Bachelor of Science in Artificial Intelligence and Cybersecurity

(27-Nov-2025)

Program Mission

The mission of the Artificial Intelligence and Cybersecurity program is to equip students with strong foundations in artificial intelligence, cybersecurity, and computing, to meet the growing demand for interdisciplinary professionals with growth mindsets in a knowledge-based economy, and to enable graduates to contribute responsibly and meaningfully to both society and industry.

Program Educational Objectives

Graduates of the program will:

1. Pursue successful careers in artificial intelligence, cybersecurity, or related computing fields.
2. Contribute to interdisciplinary projects and use their technical expertise to address real-world challenges in a socially responsible and globally aware manner.
3. Engage in continuous professional development and grow into leadership roles, demonstrating effective communication, ethical responsibility, and teamwork in dynamic technological environments.

Program Learning Outcomes

Graduates of the program will be able to:

Knowledge and Understanding	
K1	Analyze a complex problem and apply principles of computing and other relevant disciplines to elaborate solutions to it.
Skills	
S1	Design, implement, and evaluate a computing-based solution to meet a given set of requirements in the context of the program's discipline.
S2	Apply security principles and practices to maintain operations in the presence of risks and threats.
S3	Apply artificial intelligence theories, principles, and relevant mathematical models to automate processes, develop smart decision support systems, or simulate real-world situations at various complexity levels.
S4	Communicate effectively in a variety of professional contexts.
S5	Acquire and apply new knowledge as needed, using appropriate learning strategies.
Values, Autonomy, and Responsibility	
V1	Recognize professional responsibilities and make informed judgments in computing practice based on legal and ethical principles.
V2	Function effectively as a member and leader of a team engaged in activities appropriate to the program's discipline.

Courses By Areas

Area	No. of Courses	Credit Hours
Math	6	20
General Studies	10	22
Digital & Business Foundations	4	12
Computer Science	13	39
Artificial Intelligence (AI)	4	12
Cybersecurity (CyS)	4	12
Integrating AI and CyS (Intersectional Courses)	2	6
Technical Electives	1	3
Summer Training (ST) / Internship (INT)	1	1 (ST) / 6 (INT) *(INT replaces technical electives)*
Total		127 (ST) / 129 (INT)

Math			
Course Code	Course Name	LT-LB-CR	CR
MATH 101	Calculus I	4-0-4	4
MATH 102	Calculus II	4-0-4	4
MATH 201	Calculus III	3-0-3	3
MATH 208	Differential Equations & Linear Algebra	3-0-3	3
STAT 201	Introduction to Probability and Statistics	3-1-3	3
ICS 253	Discrete Structures	3-0-3	3
Total	6 Courses		20

General Studies			
Course Code	Course Name	LT-LB-CR	CR
ENGL 101	Introduction to Academic Discourse	3-0-3	3
ENGL 102	Introduction to Report Writing	3-0-3	3
ENGL 214	Academic & Prof. Communication	3-0-3	3
IAS 111	Belief and its Consequences	2-0-2	2
IAS 121	Language Foundation	2-0-2	2
IAS 212	Ethics and Governance	2-0-2	2
CGS 292	Career Essentials	0-2-1	1
PE 101	Health & Physical Education I	0-2-1	1
GS xxx	GS Elective	3-0-3	3
IAS xxx	Islamic/Arabic Elective	2-0-2	2
Total	10 Courses		22

Digital & Business Foundations			
Course Code	Course Name	LT-LB-CR	CR
ICS 104	Intro. to Programm. in Python & C	2-3-3	3
DATA 211	Intro. to Data Science	3-0-3	3
COE 292	Intro. to Artificial Intelligence	3-0-3	3
BUS 200	Business & Entrepreneurship	3-0-3	3
Total	4 Courses		12

Core Requirements			
Computer Science			
Course Code	Course Name	LT-LB-CR	CR
ICS 108	Object-Oriented Programming	3-3-4	4
ICS 202	Data Structures and Algorithms	3-3-4	4
ICS 343	Fundamentals of Computer Networks	3-3-4	4
ICS 321	Database Systems	3-0-3	3
ICS 381	Principles of Artificial Intelligence	3-0-3	3
ICS 353	Design and Analysis of Algorithms	3-0-3	3
ICS 344	Information Security	3-0-3	3
ICS 433	Operating Systems	3-1-3	3
AISC 413	Capstone Project I	0-0-0	0
AISC 414	Capstone Project II	3-0-3	3
Total	10 Courses		30
Software Engineering			
SWE 206	Introduction to Software Engineering	2-3-3	3
Total	1 Course		3
Computer Engineering			
COE 233	Digital Logic and Computer Organization	3-0-3	3
Total	1 Course		3
Data Science & Engineering			
DATA 351	Human Contexts and Ethics of Data	3-0-3	3
Total	1 Course		3
Artificial Intelligence (AI)			
ICS 485	Machine Learning	3-0-3	3
ICS 471	Deep Learning	3-0-3	3
ICS 483	Computer Vision	3-0-3	3
ICS 472	Natural Language Processing	3-0-3	3
Total	4 Courses		12
Cybersecurity (CyS)			
ICS 442	Penetration Testing and Ethical Hacking	3-0-3	3
COE 426	Data Privacy	3-0-3	3
ICS 440	Cryptography and Blockchain Applications	3-0-3	3
SWE 445	Secure Software Development	3-0-3	3
Total	4 Courses		12
AI + CyS			
ICS 467	Security in Artificial Intelligence Systems	3-0-3	3
ICS 476	Artificial Intelligence for Cybersecurity	3-0-3	3
Total	2 Courses		6
Technical Electives			
XE xxx	Technical Elective	3-0-3	3

Total	1 Course		3
Summer Training OR Internship *(Two technical electives are replaced with internship – 6 CRs)*			
AISC 399	Summer Training	0-0-1	1
AISC 398	Internship	0-0-6	6
Total	1 Course		1 / 6

Degree Plan

Summer Training Option

Freshman Year					
Term 1			Term 2		
ENGL 101	Introduction to Academic Discourse	3	ENGL 102	Introduction to Report Writing	3
IAS 111	Belief and its Consequences	2	ICS 108	Object-Oriented Programming	4
ICS 104	Intro. to Program. in Python & C	3	MATH 102	Calculus II	4
MATH 101	Calculus I	4	ICS 253	Discrete Structures	3
PE 101	Health & Physical Education I	1	IAS 121	Language Foundation	2
BUS 200	Business & Entrepreneurship	3			
	Total Credit Hours	16		Total Credit Hours	16

Sophomore Year					
IAS 212	Ethics and Governance	2	COE 292	Intro. to Artificial Intelligence	3
DATA 211	Intro. to Data Science	3	MATH 208	Differential Equations & Linear Algebra	3
ICS 202	Data Structures and Algorithms	4	ENGL 214	Academic & Prof. Communication	3
MATH 201	Calculus III	3	COE 233	Digital Logic and Computer Organization	3
SWE 206	Introduction to Software Engineering	3	ICS 343	Fundamentals of Computer Networks	4
STAT 201	Introduction to Probability and Statistics	3			
	Total Credit Hours	18		Total Credit Hours	16

Junior Year					
ICS 344	Information Security	3	ICS 321	Database Systems	3
ICS 381	Principles of Artificial Intelligence	3	DATA 351	Human Contexts and Ethics of Data	3
ICS 440	Cryptography and Blockchain Applications	3	CGS 392	Career Essentials	1
ICS 471	Deep Learning	3	ICS 353	Design and Analysis of Algorithms	3
ICS 485	Machine Learning	3	ICS 442	Penetration Testing and Ethical Hacking	3
			IAS xxx	Islamic/Arabic Elective	2
	Total Credit Hours	15		Total Credit Hours	15

Summer Session		
AISC 399	Summer Training	1

Senior Year					
ASIC 413	Capstone Project I	0	ASIC 414	Capstone Project II	3
ICS 433	Operating Systems	3	SWE 445	Secure Software Development	3
GS xxx	GS Elective	3	ICS 472	Natural Language Processing	3
ICS 467	Security in Artificial Intelligence Systems	3	ICS 476	Artificial Intelligence for Cybersecurity	3
COE 426	Data Privacy	3	XE xxx	Technical Elective	3
ICS 483	Computer Vision	3			
	Total Credit Hours	15		Total Credit Hours	15
Total Program Credit Hours = 127					

Internship Option

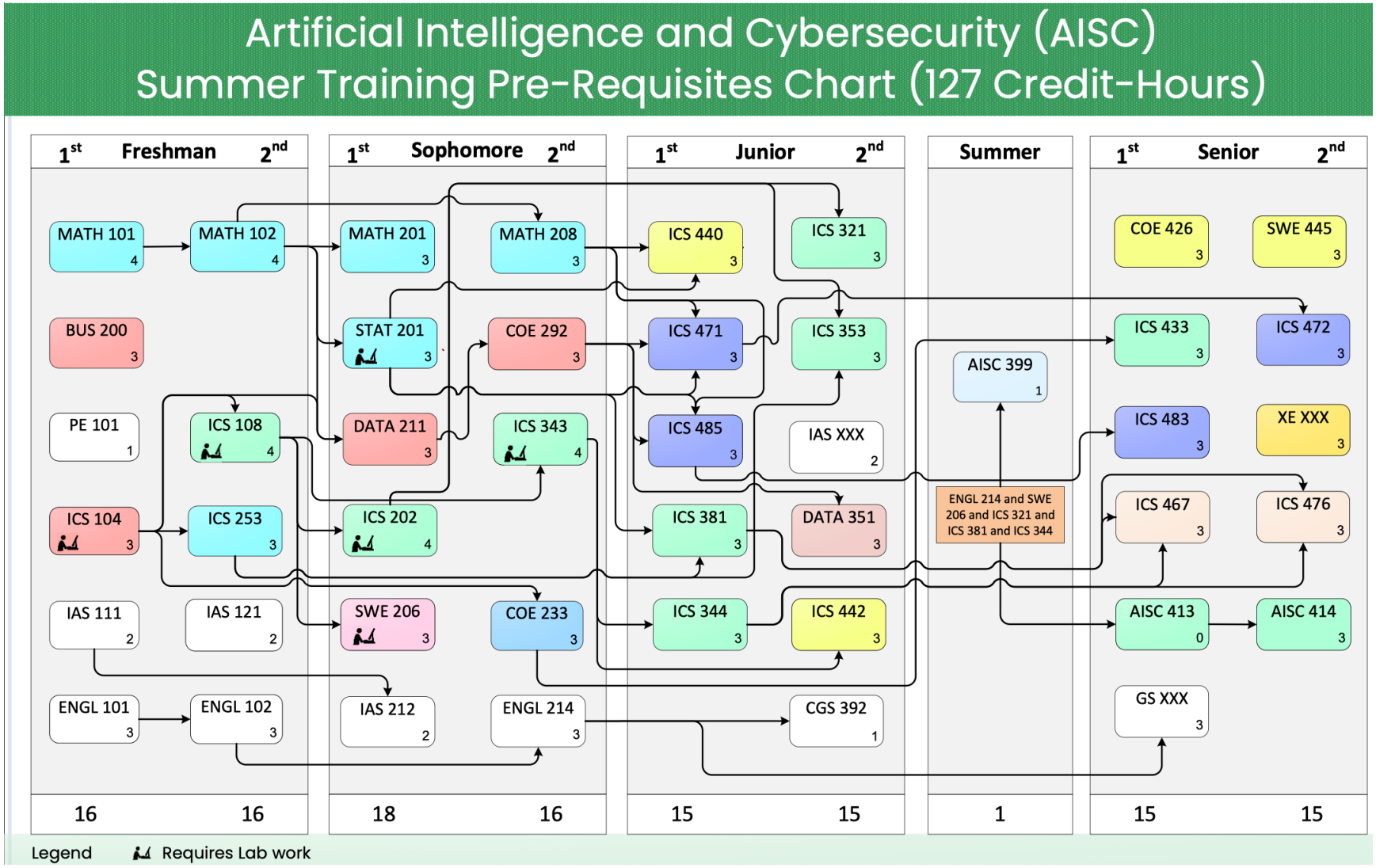
Freshman Year					
Term 1			Term 2		
ENGL 101	Introduction to Academic Discourse	3	ENGL 102	Introduction to Report Writing	3
IAS 111	Belief and its Consequences	2	ICS 108	Object-Oriented Programming	4
ICS 104	Intro. to Program. in Python & C	3	MATH 102	Calculus II	4
MATH 101	Calculus I	4	ICS 253	Discrete Structures	3
PE 101	Health & Physical Education I	1	IAS 121	Language Foundation	2
BUS 200	Business & Entrepreneurship	3			
	Total Credit Hours	16		Total Credit Hours	16

Sophomore Year					
IAS 212	Ethics and Governance	2	COE 292	Intro. to Artificial Intelligence	3
DATA 211	Intro. to Data Science	3	MATH 208	Differential Equations & Linear Algebra	3
ICS 202	Data Structures and Algorithms	4	ENGL 214	Academic & Prof. Communication	3
MATH 201	Calculus III	3	IAS xxx	Islamic/Arabic Elective	2
SWE 206	Introduction to Software Engineering	3	COE 233	Digital Logic and Computer Organization	3
STAT 201	Introduction to Probability and Statistics	3	ICS 343	Fundamentals of Computer Networks	4
	Total Credit Hours	18		Total Credit Hours	18

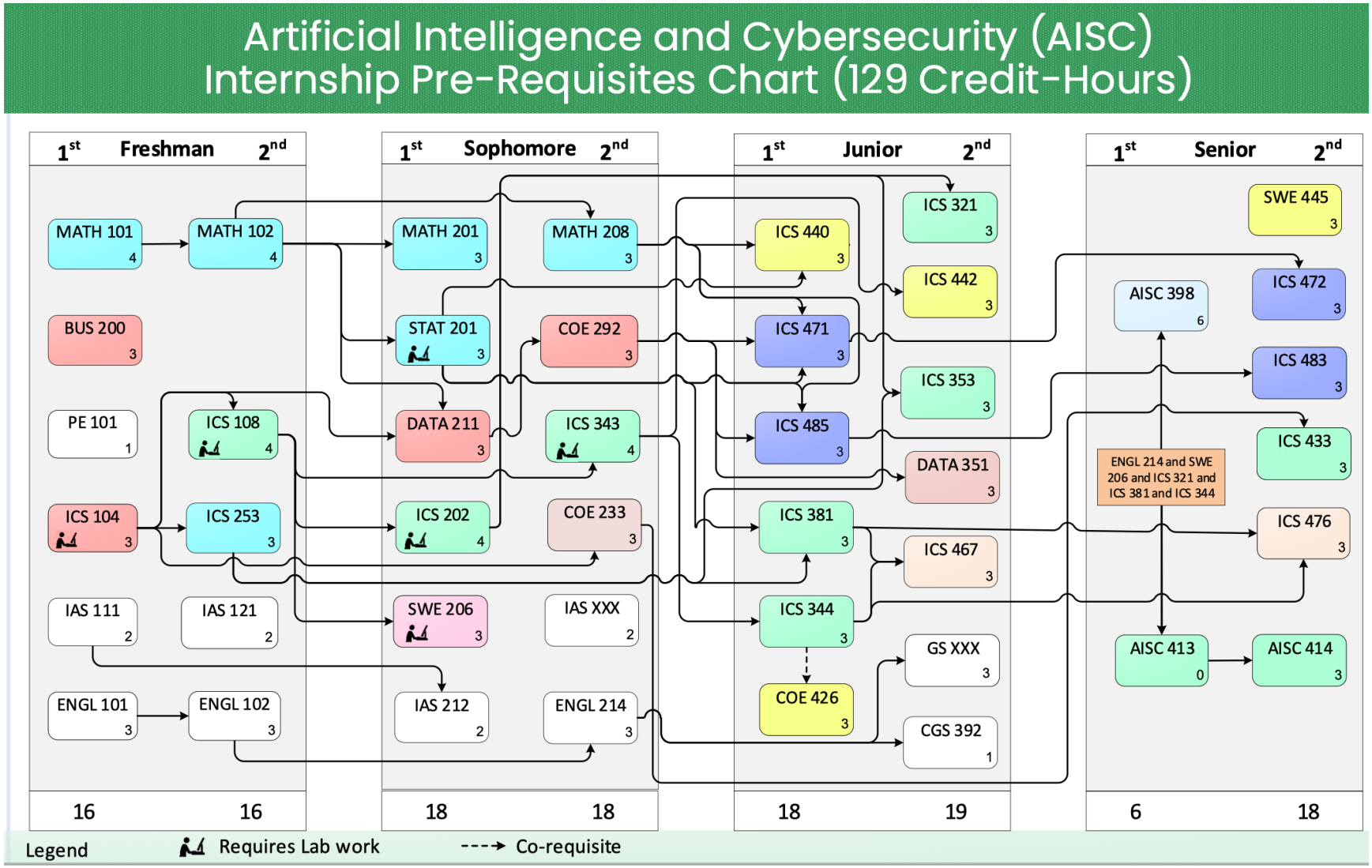
Junior Year					
ICS 344	Information Security	3	ICS 321	Database Systems	3
ICS 381	Principles of Artificial Intelligence	3	DATA 351	Human Contexts and Ethics of Data	3
ICS 440	Cryptography and Blockchain Applications	3	CGS 392	Career Essentials	1
ICS 471	Deep Learning	3	ICS 353	Design and Analysis of Algorithms	3
ICS 485	Machine Learning	3	ICS 442	Penetration Testing and Ethical Hacking	3
COE 426	Data Privacy	3	ICS 467	Security in Artificial Intelligence Systems	3
			GS xxx	GS Elective	3
	Total Credit Hours	18		Total Credit Hours	19

Senior Year					
AISC 413	Capstone Project I	0	AISC 414	Capstone Project II	3
AISC 398	Internship	6	ICS 472	Natural Language Processing	3
			SWE 445	Secure Software Development	3
			ICS 476	Artificial Intelligence for Cybersecurity	3
			ICS 483	Computer Vision	3
			ICS 433	Operating Systems	3
	Total Credit Hours	6		Total Credit Hours	18
Total Program Credit Hours = 129					

Course Flow Chart | Summer Training



Course Flow Chart | Internship (129 Credit Hours)



List of Core Courses Integrating AI and Cybersecurity

(Intersectional Courses)

ICS 467 Security in Artificial Intelligence Systems (NEW)

This course explores the security and robustness of AI systems throughout their lifecycle. Students will examine critical challenges such as adversarial attacks, data poisoning, model inversion, and real-world exploitation of AI technologies. Emphasis is placed on both red-teaming (offensive testing techniques to uncover vulnerabilities in AI models) and blue-teaming (defensive strategies to secure and harden models). Topics include robust training methods, secure data handling, monitoring for AI misuse, and AI-specific risk assessment frameworks. Through hands-on projects and case studies, students will develop the skills needed to design, evaluate, and defend secure AI systems in mission-critical environments.
Prerequisite: Senior Standing

ICS 476 Artificial Intelligence for Cybersecurity (NEW)

This course examines Artificial Intelligence as a decision-making engine across five tightly coupled themes: Introduction to AI & Cyber Security; AI Planning & Decision-Making; Defensive AI in Cyber Security; Offensive AI & Autonomous Threats; and Practical Challenges in AI/ML for Security. Students engage through lectures, case studies, and hands-on labs with real datasets, culminating in a capstone project that applies AI planning or ML techniques to either a defensive or offensive security problem.
Prerequisite: Senior Standing

Other Core Courses

ICS 108 Object-Oriented Programming

Advanced object-oriented programming; Inheritance; Polymorphism; Abstract classes and interfaces; Generic and collection classes; File input and output; Exception handling; GUI and event-driven programming; Recursion; Searching and sorting.
Prerequisite: *ICS 104*

ICS 253 Discrete Structures

Propositional Logic, Propositional Equivalence, Predicates and Quantifiers, Nested Quantifiers, Rules of Inference, Introduction to Proofs; Sets, Set Operations, Functions, Sequences and Summations; Mathematical Induction, Strong Induction, Recursive Definitions and Structural Induction; Basics of Counting, Pigeonhole Principle, Permutations and Combinations, Binomial Coefficients, Discrete Probability, Probability Theory; Recurrence Relations, Solving Linear Recurrence Relations, Generating Functions, Inclusion-Exclusion
Prerequisite: *ICS 104*

ICS 202 Data Structures and Algorithms

Review of object-oriented concepts; Basic algorithms analysis; Fundamental data structures - implementation strategies for stacks, queues, and linked lists; Recursion; Implementation strategies for tree and graph algorithms; Greedy Algorithms; Hash tables; Applications of data structures (e.g., data compression and string matching).
Prerequisite: *ICS 108*

DATA 211 Intro. to Data Science

An overview of Data driven approach, Data analytics lifecycle. Basic statistics: Variance, Co-variance, Correlation, Confidence interval and Histogram. Data frames, series, slicing, sorting. Relational database with primary and foreign key. SQL implementation in Python. Data acquisition, cleaning, scrubbing, and manipulation. Correlation analysis, PCA, Linear Regression, Gradient descent, Bayesian classifier, Decision tree, K-means clustering, Hierarchical clustering, Big data, and high-dimensional data. Overview of MapReduce and Hadoop.
Prerequisite: *MATH 102 or MATH 106, ICS 104*

SWE 206 Introduction to Software Engineering

ntroduction to software engineering discipline, software process, requirements analysis and design models. Understanding of ethical and professional issues of software engineering discipline .
Prerequisite: *ICS 108*

COE 292 - Introduction to Artificial Intelligence

Introduction to AI; Uniformed vs. informed search. Constraint satisfaction. Logic and Reasoning pattern; Propositional Logic; Reasoning Patterns. Supervised learning using Nearest Neighbor and SVM. Clustering with mean-shift algorithm. Overview of Neural Networks and training. Overview of deep learning and applications. Feature extraction techniques in Computer Vision. Applications in reinforcement learning. Ethical concerns of AI.
Prerequisite: DATA 211

COE 233 Digital Logic & Computer Organization

Number systems. Boolean Algebra and Minimization of Boolean functions. Combinational circuits analysis and design: multiplexers, decoders, adders, and the ALU. Sequential circuits analysis: flip-flops, Registers. MIPS instruction set architecture. Assembly language: selection and repetition structures. Single cycle and pipelined processor design. Memory hierarchy. ROM, RAM, and cache memories. Evaluation of processor and cache performances.
Prerequisite: ICS 104

ICS 343 Fundamentals of Computer Networks

Introduction to computer networks and layered architectures: Connectivity, topology, circuit and packet switching, TCP/IP and ISO models; Application layer: C/S model, DNS, SMTP, FTP, WWW; Transport layer: TCP and UDP, ARQ, congestion and flow control; Network layer: Internetworking, addressing and routing algorithms and protocols; Data link layer: Framing, error detection and correction, medium access control and LANs; Physical layer: Principles of data communications, circuit switching, encoding, multiplexing and transmission media; Introduction to network security.
Prerequisite: ICS201 Or ICS108

ICS 442 - Penetration Testing and Ethical Hacking

Introduction to penetration testing and ethical hacking, requirements and legal issues, setting up virtual lab; Exploring Kali Linux and Metasploit framework, hacking and penetration testing phases; Information gathering through passive and active reconnaissance, footprinting, social engineering, port scanning; Advanced fuzzing techniques; Exploitation, password attacks and gaining access to remote services; Web penetration testing and web-based exploitation; Maintaining access with backdoors and rootkits; Bypassing defense applications; Wireless and mobile device hacking techniques; Writing penetration testing report; Tools and programming available for penetration testers in both Windows and Linux platforms such as Kali Linux, OpenVAS, Burp, NMAP, Netcat, Python, etc.
Prerequisite: ICS 343 OR COE 344 OR COE 353

DATA 351 Human Contexts and Ethics of Data

Introduction to the ethical, societal, and contextual issues surrounding data collection, analysis, and use. Examples from real-world applications; implications of data on privacy, equity,

accountability, and societal trust. Case studies, discussions, and projects, enhanced critical thinking skills to analyze and address ethical dilemmas in data practices.
Prerequisite: COE 292

ICS 321 Database Systems

Basic database concepts; Conceptual data modeling; Relational data model; Relational theory and languages; Database design; SQL; Introduction to query processing and optimization; Introduction to concurrency and recovery.
Prerequisite: ICS 202

ICS 414 Senior Project II

This is the second of two courses for the multidisciplinary, capstone project. After the multidisciplinary team was formed and the project and its management were defined and detailed, the students embark on executing their tasks going through the project's software development lifecycle in order to develop the prototype software solution component of the problem at hand. The senior project offers the opportunity to integrate the knowledge acquired in preceding courses, as well as promote and instill communication skills, writing skills, and lifelong self- learning.
Prerequisite: ICS 413

ICS 433 Operating Systems

History and evolution of operating systems; Types of operating systems; Operating system structures; Process management: processes, threads, CPU scheduling, process synchronization; Memory management and virtual memory; File systems; I/O systems; Security and protection; Distributed systems; Case studies.
Prerequisite: COE 233 or COE 301

ICS 440 Cryptography and Blockchain Applications

Secret key encryption; Block and stream ciphers, Encryption standards; Number theory: Divisibility, Modular arithmetic, Group theory and Finite fields; Public key encryption: RSA, ElGamal and Rabin cryptosystems; Diffie-Hellman key exchange; Cryptographically secure hashing; Authentication and digital signatures; Digital signature standard (DSS), Randomized encryption; Cryptocurrency, Blockchain models and applications. Security issues and their solutions in Blockchain models and applications. Blockchain payment networks.
Prerequisite: [Math 208 OR MATH 260 OR ICS 253] AND STAT 319

ICS 344: Information Security

Security properties; Confidentiality, integrity, authentication, non-repudiation; Attack vectors, malicious software and countermeasures; Risk management and analysis; Security mechanisms; Secure software development; Defensive programming; Input sanitization; Symmetric and public key cryptography; User authentication and access control; Internet

security: Email and web security, network security protocols and standards such as IPSec and SSL/TLS; Security technologies and systems: Firewalls, VPNs and IDSs/IPSs; Information security process, ethical and legal issues.
Prerequisite: ICS 343 or COE 344

ICS 353: Design and Analysis of Algorithms

Basic algorithmic analysis; Analysis of iterative and recursive algorithms; Advanced algorithmic design techniques (induction, divide and conquer, dynamic programming, backtracking); The complexity classes P and NP; Basic computability; Parallel algorithms.
Prerequisite: ICS 202, ICS 253

ICS 471: Deep Learning

Feedforward networks, Loss functions, Back-propagation training, Regularization, Convolutional neural networks (CNN), Transfer learning, Recurrent and recursive networks (RNN), Vanishing gradient problem, Long-short term memory (LSTM) model, Gated recurrent units (GRUs), Autoencoders, Transformers, and Generative adversarial networks.
Prerequisite: (COE 292 or ICS 381) and (MATH 202 or MATH 208 or MATH 260 or ICS 253) and STAT 319

ICS 472 Natural Language Processing

Fundamentals of Natural language processing (NLP), linguistic representation levels, Language Modelling, Vector Space Semantics and Embedding, POS tagging, Sequence Labelling, Syntactic parsing, Semantic parsing, and key evolving applications (e.g., machine translation, question answering, summarization and information extraction).
Prerequisite: ICS 471

ICS 381: Principles of Artificial Intelligence

AI history and applications; Intelligent agents and expert systems; Introduction to AI programming; Problem solving agents by uninformed, heuristic and local search; Constraint satisfaction and programming, games and adversarial search; Knowledge-based agents: Propositional and firstorder logic, Forward and backward chaining and inference; Planning and reasoning in uncertain situations; Basics of machine learning; Natural language processing; Exposure to other applications of AI (e.g. Vision and Robotics).
Prerequisite: ICS 253
Co-requisites: STAT 319

ICS 413 Senior Project I

This is the first of two courses for the multidisciplinary, capstone project. Multidisciplinary teams will be formed, projects will be defined, and project management discussed.
Prerequisite: ENGL 214, ICS 321, SWE 206, SWE 363

COE 426 Data Privacy

Data privacy: definition and terminologies. Difference between data security and privacy. Data privacy attacks. Data privacy laws and regulations. Privacy risk and impact assessment. Privacy engineering, management, and evaluation. Data anonymization. Statistical privacy. Differential privacy. Cryptographic privacy. Homomorphic encryption. Secure multi-party computation. Secure data outsourcing. Data hiding and steganography. Anonymous networks. Trusted execution environment. Applications of privacy preserving technologies in computer systems and applications.
Prerequisite: Senior Standing

ICS 483: Computer Vision

Image acquisition, Digital image and its properties, Image preprocessing, Segmentation (Thresholding, edge- and region-based segmentation), Morphological image processing. Image feature extraction. Bag of words. Image segmentation. Object detection and classification. Shape analysis. Feature tracking. Motion analysis. Case studies (object recognition / object tracking). Note: It cannot be taken for credit with COE 487 or EE 410.
Prerequisite: ICS 485

ICS 485 Machine Learning

Essential foundations of machine learning; Instance-based learning; supervised learning (linear regression, logistic regression, support vector machines, decision tree, ensemble learning, neural networks, and generative classifiers); unsupervised learning (clustering, EM, mixture models, dimensionality reduction); Applications of Machine learning to real world problems.
Prerequisite: (COE 292 or ICS 381) and (MATH 202 or MATH 208 or MATH 260 or ICS 253) and STAT 319

List of Technical Electives

ICS 477 AI-Driven Computational Forensics (NEW) (Intersectional Course)

This course introduces the evolving field of computational forensics with a focus on modern digital crimes and the use of artificial intelligence in forensic investigations. Students will explore a wide range of forensic domains, including network forensics, dark web tracking, cryptography, and media forensics (image, audio, and video). The course emphasizes both foundational techniques and emerging threats. Key modules include forensic data acquisition, operating system artifacts, social media and text forensics, and biometric surveillance. The course also explores the integration of machine learning and deep learning in evidence analysis and threat detection. Through hands-on labs, real-world case studies, and technical deep dives, students will gain the practical skills and critical thinking needed to analyze, trace, and counteract complex cybercrimes in today's digital landscape.
Prerequisites: Senior Standing

ICS 478 Data-Driven Cybersecurity (NEW) (Intersectional Course)

The rapid growth of advanced cyber-attacks has made machine learning a vital tool in cybersecurity. This course explores ML applications in malware and botnet detection (including obfuscation, polymorphism, and DDoS detection), network and host intrusion detection using signature-based, behavioral, and unsupervised methods, and deep packet inspection. Topics also include anomaly detection in web and proxy logs, spam and phishing classification, authentication security (e.g., Kerberos, pass-the-hash/ticket attacks), and insider/masquerader threat detection using system calls and audit trails. Students will learn about alert correlation via attack graphs, fraud detection with deep learning, and the detection and defense against automated abuse such as CAPTCHA solving. The course concludes with critical issues like adversarial machine learning, privacy, and emerging areas including IoT, mobile, TinyML, and LLMs for cyber defense.
Prerequisites: Senior Standing

ICS 479 Cyber-Physical System Security (NEW)

Introduction to industrial and operational technology (OT) security. Differences between OT and information technology (IT) cybersecurity. Architecture, components, and protocols of industrial control (ICS) systems and supervisory control and data acquisition (SCADA) systems. Threats and vulnerabilities in ICS/SCADA systems. Risk assessment and management. Disaster recovery and business continuity. Standards, regulations, frameworks, and governance for industrial infrastructure systems. Case studies. Project.
Prerequisites: (COE 233 and ICS 344) OR (COE 301 and ICS 344) OR (COE 301 and COE 346)

ICS 480 Reverse Engineering and Exploitation (NEW)

Introduction to assembly language and fundamentals of reverse engineering. Advanced reverse engineering techniques and tools. Shellcode development and exploitation concepts. Stack-based buffer overflow vulnerabilities. Mitigation techniques: stack canaries, data execution prevention (DEP), and address space layout randomization (ASLR). Format string vulnerabilities. Return-oriented programming (ROP). Logical vulnerabilities: integer overflows, race conditions, and code injections. Case studies, hands-on assignments, and applied projects.

Prerequisites: *(COE 233 and ICS 344) OR (COE 301 and ICS 344) OR (COE 301 and COE 346)*

ICS 410 Programming Languages

Programming paradigms: Object-oriented, imperative, functional, and logic; Application development in these paradigms; Fundamentals of Language Design: Syntax and semantics; Language implementation: virtual machines; Compilation, interpretation, and hybrid.

Prerequisites: *ICS 202*

ICS 445 Network Management and Security

Network Management Standards, Models, and protocols. Network Management Applications, Tools, and Systems. Remote Monitoring and Management (RMM). Large scale network management techniques and systems. Security of LANs, wireless LANs, and cellular networks. Authentication, authorization, accountability, and access controls of computer networks. Network protection tools: Firewalls, Intrusion Detection and Prevention Systems, Sandboxing, proxies. Study of diverse attack types: DDoS, spoofing, flooding, hijacking, poisoning, DNS, replay attacks and their countermeasures. Hands-on experiences in network security using Kali Linux. Hands-on experiences in implementing secure, manageable networks.

Prerequisites: *COE 466*

ICS 439 Cryptography in Quantum Era

The difference between quantum cryptography and existing conventional cryptography, Integer Algorithms, Modular Arithmetic , Symmetric-key Cryptography, Perfect Secrecy, Stream and Block cipher, Group Theory, Public Key Cryptography, Quantum cryptography and cryptanalysis, Key distribution protocols, Quantum money, quantum one-time pad.

Prerequisites: *ICS 343*

ICS 474 Big Data Analytics

Introduction and foundation of big data and big-data analytics. Sources of big data. Smart clouds. Hadoop file system and Apache Spark. Storage management for big data. Machine learning and visualization with big data. Applications of big data. Big data security, privacy, and its societal impacts.

Prerequisites: *STAT 319*

ICS 486: Agent-Based Systems and Swarm Intelligence

Fundamental concepts and models of multi-agent systems (MAS) and their characteristics; Models of agency; Architectures and languages; Logics for MAS; Deductive and practical reasoning agents; Reactive and hybrid agents; Coordination, negotiation and coalition mechanisms; Learning in MAS; Agent and swarm-based models to solve an optimization problem using PSO, Ants, and GA; Implementing agent and swarm-based applications (e.g. in electronic commerce, semantic Web agents, and information retrieval).
Prerequisites: *ICS 381*

ICS 487: Intelligent Decision Support Systems

Introduction and need for Decision Support Systems (DSS). Nature of Decision problems and the elements of the decision process with examples. Essential elements of decision-making. Evolution of DSS: management information systems, decision support systems (DSS), intelligent decision support systems (IDSS). IDSS architecture, data collection, data analysis & exploration, design and implementation. IDSS techniques: case-based reasoning, decision trees, knowledge representation. Case studies and projects: e-commerce, knowledge management, recommender systems and actions.
Prerequisites: *STAT 319*

ICS 488: Knowledge Based System and Soft Computing

Introduction to knowledge and soft computing based systems; Handling imprecision and uncertainty; Probabilistic reasoning and rough sets; Structured approach to fuzzy reasoning; Machine learning and neuro computing; Evolutionary computation and genetic algorithms; Immunological computing; Hybrid computational intelligence methods; Neuro-fuzzy inference systems; Combination of genetic algorithms with neural networks; Combination of genetic algorithms with fuzzy based systems; Applications to real life applications for building expert systems and pattern recognition.
Prerequisites: *ICS 381*

MATH 405 Learning from Data

Review of basic vector and matrix operations, Orthogonality, Projection, Eigen decomposition, Factorizations, Covariance, Multivariate Gaussian, Minimum Problems, Lagrange Multipliers, Linear Programming, Least-Square Estimation, Maximum Likelihood Estimation, Gradient Descent. Applications to Machine Learning using Linear Regression and Neural Networks.
Prerequisites: *MATH 102 and STAT 319 and ICS 104*

SWE 363 Web Engineering and Development

Fundamentals of web and mobile applications and how they impact people's lives; Building responsive front-end web and mobile apps; Back-end programming of dynamic and data-driven websites; Development frameworks for web and mobile apps; Security issues of web applications; Practical applications to real-world problems.

Prerequisites: Junior Standing

SWE 463 Mobile Application Development

Comprehensive introduction to building mobile applications for devices based on Android and iOS operating systems, including use of standard integrated development environment: Android Studio and Xcode, as well as testing and debugging on devices and emulators/simulators. Topics cover programming language for iOS programming, and mobile platform APIs for user interface, graphics, networking, data, and web services
Prerequisite: ICS 108

STAT 413 Statistical Modeling

Simple and Multiple Linear Regression, Polynomial Regression, Splines; Generalized Additive Models; Hierarchical and Mixed Effects Models; Bayesian Modeling; Logistic Regression, Generalized Linear Models, Discriminant Analysis; Model Selection.
Prerequisites: MATH 405

STAT 460 Time Series (Analysis)

Examples of simple time series. Stationary time series and autocorrelation. Autoregressive moving average processes. Modeling and forecasting with ARMA processes. Maximum likelihood and least squares estimator. Non-stationary time series.
Prerequisites: STAT 310 or DATA 341

ISE 487 Predictive Analytics Techniques

Characteristics of time series, trends, seasonality, noise, stationarity; Statistical background and model evaluation methods; Time series regression, variable selection and general linear regression; Exponential Smoothing and seasonal data; ARIMA based models including MA, AR, ARMA, ARIMA and SARIMA, Model validation and parameter estimation; Advance predictive analytics: Multivariate prediction, state space models, neural networks, spectral analysis and Bayesian methods.
Prerequisites: MATH 405 and ICS 104

CIE 464 Industrial Internet of Things (IoT) Technology

Internet of Things (IoT) technology and Industrial Control Systems (ICS) for Industry 4.0, IoT/IIoT reference architectures and data flow, industrial communication technologies and networking protocols, highly distributed system architectures and computing platforms, digital twins, ICS security, predictive analytics, maintenance, and system optimization. Embedded intelligence in end devices to perform local analytics and optimization. Applications of IIoT in various areas such as energy sector, manufacturing, and smart cities *Prerequisites: ICS 343*

DATA 311 Data Engineering

Data lineage lifecycle, including question formulation, data collection and cleaning, and exploratory data analysis (EDA) and visualization. Introduction to statistical concepts such as measurement error. Techniques for scalable data processing concepts in data architecture and data stores (databases, warehousing, data lakes, data streams). Data ingestion and ETL (Extract, Transform, Load) processes. Batch vs. real-time data processing. Construction of data processing pipelines to support analytics and machine learning workflows. Workflow orchestration, automation, and the scheduling and managing of end-to-end data processing pipelines. Data observability and monitoring. Introduction to Infrastructure as Code (IaC) for data engineering. Alignment of data governance and security practices including privacy and compliance. End-to-end data hands-on data projects integrating diverse concepts, leveraging cloud platforms, tools, and techniques to design, build, and deploy data processing pipelines.

Prerequisites : *DATA 211 and ICS 202 and MATH 208*

DATA 321: Matrix Theory for Data Science

Matrix Operations. Matrix Inverses, Smith Normal Form. LU-Factorization, PLU-Factorization. Determinant and Invertibility, Cramer's Rule. Eigenvalues and Eigenvectors. Diagonalization, Multiplicity Theorems. Subspaces and Spanning, Null Space, Image Space, Eigenspace. Independence and Dimension. Orthogonality, Expansion Theorem. Rank of a Matrix, Nullity, Rank-Nullity Theorem. Similarity and Diagonalization, Symmetric Matrices. Best Approximation and Least Squares. Orthogonal Diagonalization, Principal Axes Theorem. Positive Definite Matrices, Cholesky Factorization. QR-Factorization, Power Method. Singular Value Decomposition, Pseudoinverse, Penrose Theorem. Unitary Diagonalization, Schur's Theorem, Spectral Theorem.

Prerequisites : *MATH208 or MATH 225*

Credit Restrictions : *Not to be taken for credit with MATH 432.*

DATA 322: Mathematical Modeling for Data Science

Introduction to mathematical modeling in data science. Classification of mathematical models into linear, nonlinear, and regularized models. Exploration of models for supervised learning (regression, classification) and unsupervised learning (dimension reduction, clustering). Tree-based models and ensemble techniques such as random forests and boosting. Case studies on ridge regression, lasso regression, and support vector machines, with practical applications and insights into model selection and evaluation.

Prerequisites : *DATA 211 and MATH 208*

DATA 341 Statistical Methods for Data Science

Statistical methods used to solve data problems. Topics include group comparisons and ANOVA, standard parametric statistical models, multiple linear regression, robust regression, logistic regression and classification, bias and variance, and bootstrap method. An important

focus of the course is on statistical computing and reproducible statistical analysis. The course includes hands-on experience in analyzing real world data from the social, life, and physical sciences. The R language (or a similar language like Python or Julia) is used.
Prerequisites : *STAT 319 or STAT 214*

DATA 421 Optimization for Data Science

Convex Optimization Problems, Coordinate Descent, Steepest Descent, Improving Directions Methods, Newton, Quasi-Newton, Conjugate-Gradient. Stochastic Gradient Descent. Meta Heuristics such as Evolutionary Algorithms and Particle Swarm. Applications to Data Science and Machine Learning problems.
Prerequisites : *MATH 201 and DATA 311*

COE 403 Computer Architecture

Introduction to parallel computer architecture. Power, cost, performance. Pipelined CPU cores and dynamic instruction execution. Hardware multithreading and synchronization. Vector and SIMD processing. Multilevel cache hierarchy and cache coherence. Perspectives on parallel programming. Server and storage architecture.
Prerequisite: COE 233

COE 427 Distributed Computing

Introduction to distributed computing and systems: processes, tasks, threads, and abstraction. Architectural models of distributed systems and their design issues. Mutual exclusion, condition variables, and atomic instructions. Time and synchronization. Distributed algorithms and their models of execution. Consensus and leader election protocols. Distributed file systems. Distributed ledgers. Scalability-enabling techniques: partitioning and replication. CAP theorem. Locking and transactions: 2PL and 2PC. ACID transactions Programming constructs and techniques: sockets programming, remote procedure calls. Fault-tolerance. Logging and crash recovery. Examples of distributed systems: DNS and CDN. Hands-on sessions.
Prerequisite: Senior Standing

COE 452 Principles of Cloud-based Systems

Introduction to Cloud Computing. Cloud characteristics and deployment models. Cloud architectures and enabling technologies. Cloud operations: resource provisioning and load balancing. Cloud performance guarantees: service quality metrics and service level agreement. Cloud infrastructure design, development, and migration. Cloud infrastructure management and monitoring. Cost metrics and pricing models. Cloud laws and regulations. Software-defined networking and network function virtualization. Hands-on activities and case studies. Project.
Prerequisite: ICS 343

COE 453 Cloud and Edge Computing

Internet and web protocols and technologies (HTTP). Basics of web development: frontend, backend, and full-stack (HTML, CSS, Javascript, Node.js). Web services and RESTful APIs. Introduction to utility computing: Cloud and Edge computing. Cloud Service-oriented architecture and microservices. The XaaS pyramid. Serverless computing. Cloud resource management. Virtualization and containerization (Docker and Kubernetes). Cloud data storage: BigTable, Dynamo, and Cassandra. Batch cloud processing: MapReduce and Hadoop, Spark, BigTable. Cloud-native applications. Security of Cloud computing. Hands-on activities and projects.

Prerequisite: ICS 343

COE 454 Internet of Things

IoT systems design and architecture: elements of IoT system, potentials, constrains, and applications. IoT access technologies: 802.15.4, BLE, LoRaWAN, NB-IoT, Sigfox, and 802.11ah. IoT networking protocols: IPv4, IPv6, 6LoWPAN, and RPL. IoT application layer protocols: HTTP, MQTT, and CoAP. Wireless Personal Area Network (WPAN) using ZigBee network. Low Power Wide Area Network (LPWAN) using LoRAWAN. Machine-to-Machine (M2M) and Machine-to-Cloud (M2C) communication. IoT network architecture: cloud, fog, and edge layers. IoT system security. Data analytics for IoT.

Prerequisite: ICS 343

COE 466 Quantum Architecture and Algorithms

An introduction to the model of quantum computation, quantum hardware, quantum processors, quantum circuits and instruction sets, quantum programming languages, quantum Fourier transform, quantum error correction, quantum algorithms, and applications of quantum computing.

Prerequisite: COE 292 and MATH 208

COE 484 Introduction to Robotics

Taxonomy of robots, robot arms, autonomous robots, robotic sensor networks, Internet robotics and applications. Kinematics, linear algebra, motion coordination, singularities, and multiple solutions. Modeling robots using state-space representation, linearization, LTI systems, internal stability, input-output stability, output and state feedback. Controller design techniques using pole-placement, controllability, and observability matrices. Motion planning, Bug, Dijkestra, A*, D* algorithms, probabilistic sampling. Robot vision, essential image processing filters, camera models, image motion and tracking, visual servoing.

Prerequisite: Senior Standing