M.S. with a Major in Datacenter Systems Engineering

Candidates must satisfy a total of 30 term credit hours (TCH) with a minimum G.P.A. of 3.00 on a 4.00 scale.

All students must complete 15 term credit hours (TCH) of the core curriculum.

Core Courses

CS 7346 Cloud Computing and Virtualization Technologies

Explores architectures for cloud computing and provides hands-on experience with virtualization technologies. Topics include cloud computing architectures such as infrastructure as a service, platform as a service, and software as a service. Covers programming models for cloud computing, the fundamentals of virtualization technologies that enable scalability, and an introduction to the security and energy efficiency challenges of cloud computing.

CS 7349 Data and Network Security

Covers conventional and state-of-the-art methods for achieving data and network security. Private key and public key encryption approaches are discussed in detail, with coverage of popular algorithms such as DES, Blowfish, and RSA. In the network security area, the course covers authentication protocols, IP security, Web security, and system-level security. *Prerequisite*s: CSE 7339 or equivalent, and instructor permission.

ECE 7301 Power Management for Industrial and Mission-Critical Facilities

Overview of the issues in power management (maximize uptime, minimize costs, reduce risk, improve reliability, and increase operation efficiency) in a data center or other mission-critical facility. Topics include DC and AC power concepts (three-phase power, etc.), tier level rankings and their impact on design and cost, redundancy and fault tolerant integration to avoid single points of failure, power quality indices and methods to improve power quality, introduction to AC and DC distribution systems in data centers, design and installation of LED lighting systems, UPS, battery, generators, uninterrupted operating capability in power distribution, air conditioning and air distribution architecture, energy efficiency in data centers, fault protection and system grounding, system security (fire detection systems, pre-action sprinkler systems, dry suppression systems, etc.), comprehending IT hardware refresh cycles, and standardization in energy infrastructure.

EMIS 7357 Analytics for Decision Support

In a rapidly changing, complex environment, successful enterprises make mission-critical choices using decision-support systems, which apply analytical methods to massive organizational data sets to evaluate options, give insight to likely outcomes, and make recommendations of the “best” decisions to pursue. Course topics include 1) framing and understanding decision-making needs and processes to define, evaluate, and identify appropriate strategic, operational, or execution-level decisions; 2) identifying, collecting, and managing large-scale data needed for decision support; and 3) employing decision-support software in areas such as optimization and data mining. Credit is not allowed for both EMIS 7357 and EMIS 3309.

CEE 7380 (ME 7380) Management of Industrial and Mission-Critical Facilities

Efficient industrial centers require balanced consideration with respect to facility design and function. Mission-critical component management and information technology systems are designed for exceptionally reliable performance and efficient operation. This course emphasizes the component systems that are designed to maintain a high level of function. Covers electrical and mechanical reliability, efficiency, readiness, robustness, and flexibility, and the management of the information technology systems. Explores strategies designed to eliminate costly downtimes, with emphasis on standby generators; automatic transfer switches; uninterruptable power supplies; fuel, fire, and battery systems; energy security; and environmental and cooling technologies. Presents the implementation of sustainable technology, green certifications, and alternative energy strategies that are compatible with the mission-critical requirements of the facility. Includes operational approaches to reduce energy requirements for power and cooling, mandated safety standards, and environmental codes. *Prerequisite*: Graduate standing or permission of the instructor.

Group I Electives

All students must complete 9 term credit hours (TCH) from the following specializations.

Suggested Specialization in Facilities Infrastructure Management

CEE 7325 Disaster Management

This course introduces the student to basic concepts in disaster management. Drawing on a range of sources from the textbook to the U.S. National Response Plan to research papers, the course covers the fundamentals of preparedness, mitigation, response, and recovery. An all-hazards approach is taken, providing analysis of natural, technological, and man-made disasters. In addition to discussing the basic theories of disaster management, the course introduces the student to key methods in the field, including simulation modeling, consequence analysis tools, design criteria, statistical and case study methods (lessons learned), and risk analysis.

CEE 7370 Facility Planning

The overall planning process for construction projects is presented. The three divisions of planning: program planning, project planning, and activity planning are presented in an integrated manner. Included are different modeling approaches for the planning process.

CEE 7366 Introduction to Facilities Engineering Systems

The interrelationships of fire protection, HVAC, electrical, plumbing, lighting, telecommunications, energy management systems for buildings are examined. A life cycle approach examines each of these systems with respect to cost, durability, maintainability, operability, and safety. Facility operations, facility maintenance and testing, and assessments are discussed.

CEE 7369 Electrical Mechanical and Piping Systems for Buildings

Mechanical and electrical systems for buildings are examined with emphasis on practical aspects of the subjects. Space planning and architectural considerations, including cost and environmental impact of the mechanical and electrical systems are presented. *Prerequisite*s: Undergraduate introduction to electrical circuits, classical mechanics, and fluid dynamics, or instructor's approval.

CEE 7384 Energy Management for Buildings

Procedures to select energy saving options for buildings are examined with emphasis on practical aspects of the subjects. Space planning, architectural considerations, cost and environmental impact of the mechanical and electrical systems are considered along with optimizing the life cycle cost of the proposed alternative. Software for life cycle cost and energy analysis are used to calculate energy consumption and compare energy features of proposed, audit-determined feasible changes to a building.

EETS 7307 Telecommunications for Data Systems Engineering

Covers topics related to the technologies and physical management of corporate telecommunications systems, including current voice, data, and wireless telecommunications technologies and hardware. Legal and regulatory topics include a review of regulatory agency responsibilities. Also, intellectual property, net neutrality, privacy and fraud, and facilities planning and management processes, including lease analysis, licensing and permits, bidding contracts, development of specifications, and supplier and vendor management as they pertain to telecommunications systems. Examines engineering topics of fire protection, HVAC, electrical, plumbing, and lighting, and energy management systems for telecommunications. *Prerequisite*s: 1 year of physics, including electricity and magnetism, and 1 year of calculus.

EMIS 7347 Critical Infrastructure Protection/Security Systems Engineering

The purpose of the course is to present systems engineering (SE) concepts as applied to the protection of the United States' critical infrastructure (CI). A top-level systems viewpoint provides a greater understanding of this system-of-systems (SOS). Topics include the definition and advantages of SE practices and fundamentals; system objectives that include the viewpoint of the customer, users, and other stakeholders; the elements of the CI and their interdependencies; the impact transportation system disruptions; and system risk analysis. *Prerequisites*: EMIS 7301 and EMIS 7303.

EMIS 8363 Engineering Finance

Develops an understanding of corporate financial decisions for engineers. Topics include cost of capital, capital budgeting, capital structure theory and policy, working capital management, financial analysis and planning, and multinational finance. *Prerequisite*: EMIS 8361 or a knowledge of time value of money.

ME 7330 Heat Transfer

Application of the principles of conduction, convection, and radiation heat transfer. Steady and unsteady state, special configurations, numerical and analytical solutions, and design are topics included. *Prerequisite*: ME 3332 or permission of the instructor.

ME 7335 Convection Cooling of Electronics

This course will begin with a review of the fundamental concepts of convection heat transfer, followed by applications of these principals to the convective cooling of electronic components and systems. The following special topics will be emphasized: design of natural- and forced- convection heat sinks with both air and liquid-cooling, fan and pump selection procedures, including piezoelectric fans and micro-pumps, acoustic fan noise and noise measurement techniques, augmentation of convection heat transfer in the form of plate-fin and pin-fin extended surfaces, spray cooling, jet-impingement cooling, micro-channel cooling, heat pipes, and capillary pumped loops. In addition, the course will cover pool boiling and flow boiling as applied to the thermal management of electronics. The design of electronic chassis with flow through cold-walls and edge-cooled PWBs will be examined. Several industry-related applications will be used as examples. *Prerequisite*: Senior undergraduate or graduate student standing.

ME 7336 Intermediate Fluid Dynamics

Review of fundamental concepts of undergraduate fluid mechanics and introduction to advanced fluid dynamics, industrial irrotational flow, tensor notation, and the Navier-Stokes equations. *Prerequisite*: ME 2342 or permission of the instructor.

ME 7344 Conductive Cooling of Electronics

This course will begin with a review of the fundamental concepts of conduction heat transfer, followed by applications of these principals to the conductive cooling of electronic components and systems. The following special topics will be emphasized: contact conductance, interface thermal resistance, heat spreaders, thermal interface materials (TIMs), phase change materials (PCMs), thermoelectric devices, Stirling cycle refrigerators, and the cooling of special electronic components, such as multi-chip modules, power modules, high-density power supplies, and printed wiring boards. The thermal management by conduction of GaAs and GaN MMICs (monolithic microwave integrated circuits) will be featured. Both steady state and transient analyses will be employed, including a discussion of transient junction-to case thermal resistance measurements. *Prerequisite*: Senior undergraduate or graduate student standing.

ME 7383 (CEE 7383) Heating, Ventilation and Air Conditioning

Selection and design of basic refrigeration, air conditioning, and heating systems are treated. Load calculations, psychometrics, cooling coils, cooling towers, cryogenics, solar energy applications, and special topics are included. *Prerequisites*: ME 2331 and 3332 or permission of the instructor.

ME 8385 Conduction Heat Transfer

Analytical and numerical methods are applied to several cases of steady and unsteady state conduction. Temperature dependent properties, multi-dimensional system, and heat sources are included.

ME 8387 Radiation Heat Transfer

Basic laws and definitions of thermal radiation. Radiation properties of surfaces. Basic equations for energy transfer in absorbing, emitting and scattering media. Applications to combined conduction-radiation and convention-radiation problems. *Prerequisite*: ME 3332 or permission of the instructor.

CEE 7381 (ME 7381) Site Selection for Industrial and Mission-Critical Facilities

Efficient industrial centers and facilities with mission-critical subsystems such as datacenters require balanced considerations with respect to facility design and site location. Site location plays an integral role in creating successful projects that especially support high reliability and promote sustainable design. While the important factors may vary from site to site, in any given instance a single factor can undermine the success of an otherwise excellent project. Ready availability and proper site selection that minimizes risk of disruption are particularly important factors for successful operation. Covers siting considerations, including power needs, electrical mix, weather patterns, building codes, proximity to the workforce and transportation, and other topics that bear on reliable operation. Emphasizes strategies of site selection to adequately safeguard hardware and mission-critical data. *Prerequisite*: Graduate standing or permission of the instructor.

Suggested Specialization in Data Engineering, Analytics

CS 7330 File Organization and Database Management

A survey of current database approaches and systems, and the principles of design and use of these systems. Covers query language design and implementation constraints, and applications of large databases. Includes a survey of file structures and access techniques. Also, the use of a relational database management system to implement a database design project. *Prerequisite*: CSE 2341.

CS 7340 Service-Oriented Computing

Service-oriented computing (SOC) is the computing paradigm that utilizes services as fundamental elements for developing applications. Service providers expose capabilities through interfaces. Service-oriented architecture maps these capabilities and interfaces so they can be orchestrated into processes. Fundamental to the service model is the separation between the interface and the implementation, such that the invoker of a service need only (and should only) understand the interface; the implementation can evolve over time, without disturbing the clients of the service. Topics include Web architecture, HTTP, XML, SOAP, REST, BPEL, and developing interfaces that connect to independent services. The course will be of interest to those interested in creating and/or aggregating Web services and developing user interfaces for the display of those services. *Prerequisite*: Senior or graduate standing. Programming experience is required.

CS 7347 XML and the Enterprise

XML, the Extensible Markup Language, is widely used to define vocabularies for a wide range of applications, including software configuration, data exchange, and Web-based protocols. This course provides a detailed examination of XML as an enterprise technology. Focuses on APIs, interfaces, and standards that are driving this technology, including DTDs and XML Schema to structure XML data, XSLT to transform XML, XML protocols for distributed computing, and XML security initiatives. Students gain a broad understanding of XML and the technical issues and tradeoffs among different alternatives for processing XML. *Prerequisite*s: An understanding of object-oriented concepts and familiarity with Java and/or C++.

CS 8316 User Interface Design

Design methodologies for user interfaces. Includes life cycles for UI development, human factors issues, prototyping, user analysis and evaluation, and design techniques. Students perform the analysis, design, and evaluation of a UI through two iterations.

CS 8321 Machine Learning and Neural Networks

Introduction to the principles and motivation behind forms of machine learning, including neural networks. Survey of important topics and current areas of research, including back propagation, Boltzmann machines, clustering, inductive learning, genetic learning, and analogy. Strengths and weaknesses of each type of learning algorithm. *Prerequisite*: CSE 7320 or permission of the instructor.

CS 8331 (EMIS 8331) Data Mining

Examines advanced data mining topics, including temporal mining. Web mining, spatial mining and text mining. Case studies and projects. *Prerequisite*: CSE 7331.

CS 8337 (EMIS 8337) Information Retrieval

Examination of techniques used to store and retrieve unformatted/textual data. Examination of current research topics of data mining, data warehousing, digital libraries, hypertext, and multimedia data. *Prerequisite*: CSE 7330.

EMIS 7352 Information System Architecture

The architecture of an information system (IS) defines that system in terms of components and interactions among those components. This course addresses IS hardware and communications elements for information engineers, including computer networking and distributed computing. It addresses the principles, foundation technologies, standards, trends, and current practices in developing an appropriate architecture for Web-based and non-Internet information systems.

EMIS 7353 Information System Design Strategy

This course surveys the fundamentals of software engineering and database management systems (DBMS) for information engineers. It covers the principles, foundation technologies, standards, trends, and current practices in data-centric software engineering and systems design, including object-oriented approaches and relational DBMS. The focus is on system design, development, and implementation aspects, and not the implementation in code.

Suggested Specialization in Networks, Virtualization and Security

EMIS 7382 Information Technology Security and Risk Management

This course is for non-technical managers and executives with decision-making responsibility in information security governance and risk management. Topics include information security organizations and policies, governance, program development and management, information risk management, legal and regulatory compliance, and business continuity planning.

EMIS 8364 Engineering Management

How to manage technology and technical functions from a pragmatic point of view. How to keep from becoming technically obsolete as an individual contributor and how to keep the corporation technically astute. This course will look at the management of technology from three distinct viewpoints: 1) the management of technology from both an individual and a corporate perspective, 2) the management of technical functions and projects, and 3) the management of technical professionals within the organization. *Prerequisite*: Graduate standing in engineering.

EMIS 8356 Information Engineering and Global Perspectives

This course examines global and information aspects of technology-based and information-based companies. Topics include modern business processes, the strategic use of information technology, and integration of global information resources for competitive advantage. *Prerequisite*: EMIS 7360.

CS 7339 Computer System Security

Investigates a broad selection of contemporary issues in computer security, including an assessment of state-of-the-art technology used to address security problems. Includes sources for computer security threats and appropriate reactions, basic encryption and decryption, secure encryption systems, program security, trusted operating systems, database security, network and distributed systems security, administering security, and legal and ethical issues. *Prerequisite*: CSE 5343 or equivalent.

CS 7344 Computer Networks and Distributed Systems

Introduction to network protocols, layered communication architecture, multimedia applications and protocols, quality of service, congestion control, optical networks, DWDM, network survivability and provisioning, wireless networks. There will be an interdisciplinary project requiring the use of currently available network design and simulation tools. *Prerequisite*: C- or better in CSE 4344.

CS 7359 Software Security

As software is delivered across network and Web-based environments, security is critical to successful software deployment. This course focuses on software security issues that pertain to the network application layer in the classic OSI model. At the application network layer, issues related to encryption, validation, and authentication are handled programmatically rather than at the network level. Students work with APIs for cryptography, digital signatures, and third-party certificate authorities. The course also explores issues related to XML and Web services security by examining standards and technologies for securing data and programs across collaborative networks. *Prerequisite*: C- or better in CSE 7339.

CS 8343 Advanced Operating Systems (Virtualization)

Theoretical and practical aspects of operating system design, implementation, system organization, and resource management. The emphasis on distributed operating systems, and advanced research issues. *Prerequisite*: CSE 7343.

CS 8349 Advanced Network and System Security

In-depth analysis of secure networks and systems, security audit, intrusion detection and prevention, storage security, firewall configurations, security log analysis, DMZs, honeypots, malicious codes, and mobile and grid computing security. *Prerequisite*: CSE 7349.

CS 8352 (ECE 8372) Cryptography and Data Security

Cryptography is the study of mathematical systems for solving two kinds of security problems on public channels: privacy and authentication. Covers the theory and practice of both classical and modern cryptographic systems. The fundamental issues involved in the analysis and design of a modern cryptographic system will be identified or studied. *Prerequisite*: EE/STAT/CSE 4340 or equivalent.

EETS 7304 Network Protocols

This course is an introductory graduate course on the protocol architecture of the Internet, following a bottom-up approach to the protocol layers. The objective of this core course is to provide an understanding of the internetworking concepts in preparation for advanced networking courses. The first part of the course covers networking technologies such as local area networks, packet switching, and ATM. The second part of the course examines the Internet protocol (IP) and TCP/UDP in-depth. The last part of the course is an overview of important application protocols such as HTTP, client/server computing, SMTP, FTP, and SNMP. *Prerequisite*: EETS 7301 or equivalent.

EETS 8311 Intelligent Networks

A comprehensive course in providing broad knowledge in IN by exploring the theoretical network/call models of the ITU-T and ANSI and practical experiences of implementing IN technologies and services. Important IN elements such as the Service Creation Environment (SCE), Service Management Systems (SMS), Service Control Point (SCP), Signal Transfer Point (STP), Service Switching Point (SSP), Intelligent Peripheral (IP) will be explained in details. Implementation scenarios for IN elements starting with the ITU-T Service Independent Building Blocks (SIB) to actual service deployment will be described. Harmonization of IN with Telecommunications Management Network (TMN), the future of IN with migration to Telecommunication Information Networking Architecture (TINA), and hurdles to IN – e.g., feature interaction, Local Number Portability (LNP) example, and IN/IP/CTI integration – will be covered. Live demos of IN service creation and execution will be available. *Prerequisite*: EETS 5301 or permission of the instructor.

Group II Electives

All students must complete 6 term credit hours (TCH) from the following graduate-level courses approved by the adviser and offered by the Lyle School of Engineering, the Cox School of Business, the Departments of Physics, Chemistry, Mathematics or Statistics.