and failure time data with different types of censoring.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Course typically offered:**
Main Campus: Fall
Online Campus: Fall
Distance Campus: Fall

**SIE 611: Human Cognition and Behavior Modeling** (3 units)
**Description:** This course is aim at introducing a new set of computational methods in human cognition and behavior modeling, including basic and advanced mathematical models, queuing network, and discrete event simulation. Students will also get familiar the assumption of major human performance models and major steps in performing human cognitive and behavior modeling with queuing theory. Compared to experimental methods as the traditional approach to study human cognitive system, this new modeling course offers a fresh way of thinking in multidisciplinary research and allows students to build engineering models of human cognitive systems. These models are able to predict human behavior and cognition, including reaction time, error rate, mental workload, brain waves (Event-Related Potential), with knowledge in operations research (OR) (e.g., queueing theory) and system simulation (discrete-event simulation). This course systematically introduces a new and exciting multidisciplinary area in human factors, operations research, system simulation, computer science, psychology, and neuroscience.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Course typically offered:**
Main Campus: Fall
Online Campus: Fall
Distance Campus: Fall

**Recommendations and additional information:** SIE 512. Highly suggested. Not enforced.
**Field trip:** N/A

**SIE 631: Distributed Multi-Paradigm Simulation Systems** (3 units)
**Description:** Emphasis on current research problems including simulation based control, distributed federation of simulations, and multi-paradigm (system dynamics, discrete event based, agent-based) simulations.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Course typically offered:**
Main Campus: Spring

**Recommendations and additional information:** SIE 431 or MIS 521.

**SIE 640: Large-Scale Optimization** (3 units)
**Description:** Decomposition-coordination algorithms for large-scale mathematical programming. Methods include generalized Benders decomposition, resource and price directive methods, subgradient optimization, and descent methods of nondifferentiable optimization. Application of these methods to stochastic programming will be emphasized.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Course typically offered:**
Main Campus: Fall
Online Campus: Fall
Distance Campus: Fall

**Recommendations and additional information:** SIE 544 or SIE 545.

**SIE 644: Integer and Combinatorial Optimization** (3 units)
**Description:** Modeling and solving problems where the decisions form a discrete set. Topics include model development, branch and bound methods, cutting plane methods, relaxations, computational complexity, and solving well-structured problems.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Course typically offered:**
Main Campus: Spring
Online Campus: Spring
Distance Campus: Spring

**Recommendations and additional information:** SIE 544.

**SIE 645: Nonlinear Optimization** (3 units)
**Description:** This course is devoted to structure and properties of practical algorithms for unconstrained and constrained nonlinear optimization.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Course typically offered:**
Main Campus: Spring
Online Campus: Spring
Distance Campus: Spring

**Recommendations and additional information:** SIE 544 or SIE 545.

**SIE 649: Topics of Optimization** (3 units)
**Description:** Convexity, optimality conditions, duality, and topics related to the instructor's research interests; e.g., stochastic programming, nonsmooth optimization, interior point methods.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Course typically offered:**
Main Campus: Fall
Online Campus: Fall
Distance Campus: Fall

**Recommendations and additional information:** SIE 544 or SIE 545.

**SIE 654: Advanced Concepts in Systems Engineering** (3 units)
**Description:** Modeling and design of complex systems using the Unified Modeling Language (UML), the Systems Modeling Language (SysML) and Wymorian System Theory. Applications come from systems, hardware and algorithm design. Course will emphasize architecture, requirements, testing, risk analysis and use of various systems design tools.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Course typically offered:**
Main Campus: Spring
Online Campus: Spring
Distance Campus: Spring

**Recommendations and additional information:** SIE 554A.

**SIE 658: Advanced Model-Based Systems Engineering** (3 units)
**Description:** Advanced topics in model-based systems engineering (MBSE), which is the formalized application of modeling to support system requirements, design, analysis, verification and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases. The course examines and compares extent approaches to the generation and use of such models and current research in this subfield of systems engineering.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Course typically offered:**
Main Campus: Spring

**Recommendations and additional information:** SIE-458/558 OR SIE 454A/554A - The Systems Engineering Process OR Instructor's Consent.

**SIE 678: Transportation Systems** (3 units)
**Description:** Special topics in the analysis and design of transportation systems, including advanced traffic management, network routing, dynamic traffic estimation and assignment, network design, intermodal distribution and transportation, and intelligent transportation systems.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Lecture Required
**Course typically offered:**
Main Campus: Spring
Online Campus: Spring
Distance Campus: Spring

**Recommendations and additional information:** SIE 305, SIE 321; SIE 540 or SIE 544; some knowledge of network modeling.

**SIE 695A: Doctoral** (1 - 3 units)
**Grading basis:** Alternative Grading: S, P, F
**Career:** Graduate
**Course Components:** Colloquium Required
**Repeatable:** Course can be repeated for a maximum of 12 units.
**Equivalent to:** EXSS 695A, NEUR 695A, NEUR 695A, NRSC 695A, NRSC 695A, PSIO 695A, PSY 695A, PSY 695A, SLHS 695A, SPH 695A
**Course typically offered:**
Main Campus: Fall, Spring

**Recommendations and additional information:** consult department before enrolling.

**SIE 696: Special Topics in Advanced Systems & Industrial Engineering** (3 units)
**Description:** This course is designed to provide a flexible advanced topics course across several domains in the field of Systems Engineering, Industrial Engineering, and Engineering Management. Students will develop and exchange scholarly information in a small group setting. Selected advanced topics in Systems and Industrial Engineering and Operations Research, such as 1) optimization, 2) stochastic systems, 3) systems engineering and design, 4) human cognition systems, and 5) informatics.
**Grading basis:** Regular Grades
**Career:** Graduate
**Course Components:** Seminar Required
**Repeatable:** Course can be repeated a maximum of 3 times.
**Course typically offered:**
Main Campus: Fall, Spring, Summer

**Recommendations and additional information:** 1) Backgrounds in high-level programming language, probability and statistics, linear algebra, and math analysis, or 2) consent of instructor

**SIE 699: Independent Study** (1 - 6 units)
**Description:** Qualified students working on an individual basis with professors who have agreed to supervise such work. Graduate students doing independent work which cannot be classified as actual research will register for credit under course number 599, 699, or 799.
**Grading basis:** Alternative Grading: S, P, F
**Career:** Graduate
**Course Components:** Independent Study Required
**Course typically offered:**
Main Campus: Fall, Spring, Summer
Online Campus: Fall, Spring, Summer
Distance Campus: Fall, Spring, Summer

**SIE 900: Research** (1 - 6 units)
**Description:** Individual research, not related to thesis or dissertation preparation, by graduate students.
**Grading basis:** Alternative Grading: S, P, F
**Career:** Graduate
**Course Components:** Independent Study Required
**Repeatable:** Course can be repeated a maximum of 99 times.
**Course typically offered:**
Main Campus: Fall, Spring, Summer

**SIE 909: Master's Report** (1 - 12 units)
**Description:** Individual study or special project or formal report thereof submitted in lieu of thesis for certain master's degrees.
**Grading basis:** Alternative Grading: S, P, F
**Career:** Graduate
**Course Components:** Independent Study Required
**Repeatable:** Course can be repeated a maximum of 99 times.
**Course typically offered:**
Main Campus: Fall, Spring, Summer
Online Campus: Fall, Spring, Summer
Distance Campus: Fall, Spring, Summer

**SIE 910: Thesis** (1 - 12 units)
**Description:** Research for the master's thesis (whether library research, laboratory or field observation or research, artistic creation, or thesis writing). Maximum total credit permitted varies with the major department.
**Grading basis:** Alternative Grading: S, P, F
**Career:** Graduate
**Course Components:** Independent Study Required
**Repeatable:** Course can be repeated a maximum of 99 times.
**Course typically offered:**
Main Campus: Fall, Spring, Summer
Online Campus: Fall, Spring, Summer
Distance Campus: Fall, Spring, Summer

**SIE 920: Dissertation** (1 - 12 units)
**Description:** Research for the doctoral dissertation (whether library research, laboratory or field observation or research, artistic creation, or dissertation writing).
**Grading basis:** Alternative Grading: S, P, F
**Career:** Graduate
**Course Components:** Independent Study Required
**Repeatable:** Course can be repeated a maximum of 99 times.
**Course typically offered:**
Main Campus: Fall, Spring, Summer
Online Campus: Fall, Spring, Summer
Distance Campus: Fall, Spring, Summer