

INFORMATION SYSTEMS ENGINEERING

The *Information Systems Engineering (ISE)* program provides students with the knowledge to manage and engineer as well as to develop, deploy, and maintain complex and large-scale systems. Learn to engineer systems that assist humans in making high-level decisions based on synthesizing low-level data. Learn how to empower these systems to achieve their goals using AI and ML components while assuring their safety and reliability even under adversarial conditions. Ensure that information systems behave in fair, ethical, and socially acceptable ways.

Courses are offered at the Applied Physics Laboratory and online.

Program Committee

David Silberberg, Program Chair

Principal Professional Staff
JHU Applied Physics Laboratory

Anthony N. Johnson, Program Manager

Senior Professional Staff
JHU Applied Physics Laboratory

David Bader

Professor and Director of the Institute for Data Science
New Jersey Institute of Technology

John "Jack" Callahan

CTO of Veridium
Principal Professional Staff
JHU Applied Physics Laboratory

Jeff Chavis

Principal Professional Staff
JHU Applied Physics Laboratory

Laura Freeman

Director, Intelligent Systems Division – National Security Institute
Virginia Tech

Dennis Patrone

Principal Professional Staff
JHU Applied Physics Laboratory

Wende Peters

Senior Vice President & Technology Manager
Cyber Defender Platform Integration & Automation
Bank of America

Jane Pinelis

Chief of AI Assurance (CDAO)
Principal Professional Staff
JHU Applied Physics Laboratory

Lynn Reggia

Principal Professional Staff
JHU Applied Physics Laboratory

Lanier Watkins, Chair Computer Science and Cybersecurity

Principal Professional Staff
JHU Applied Physics Laboratory

Programs

- Information Systems Engineering, Graduate Certificate (<https://e-catalogue.jhu.edu/engineering/engineering-professionals/information-systems-engineering/information-systems-engineering-graduate-certificate/>)
- Information Systems Engineering, Master of Science (<https://e-catalogue.jhu.edu/engineering/engineering-professionals/information-systems-engineering/information-systems-engineering-master-science/>)
- Information Systems Engineering, Post-Master's Certificate (<https://e-catalogue.jhu.edu/engineering/engineering-professionals/information-systems-engineering/information-systems-engineering-post-masters-certificate/>)

Courses

EN.635.601. Foundations of Information Systems Engineering. 3 Credits.

Creating and operating large-scale information systems requires a holistic approach that manages the blending of software, hardware, networks, and security inherent in modern systems. This course introduces key elements and processes required for designing, analyzing, developing, and integrating complex information systems. The course focuses on the systems engineering approach with specific emphasis on design, development, and deployment. Topics covered include requirements engineering, architecture development, security engineering, cost-benefit analysis, information and networking technologies, and operations. Course Note(s): The required foundation courses may be taken in any order but must be taken before other courses in the degree.

EN.635.603. AI/ML Ops. 3 Credits.

This course is designed to provide an in-depth understanding of AI/ML Ops, a discipline that combines artificial intelligence (AI) and machine learning (ML) with operations and IT practices. The course covers the introduction to AI and ML Ops, including the framework for building and deploying AI/ML models, the infrastructure for ML, data management, and the road to AI adoption. The course also provides insights into model training and deployment, AI/ML Ops features, stages of AI/ML Ops, preparing for production, deploying to production, AI/ML security, governance, and future trends in AI/ML Ops. The course will conclude with practical applications of AI/ML Ops. By the end of the course, students will have the skills to design and implement an MLOps strategy for an organization. Prerequisites: Working knowledge of Python

EN.635.611. Principles of Network Engineering. 3 Credits.

This course provides a introductory technical overview of networking and telecommunications for the engineering practitioner. Topics include voice, data, and video communication system fundamentals, including signaling, frequency concepts, transmission media, multiplexing, spread spectrum, signal encoding, error control, switching, and basic terminology. The OSI and TCP/IP reference models are examined along with the basic concepts of protocols, service interfaces, encapsulation, and layering. The course also covers networking and telecommunication techniques, applications technology, and networking topologies and Internetworking architectures. Specific areas discussed include LAN system fundamentals, such as IEEE 802.3 Ethernet, IEEE 802.11 wireless LANs and IEEE 802.15/Bluetooth; and wide-area systems such as cellular and satellite networks. TCP/IP infrastructure and protocols are extensively covered including IP routing, transport layer protocols, and applications including web, email, and real-time applications such as Voice over IP (VoIP). The course also covers the basic principles and protocols for Network Security (IPsec, SSL/TLS) and Management (SNMP).

EN.635.621. Principles of Decision Support Systems. 3 Credits.

Businesses and organizations are flooded with a variety of data from a vast number of sources. Data analysis and use of data analytics in data-driven decision-making processes has become the go-to strategy for business success and for gaining sustainable competitive advantage. This course will introduce students to the technologies that are generally and collectively called “analytics” used to support effective decision-making processes for business. Course topics will cover the latest trends in analytics, including scalable AI, machine learning, IoT, and smart/robo-collaborative assisting systems, composable data and analytics, data fabric, small data models, and XOps. This course will enable students to apply deep knowledge of predictive, descriptive analytics, big data, and web analytics to the development of the best business solutions for their organizations. They will also know which kinds of analytics to apply to specific decision contexts.

EN.635.627. Intelligent Decision Support Systems. 3 Credits.

Businesses and organizations are flooded with a variety of data from a vast number of sources. Data analysis and use of data analytics in data-driven decision-making processes has become the go-to strategy for business success and for gaining sustainable competitive advantage. This course will introduce students to the technologies that are generally and collectively called “analytics” used to support effective decision-making processes for business. Course topics will cover the latest trends in analytics, including scalable AI, machine learning, IoT, and smart/robo-collaborative assisting systems, composable data and analytics, data fabric, small data models, and XOps. This course will enable students to apply deep knowledge of predictive, descriptive analytics, big data, and web analytics to the development of the best business solutions for their organizations. They will also know which kinds of analytics to apply to specific decision contexts.

EN.635.631. Foundations of Data Analytics. 3 Credits.

This foundation course provides an overview of data analysis process, and introduces students to common techniques for data preprocessing, feature extraction, and the creation of statistical models. In particular, students will develop competence in areas of high importance for data scientists and engineers, such as: exploring the trade-off between bias and variance, selecting and creating features, regularizing models, determining optimal hyperparameters, and evaluating model performance. Multiple datasets and data types (e.g., unstructured text, imagery, and time-varying signals) will be considered with the goal of building student confidence across a spectrum of analysis challenges. Particular topics include linear and non-linear regression, decision trees, various approaches to dimensionality reduction, clustering, topic modeling, Bayesian methods, and neural networks. Prerequisite(s): Programming experience in Python, introductory linear algebra, and probability theory recommended.

EN.635.632. Engineering Data Intensive Systems. 3 Credits.

This course provides students with a solid understanding of the data engineering concepts needed to implement reliable data intensive systems. With the emergence of data science as a new field of study, data engineering has gained prominence as a discipline in its own right. Designing and deploying data intensive applications for production environments require skills and experience beyond data science. We start with the basic building blocks of data models, query languages, storage, retrieval, encoding, and schema evolution. Then we move on to distributed data where we examine the unique challenges faced with implementing distributed data systems and some approaches for mitigating these challenges. Throughout the course we consider reliability, scalability, and performance aspects of data stores, batch processing and streaming systems. To deepen our understanding of these concepts, students will implement data systems on their own personal computers using Docker. The technologies you will be working with include Jupyter Notebook, SQL engines, Apache Avro, Elasticsearch (and Kibana), Apache Spark, and Apache Kafka.

Prerequisite(s): EN.635.601 Foundation of Information Systems Engineering. Prior experience with databases, SQL, and Python is recommended.

EN.635.661. Principles of Human Computer Interaction. 3 Credits.

Well-designed human-computer interaction (HCI) is critical to the success of computer and information systems. This course focuses on the HCI design process and covers the underlying scientific principles, HCI design methodology, and the user-interface technology used to implement HCI. Topics include human cognition, HCI theories, user observation and task analysis, prototyping and evaluation techniques, user interface modalities and graphical user interface components, and accessibility. Selected additional topics may include HCI in website design, support of collaborative work, human interaction with automation, and ubiquitous computing. Student design projects are an integral part of the course. Reading the current HCI research literature is also required.

EN.635.671. Data Recovery & Continuing Operations. 3 Credits.

Data recovery and continuing operations refers to the processes, plans, and technologies required for an enterprise to achieve resiliency given unexpected events that may disrupt IT operations. This course provides an overview of the storage technologies to address backup, disaster recovery, and business continuity. Technologies that address auditing, redundancy, and resiliency in the infrastructure (e.g., networks, power, cooling, etc.) are described. Beyond the technologies, processes and plans for continuing operations are covered, including issues such as business continuity, disaster recovery, and risk management.

Prerequisite(s): EN.635.621 Principles of Decision Support Systems is recommended and may be taken concurrently.

EN.635.672. Privacy Engineering. 3 Credits.

Personal information has become a new class of digital property with immense value in commerce and of intense importance to national security and intelligence. Engineering any information system now requires a professional to protect privacy, preserve the information's functional value, and navigate complex domestic and international legal and engineering rules. Students will use new visual modeling and analysis tools for designing and executing privacy solutions in both the commercial and governmental sectors. Students will build a final specification for a privacy solution involving regulated personal information.

EN.635.673. Protecting Critical Infrastructure Against Cyber Attacks. 3 Credits.

Cybersecurity is one of the most critical national issues of our time. The trend for cyber-attacks is rapidly increasing in enterprise networks and is extending into other domains like the Internet of Things (IoT) and Industrial Control Systems (ICS). Our 16 Critical Infrastructures are the powerhouses for our military might and our huge economy, and thus protecting these assets is paramount. This class will: (1) introduce students to the history of the problem of Cybersecurity, (2) introduce students to the 16 Critical Infrastructures, and (3) provide students hands-on experience with developing Cybersecurity technology to assess, defend, and monitor enterprise, IoT, and ICS networks.

EN.635.676. Cybersecurity in Information Systems. 3 Credits.

This course describes the systems security engineering process, focusing on security during the design and implementation of information systems. Topics include architecture and design principles, risk assessment, resiliency, and security metrics. The course addresses emerging topics in cybersecurity including wireless security, cloud security, cross domains and the government standards and processes for secure information systems; surveys many aspects of cybersecurity and its impact on the enterprise; and lays the groundwork to architect and build a natively more secure system that can withstand hacking attacks and continue to deliver basic functionality to the enterprise. We will address the federal government standards and recommendations as well as industry's best practices. Students will cover the basic concepts of information security and research the latest security incidents including external attacks and internal leaks to assess and analyze the exploited vulnerabilities. By learning from current incidents, students can build systems that adapt quickly to emerging threats and potentially continue to serve the enterprise, even while under attack. Additionally, the course addresses the assessment of emerging technologies to determine the potential threats to the enterprise as well as the usability to secure the enterprise. Finally, we will address the subject of legal and ethical access control and the balance between privacy and security.

EN.635.682. Website Development. 3 Credits.

This course covers the design and implementation of websites. Various web standards, as developed by the World Wide Web Consortium and browser manufacturers are studied. HTML5 specifications are covered, including topics such as text control, images, hypertext links, forms, and embedded objects (e.g., video and audio). Cascading style sheets (CSS3), a client-side language (such as JavaScript), and server-side programming are also covered. Design and development topics include ease of use/navigation, download time, maintaining a consistent look and feel across multiple pages, building mobile-friendly websites, and Web server selection and configuration. Additional topics include web tools, privacy and security, XML, JSON, and AJAX.

EN.635.683. E-Business: Models, Architecture, Technologies, and Infrastructure. 3 Credits.

This course explores fundamental aspects of the e-Business (electronic business) phenomenon that is currently sweeping through the global economy, as well as design principles and technology used to build computer-based systems in order to support the notion of e-Business. E-Business (electronic business) is an umbrella term, an interdisciplinary topic encompassing both business and technology. This topic addresses a variety of business activities, business processes, and strategic business functions conducted over the Internet in order to service customers, to collaborate with business partners, and to maintain and sustain competitive advantage in the networking economy. The course introduces contemporary management philosophies as they have come to be used for the marketing, selling, and distribution of goods and services through the Internet and other electronic media. The course explores approaches of defining drivers and use cases of conducting electronic business. This course provides an overview of principles and analysis of different models of electronic business. It enables students to design effective e-Business models built on a foundation of business concepts, knowledge of the e-Business environment, and an understanding of the influence of the Internet on business stakeholders, including customers, suppliers, manufacturers, service makers, regulators, managers, and employees. In this course students undertake value analysis and learn to describe value propositions. Business architecture and software infrastructure used to engineer and build e-Business systems will be explained. The modern information technologies associated with the delivery of business capabilities over the Internet will be discussed. The course content will be reinforced by a variety of assignments.

EN.635.711. Advanced Topics in Network Engineering. 3 Credits.

This course is designed to provide an advanced treatment of key topic areas in networking and telecommunications for students who have mastered the basic principles of network engineering. Key operational systems, protocols, and technologies are explored in local, wide, metro-area, storage, and wireless networking. Major topic areas include advanced LAN/WLAN technologies (Power over Ethernet, IEEE 802.1x authentication, VLANs, link aggregation, etc.), Storage Area Network technologies, Virtualized/Cloud networking, Optical Networking, IPv6, Spanning Tree and Dynamic IP routing protocols, "LastMile" Networking (DSL, Cable Modems, etc.), Label Switching, Multicasting, and Multicast routing, real-time application support mechanisms, Quality of Service protocols, Advanced Transport Layer topics (Congestion Notification, TCP options, etc.), and Network Security (address translation, VPNs, stateful inspection, etc.). A major component of the course will be a design project on one of the topic areas covered in the class.

Prerequisite(s): EN.635.611 Principles of Network Engineering or EN.605.671 Principles of Data Communications Networks or equivalent.

EN.635.775. Cyber Operations, Risk, and Compliance. 3 Credits.

This course provides a solid foundation of potential civil and criminal areas of liability, and certain areas in which compliance and risk management are critical. The overarching theme is detection and reduction of potential legal/cybersecurity risks. We start by exploring the legal and regulatory environment that influences and supports cyber-based activities and programs, focusing on multidisciplinary or integrated views of enterprise risk management. We will address key risk management issues from the legal and cybersecurity aspects and analyze legal/ cybersecurity issues in several of the critical infrastructure sectors, such as the financial services, healthcare and public health, and transportation systems sectors. We also review legal and regulatory compliance issues to address cybersecurity risk management for systems development, acquisition, and operation. This includes material impacting the manner in which the cyber community operates, for example, FITARA (Federal Information Technology Acquisition Reform Act) Enhancement Act of 2017. We then review the authoritative guidance provided by the National Institute of Standards and Technology (NIST) Cybersecurity Framework. The Framework is voluntary for the sixteen critical information sectors and mandatory for the federal government, hence the focus on NIST. Risk management threat detection and avoidance is analyzed from an integrated legal/cybersecurity perspective, including system objectives to avert legal liability and minimize enterprise and human loss. Examples address financial services, healthcare and public health, and transportation (mobile devices and autonomous vehicles) systems, and cyber-physical systems (CPS) or Internet of Things (IoT). The overall constitutional and statutory basis within which all cyber law and policy operates is identified and reviewed.

EN.635.776. Building Information Governance. 3 Credits.

Businesses and government agencies confront increasingly complex rules and standards establishing the requirements for how digital information assets are to be created, stored, maintained, accessed, transmitted, received, and disposed. Information system engineers face enormous compliance risks, functional inefficiencies, and remediation costs if they are unprepared to navigate and master all of the technology, business, and legal rules against which digital information must be governed. All of these variables have become more complex as governments and industry partner more closely in counterterrorism investigations and defenses. This course enables engineers to explore and understand these rules and to develop better leadership skills across teams engaged in designing and managing complex governance projects. Assignments will expose engineers to, and teach them to navigate, the traps that global, cloud-based services present. Students completing the course will be able to contribute effectively to the cutting-edge, demanding projects ahead—"big data" transactions, real-time reporting to official agencies, electronic discovery, privacy, and compliance. Students will be expected to actively participate in class exercises, complete written assignments, and develop and present a final written governance proposal.

EN.635.782. Ethics in Intelligent Systems. 3 Credits.

This course is to fortify and enrich the values-assessment and critical thinking skills of engineers as they grapple with the numerous ethical challenges in their professional and personal lives. To that end, the course will define and delineate some global, macro-level concepts and approaches to ethics; move on to review some ethical issues unique to engineers as they apply intelligent technologies such as artificial intelligence and machine learning to developing complex systems; and finally present some finite cases studies and concrete situations by which to apply these ethical principles. This class will stimulate students to help identify a critical thinking zeitgeist and framework by which to filter, absorb and resolve complex ethical problems and questions in both their professions and at the personal level. This class will be completely value-neutral and hence devoid of any one overarching governing ethical school of thought; thus, we are ecumenical in our approaches. Having said that, the IEEE ethically aligned design standards are noteworthy and very salutary to any exploration. This course will make use of a variety of current, recent historical and classical materials to illustrate major themes.

EN.635.792. Entrepreneurship, Innovation, and Corporate Success. 3 Credits.

In many companies and government/military organizations, engineers are expected to be both innovators and creative managers. Organizations that desire to grow and to create value for their stakeholders depend on using all available capital resources: financial, human, intellectual and physical. They then seek to defend and control the value created. This course explores the engineer's roles in innovation, invention, and value creation as a driving force in entrepreneurial technology ventures, established companies and governmental/military organizations, and the ways in which these organizations must plan to take full advantage of innovation as the only true competitive weapon in the battle for long-term success. Particular attention will be paid to collaboration and communication as key skills of the engineer/innovator/manager.

EN.635.795. Information Systems Engineering Capstone Project. 3 Credits.

This course is designed for students who would like to conduct a major independent project involving a substantial enterprise information system design that builds upon and applies elements of the ISE curriculum. The project includes requirements analysis, IT architecture design, network design, software integration, decision support applications, and deployment planning. Interim deliverables include presentations to the course advisors. Project proposals are required and a mentor will be assigned to the student. The objective is to deliver a novel and innovative approach to solve deficiencies in building, operating and securing Information systems that utilize emerging technologies and techniques. Prerequisite(s): Completion of eight courses in the ISE curriculum, including all ISE foundation courses. Course Note(s): Students may not receive graduate credit for both EN.635.795 and EN.635.802 Independent Study in Information Systems Engineering II.

EN.635.801. Independent Study in Information Systems Engineering I. 3 Credits.

This course permits graduate students in Information Systems Engineering to work with a faculty mentor to explore a topic in depth or conduct research in selected areas. Requirements for completion include submission of a significant paper. Prerequisite(s): Seven ISE graduate courses including the foundation courses, three concentration area courses, and two courses numbered 635.7xx; or admission to the Post-Master's Certificate. Students must also have permission of a faculty mentor, the student's academic advisor, and the program chair.

EN.635.802. Independent Study in Information Systems and Technology**II. 3 Credits.**

Students wishing to take a second independent study in information systems engineering should sign up for this course. Prerequisite(s): EN.635.801 Independent Study in Information Systems Engineering I and permission of a faculty mentor, the student's academic advisor, and the program chair. Course Note(s): Students may not receive graduate credit for both EN.635.802 and EN.635.795 Information Systems Engineering Capstone Project.