Master of Engineering (M.Eng)
Aerospace Systems Engineering concentration (32 hours)

Aerospace Core Coursework (8 hours)

AE 542, Aerospace Systems Engineering I
Credit: 4 hours.

Aerospace systems engineering principles, processes and practices for the definition of spacecraft, aircraft, launch and associated systems, and the application of the systems approach across the development life cycle.

Prerequisite: Any of AE 442, AE 443, ME 470, ECE 445, ECE 411; CS 492, CS 493, or CEE 465.

AE 543, Aerospace Systems Engineering II
Credit: 4 hours.

Fundamental aerospace industry methods for control of an engineering development effort of a complex aerospace system typical in development of spacecraft, launch vehicles, aircraft, remotely controlled vehicles, and associated supporting infrastructure system in current acquisition environments. Standards and techniques to control risk, integration of technologies, and exploration of "design-to" process tailoring and systematically make design decisions.

Prerequisite: AE 542.

• Select two additional courses from approved list (below)

Approved List for Additional Aerospace Core Coursework (8 hrs)

AE 402, Orbital Mechanics
Credit: 3 OR 4 hours.

Analysis of orbits in an inverse-square gravitational field; elementary rocket dynamics, impulsive orbit transfer and rendezvous, and Lambert's Theorem with applications; patched-conic trajectories, planetary gravity-assist maneuvers, and linearized orbit theory with application to simplified analytical models; perturbations.

3 undergraduate hours. 3 or 4 graduate hours.
Prerequisite: AE 202.

AE 403, Spacecraft Attitude Control
Credit: 3 OR 4 hours.

Theory and applications of spacecraft attitude dynamics and control; Euler angles, direction cosines, quaternions, and Gibbs-Rodrigues parameters; attitude sensors and control actuators; spin, three-axis active, reaction wheel, control moment gyro, and gravity gradient control systems; environmental effects.

3 undergraduate hours. 3 or 4 graduate hours.
Prerequisite: AE 352 and AE 353.

AE 416, Applied Aerodynamics
Credit: 3 OR 4 hours.

Two-dimensional and finite wing theory with emphasis on the mechanisms of lift and drag generation; Reynolds number and Mach number effects; drag analysis; high-lift wing systems; propeller and rotor aerodynamics; control surface design; application of V/STOL aerodynamics.
3 undergraduate hours. 3 or 4 graduate hours.
Prerequisite: AE 311.

AE 419, Aircraft Flight Mechanics
Credit: 3 OR 4 hours.

Steady and quasi-steady aircraft flight performance; take-off and landing, climbing and diving, cruise, level turn, and energy methods; longitudinal, directional, and lateral static stability and control; longitudinal and lateral motion and dynamic stability.

3 undergraduate hours. 3 or 4 graduate hours.
Prerequisite: AE 202 and AE 353.

AE 434, Rocket Propulsion
Credit: 3 OR 4 hours.

Basic principles of chemical rocket propulsion and performance, rocket component design, liquid rockets, solid rocket motors, combustion processes, combustion instability.

3 undergraduate hours. 3 or 4 graduate hours.
Prerequisite: AE 312 and AE 433.

AE 502, Advanced Orbital Mechanics (Last offered Spring 2018)
Credit: 4 hours.

Circular-restricted three-body problem; surfaces of zero velocity, libration points, and halo orbits; perturbed two-body motion; Gauss and Lagrange planetary equations, Hamilton's principle, canonical equations and Delaunay variables; application to artificial Earth satellites; orbit determination.

Prerequisite: AE 402.

AE 504, Optimal Aerospace Systems

Credit: 4 hours.

Formulation of parameter and functional optimization problems for dynamic systems; applications of optimization principles to the control and performance of aerospace vehicles, including optimal flight paths, trajectories, and feedback control.

Prerequisite: AE 352.

AE 508, Optimal Space Trajectories

Credit: 4 hours.

Optimal rocket trajectories in inverse-square and linearized gravitational fields; orbital transfer, intercept, and rendezvous; high-thrust (impulsive) and low-thrust (continuous) trajectories; primer vector theory and applications; cooperative rendezvous.

Prerequisite: Credit or concurrent registration in AE 504.

AE 511, Transonic Aerodynamics (Last offered Fall 2010)

Credit: 4 hours.

Fundamentals of transonic flows; transonic characteristics and flow modeling, shock wave development, properties of shock wave, transonic similarity, shock-boundary layer interactions, three-dimensional effects, transonic solution techniques, transonic design, and transonic testing. Prerequisite: ME 410.

AE 512, Molecular Gas Dynamics

Credit: 4 hours.

The course focuses on the molecular description of physical and chemical processes in gases. The molecular viewpoint is essential to promote the understanding of physical processes occurring at very high temperatures and low pressures. These conditions are typically encountered in high speed and non-equilibrium gas flows. After a brief review of the fundamental concepts of statistical mechanics and chemical thermodynamics, the course focuses on the fundamentals of kinetic theory of gases, equilibrium chemistry, non-equilibrium kinetics and non-thermal radiation.

4 graduate hours. No professional credit. Prerequisite: AE 311, AE 312, ME 300.

AE 515, Wing Theory

Credit: 4 hours.

Theoretical analysis of the aerodynamic characteristics of two- and three-dimensional wings and multiple-body systems in subsonic and supersonic flows.

Prerequisite: AE 416.

• Or other appropriate course selected with approval of advisor

Recommended Systems Engineering Electives (8 hrs)

AE 504 - Optimal Aerospace Systems
Credit: 4 hours.

Formulation of parameter and functional optimization problems for dynamic systems; applications of optimization principles to the control and performance of aerospace vehicles, including optimal flight paths, trajectories, and feedback control.

Prerequisite: AE 352.

AE 554 - Dynamical Systems Theory
Credit: 4 hours.

This course is structured to introduce the graduate students into advanced concepts of the geometric theory of nonlinear dynamics. Topics to be discussed include vector fields and maps, conjugacies, structural stability and Peixoto?s theorem, dynamical systems on two-manifolds; center manifold theory and normal forms for vector fields and maps; local bifurcations of vector fields and maps, co-dimension 1 and 2 bifurcations; global bifurcations, the Smale horseshoe map and invariant Cantor sets, the shift map and symbolic dynamics, chaos in the horseshoe, Conley ? Moser conditions for chaos, hyperbolic invariant sets, Moser?s theorem and Smale-Birkhoff homoclinic theorem, homoclinic bifurcations and Newhouse sinks; homoclinic and subharmonic Melnikov theories, conditions for homoclinic chaos, chaos in perturbed Hamiltonian systems; applications to mechanics. This course will demonstrate how these advanced concepts can be applied to the study of response, stability and bifurcation behavior of engineering systems.

Same as TAM 516. 4 graduate hours. No professional credit. Prerequisite: TAM 416 and either ME 340, TAM 412 or AE 352.

AE 555 - Multivariable Control Design (Last offered Spring 2016)
Credit: 4 hours.

Frequency-response design specifications; algebraic and analytic constraints in scalar systems; uncertainty representation; Nyquist stability theory, small gain condition, and multi-input multi-output systems; singular value decomposition; robustness and u-function; linear quadratic regulator based design; recovery of LQ Design properties; Kalman filter; Riccati equations; H-infinity based design; reduction; balanced truncation; Hankel singular values; coprime factor reduction; loop shaping. Same as GE 521. Prerequisite: ECE 515.

IE 400 – Design and Analysis of Experiments
Credit: 3 OR 4 hours.

Concepts and methods of design of experiments for quality design, improvement and control. Simple comparative experiments, including concepts of randomization and blocking, and analysis of variance techniques; factorial and fractional factorial designs; Taguchi's concepts and methods; second-order designs; response surface methodology. Engineering applications and case studies.

3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: IE 300.

IE 411 - Optimization of Large Systems
Credit: 3 OR 4 hours.

Practical methods of optimization of large-scale linear systems including extreme point algorithms, duality theory, parametric linear programming, generalized upper bounding technique, price-directive and resource-directive decomposition techniques, Lagrangian duality, Karmarkar's algorithm, applications in engineering systems, and use of state-of-the-art computer codes.

3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: IE 310 and MATH 415.

IE 413 – Simulation
Credit: 3 or 4 hours.

Use of discrete-event simulation in modeling and analysis of complex systems. Data structures and event-list management; verification and validation of simulation models; input modeling, including selection of probability distributions and random variate generation; statistical analysis of output data.

Same as CS 482. 3 undergraduate hours. 4 graduate hours. Prerequisite: CS 101 and IE 310.

IE 431 – Quality Engineering
Credit: 3 hours.

Quality Engineering principles and the Six Sigma Define-Measure-Analyze-Improve-Control (DMAIC) process. Application of concepts and methods of statistical process control, designed experiments, and measurement systems analysis to cases of quality and productivity improvement; application of the fundamentals of quality engineering and the Six Sigma to areas of produce development, service enterprise, and manufacturing processes.

3 undergraduate hours. 3 graduate hours. Prerequisite: IE 300.

IE 513 - Optimal System Design

Credit: 4 hours.

This course is designed to address the fundamental mathematical theories for complex engineering system (product) design optimization in multidisciplinary environment. The course starts with the basics of nonlinear programming (continuous optimization), then expands to the area of multidisciplinary design optimization (MDO) in depth. Analytical Target Cascading (ATC) - a well-established hierarchical optimization method - is covered in-depth with assignments in written and programming forms. After a successful completion of the course, the students will be able to model and solve basic MDO problems and apply MDO in a research-based semester project. Prior experience in coding (in Matlab or similar) will be helpful but not required.

4 graduate hours. No professional credit. Prerequisite: IE 310.

IE 529 – Stats of Big Data and Clustering

Credit: 4 hours.

This course will cover various foundational topics in data science. Parametric and non-parametric methods. Hypothesis testing; Regression; Classification; Dimension reduction; and Regularization. Unsupervised and semi-supervised learning, along with a few case studies.

4 graduate hours. No professional credit. Prerequisite: MATH 415 and IE 300 or equivalent. All ISE graduate students and students enrolled in the Master of Science in Advanced Analytics (MSAA) are eligible to take the course.

IE 531 - Algorithms for Data Analytics

Credit: 4 hours.

This course will introduce the student to a set of algorithms for data analytics which include: hashing, indexes, caching; algorithms for structured datasets; streaming data modes; PageRank algorithms for market-basket models; clustering algorithms; and case studies.

4 graduate hours. No professional credit. Prerequisite: IE 411, CS 225. ISE graduate students and students enrolled in the Master of Science in Advanced Analytics (MCAA) are eligible to take the course.

ME 402 - Design of Thermal Systems

Credit: 3 OR 4 hours.

Selection of components in fluid- and energy-processing systems to meet system-performance requirements; computer-aided design; system simulation; optimization techniques; investment economics and statistical combinations of operating conditions.

3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: Credit or concurrent registration in ME 320.

ME 540 – Control System Theory and Design

Credit: 4 hours.

Feedback control systems emphasizing state space techniques. Basic principles, modeling, analysis, stability, structural properties, optimization, and design to meet specifications.

Same as ME 540. Prerequisite: ECE 486.

SE 411 - Reliability Engineering

Credit: 3 OR 4 hours.

Concepts in engineering design, testing, and management for highly reliable components and systems.
3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: IE 300.

SE 450 – Decision Analysis I

Credit: 3 OR 4 hours.

Rules of thought that transform complex decision situations into simpler ones where the course of action is clear. Practical application of decision analysis in large organizations; methods to generate insights into real-life decision problems, avoid the common pitfalls in decision processes, and overcome the possible barriers to implementing a high-quality decision-making process for individual and organizational decision making; graphical representations of decision problems such as decision diagrams and utility diagrams.

3 or 4 undergraduate hours. 3 or 4 graduate hours. Prerequisite: IE 300.

SE 498 DA2 – Decision Analysis II

Credit: 1 to 4 hours.

Subject offerings of new and developing areas of knowledge in general engineering intended to augment the existing curriculum. See Class Schedule or departmental course information for topics and prerequisites.

1 to 4 undergraduate hours. 1 to 4 graduate hours.

SE 524 – Data-Based Systems Modeling

Credit: 4 hours.

Identification and building of mathematical and computational models directly from data. Systems and model types, such as state-space and distributed-parameter; parametric estimation methods, such as regression and least-squares recent subspace identification methods; data preprocessing techniques; model validation methods. Assignment applications to a wide range of dynamical systems, including biological, electro-mechanical, and economic.

4 graduate hours. No professional credit. Prerequisite: SE 424 and IE 300.

SE 525 – Control of Complex Systems

Credit: 4 hours.

Control methodologies for complex (i.e., interconnected) dynamic systems. A unified framework based on the vector Liapunov functions concept is used to examine various methodologies: decentralized overlapping control; optimal control of interconnected systems; multi-player differential game theory; decentralized optimization and its link with the multi-criteria optimization. Illustrative examples in areas such as control of groups of unmanned vehicles, control of power systems, and coverage control.

4 graduate hours. No professional credit. Prerequisite: SE 424.

SE 530 – Multi attribute Decision making

Credit: 4 hours.

Tools for subjective multiple attribute decision making when present or future states of nature are uncertain. Exploration of current research in developing computer aids to decision making. Issues in descriptive versus normative approaches in the context of the interface between operations research and artificial intelligence. Multiattribute utility analysis from theoretical foundations through assessment procedures, practice, and pitfalls of potential cognitive bases.

4 graduate hours. No professional credit.
Prerequisite: CEE 202 or IE 3

Approved Lists of Professional Development Coursework (8 hrs)

Students must complete 4 credit hours from List A and 4 credit hours from List B.

List A

AE 597, Independent Study

Credit: 1 TO 4 hours.

Independent theoretical and experimental projects in aerospace engineering.

May be repeated. Prerequisite: Consent of instructor.

TE 401, Developing Breakthrough Projects

Credit: 1 TO 4 hours.

Project-based exploration with teams of students working together in a large innovation and entrepreneurial context. Encourage development of innovative, leadership, and entrepreneurial skill sets, including financing, marketing, sales, operations, business plans, and management.

1 to 4 undergraduate hours. 1 to 4 graduate hours. May be repeated.

ENG 572, Professional Practicum

Credit: 1 TO 8 hours.

Internship or equivalent experience as it relates to the student's field of study. Student will complete a comprehensive written report, develop a website, and/or give an oral presentation that relates to his/her internship experience.

1 to 8 graduate hours. No professional credit. May be repeated in separate terms to a maximum of 8 hours.

ENG 573, Capstone Project

Credit: 1 TO 8 hours.

Design project pertinent to student's field of study. Student will complete a comprehensive written report, develop a website, and/or give an oral presentation that relates to his/her project.

1 to 8 graduate hours. No professional credit. May be repeated in separate terms to a maximum of 8 hours.

List B

TE 450, Startup: Inc, Fund, Contracts, IP
Credit: 3 hours.

Explore legal tools used in constructing and operating companies. Topics include: issues with business formation, intellectual property, NDA, contracts, and other corporate legal issues impacting startups.

3 undergraduate hours. 3 graduate hours.

TE 460, Lecture in Engineering Entrepreneurship
Credit: 1 hours.

Fundamental concepts of entrepreneurship and commercialization of new technology in new and existing engineering and high-tech businesses. Guest speaker topics vary, but typically include: evaluation of technologies and business ideas in general; commercializing new technologies; financing through private and public sources; legal issues; product development; marketing; international business issues.

1 undergraduate hour. 1 graduate hour. May be repeated in separate terms to a maximum of 2 hours, if topics vary; instructor approval required. Credit is not given for both TE 360 and TE 460.

TE 461, Technology Entrepreneurship
Credit: 3 hours.

Product design, marketing, financials, and the general business planning preparation required for start-up companies. Many start-up companies have emerged from this course. Students can work in teams (members can be from outside of class) or individually. Students without a particular idea may be provided an option to participate in PIRL (Product Innovation Research Lab) with the School of Art & Design, but spots are limited.

3 undergraduate hours. 3 graduate hours.

TE 466, High-Tech Venture Marketing
Credit: 2 hours.

Cornerstone marketing concepts for innovators and engineers to enable analysis of products and technologies from a marketing perspective: engineering product development and adoption life cycle; objectives and strategies; marketing management; communication skills; sales process and tactics; special considerations for new high-tech engineering products and innovations.

2 undergraduate hours. 2 graduate hours. Credit is not given for both ENG 466 and BADM 365.

TE 560, Managing Advanced Technology I (Last offered Fall 2015)
Credit: 1 hours.

Business perspective of managing advanced technology in industry: strategic context of advanced technology; analytical financial tools used to estimate its potential value; legal concepts important in its management; interpersonal issues related to leading and advocating on behalf of advanced technology groups.

Same as TE 560. (ENG 560)

TE 565, Technology Innovation & Strategy
Credit: 2 hours.

Concepts and frameworks for analyzing how firms can create, commercialize and capture value from technology-based products and services. Business, commercialization, and management aspects of technology. Emphasis on reasons that existing firms or startups which have successfully commercialized products or services fail to sustain their success as technology changes and evolves.

2 graduate hours. No professional credit. Prerequisite: STAT 400.

TE 566, Finance for Engineering Management
Credit: 2 hours.

Cornerstone financial concepts for engineering management to enable analysis of engineering projects from a financial perspective: income statements; the balance sheet; cash flow statements; corporate organization; the time value of money; net present value; discounted cash flow analysis; portfolio theory.

2 graduate hours. No professional credit.

TE 567, Venture Funded Startups
Credit: 1 hours.

Concepts, tools, and language used by venture capitalists (VCs). Venture-scale opportunity assessment and articulation; venture capital financing and valuation; deal structure; term sheets; financial plans for startups; customer development and marketing; product iterations; sales execution.

1 graduate hour. No professional credit. Prerequisite: TE 566.

Students may select a different course with professional development components in consultation with advisor.