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King Fahd University of Petroleum & Minerals
College of Computer Science and Engineering
Information and Computer Science Department

BS Program in Software Engineering – Student Guide

November 9, 2026

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Revision History

Date	Version	Description	Author(s)
Nov 9, 2026		As per instructions from Vice President Academic Affairs: Replace MATH 371 (from the Science Elective Courses) with CIE 301.	Farag Azzedin
August 13, 2025	1.7	Updated degree plan and prerequisite flowchart to reflect updating the senior project courses, adding the ICS 353 course, removing the CHEM 101 course, updating STAT 319 to become STAT 201 and adding the science elective SC XXX course, with a list of science elective courses.	Wasfi Al-Khatib, Farag Azzedin and Mahmood Niazi
November 8, 2023	1.6	Updated degree plan and degree chart to update summer training credit hour.	Sajjad Mahmood
October 10, 2022	1.5	Update the AI CX course number and title. Updated CX details. Added the course title, description, and prerequisites of SWE 455. Updated the title and description of ICS 471. Updated the description and prerequisites of ICS 485. Updated the description and prerequisites of ICS 472. Updated the prerequisites of ICS 440.	Sajjad Mahmood
August 31, 2022	1.4	Updated degree plan and degree chart to update prerequisite of CGS 392.	Sajjad Mahmood
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March 2, 2021	1.1	Updated pre-requisite chart to fix missing pre-requisite of ISE 291; updated elective course list; added concentration details.	Sajjad Mahmood
August 27, 2020	1.0	Prepared student guide based on the new program.	Sajjad Mahmood

1. Introduction

The Department of Information and Computer Science offers a BS in Software Engineering. The current program was revised and approved in 2020. The program has been developed considering IEEE/ACM Software Engineering SE2014 guidelines and meets ABET's Engineering Accreditation Criteria (EAC).

1.1 Software Engineering Program Mission

To provide high-quality education in software engineering that prepares students for professional careers and postgraduate education with an emphasis on applying engineering principles to software development.

1.2 Software Engineering Program Education Objectives

Graduates of the software engineering program will:

1. Be successful in performing the duties of a software engineering-related position.
2. Be successful in completing an advanced degree program.
3. Work as individuals with minimum guidance and as leaders or members in teams.
4. Follow appropriate practices within a professional, legal, and ethical framework.
5. Maintain currency through self-learning or other professional development.

1.3 Software Engineering Student Learning Outcomes

The software engineering program enables students to acquire, by the time of graduation, the following learning outcomes:

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
3. An ability to communicate effectively with a range of audiences.
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
5. An ability to function effectively on a team whose members provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
6. An ability to develop and conduct appropriate experimentation, analyze, and interpret data, and use engineering judgment to draw conclusions.
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

2 Degree Requirements

(a) Math & Science Requirements (31 credit hours)		Credit Hours
Natural Sciences	PHYS 101 (4), PHYS 102 (4)	8
Mathematics	MATH 101 (4), MATH 102 (4), MATH 201 (3), MATH 208 (3), STAT 201 (3), ICS 253 (3)	20
Science Elective	SC XXX (3)	3
		31

(b) General Studies Requirements (22 credit hours)		Credit Hours
English	ENGL 101 (3), ENGL 102 (3), ENGL 214 (3)	9
Islamic and Arabic studies	IAS 121 (2), IAS 111 (2), IAS 212 (2), IAS XXX (2)	8
Global & Social Studies	CGS 392 (1), GS XXX (3)	4
Physical Education	PE 101 (1)	1
		22

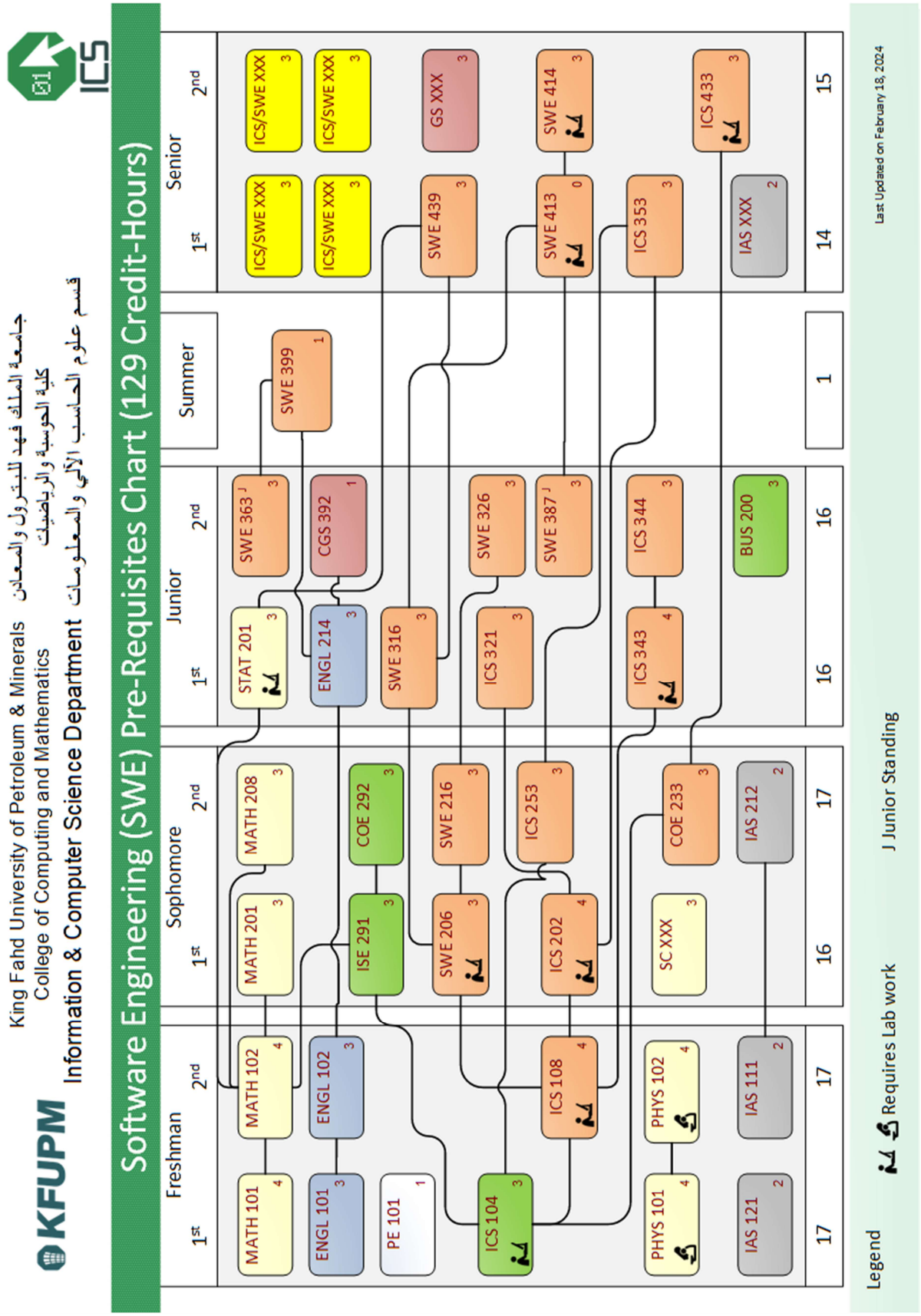
(c) Digital Foundation & Business Requirements (12 credit hours)		Credit Hours
Digital Foundation	ICS 104 (3), ISE 291 (3), COE 292 (3)	9
Business Studies	BUS 200 (3)	3
		12

(d) **Core Requirements (51 credit hours**)		Credit Hours
SWE	SWE 206 (3), SWE 216 (3), SWE 316 (3), SWE 326 (3), SWE 363 (3), SWE 387 (3), SWE 413 (0), SWE 414 (3), SWE 439 (3)	24
CS	ICS 108 (4), ICS 202 (4), ICS 321 (3), ICS 344 (3), ICS 343 (4), ICS 353 (3), ICS 433 (3)	24
COE	COE 233 (3)	3
		51

(e) Core Electives (12 credit hours)		Credit Hours
Major Electives	Four SWE/ICS XXX courses	12
		12

(f) Summer Training (1 credit hours)		Credit Hours
Summer Training	SWE 399 (1)	1
		1
The total number of credit hours required is		**129**

2.1 Degree Flow Chart



2.2 Degree Plan

Course		Title	LT	LB	CR	Course		Title	LT	LB	CR
First Year (Preparatory)											
ENGL	01-x	Preparatory English I (First Quarter)	15	5	4	ENGL	03-x	Prep. English III (Third Quarter)	15	5	4
ENGL	02-x	Preparatory English II (Second Quarter)			4	ENGL	04-x	Pre. English IV (Fourth Quarter)			4
MATH	001	Prep. Math 1	3	1	4	MATH	002	Prep. Math II	3	1	4
PYP	001	Pre. Physical Science	2	0	2	PYP	002	Prep. Computer Science	0	2	1
PYP	003	University Study Skills	0	2	1	PE	004	Prep. Eng. Technology	0	2	1
PE	001	Prep. Health and Physical Edu. 1	0	2	1	PE	002	Prep. Health and Physical Edu. II	0	2	1
			20	10	16				18	12	15
Total Credit required in Preparatory Program: 31											
Second Year (Freshman)											
ENGL	101	Intro. To Academic Discourse	3	0	3	ENG	102	Intro. To Report Writing	3	0	3
IAS	121	Language Foundation	2	0	2	IAS	111	Belief & Its Consequences	2	0	2
ICS	104	Introduction to Programming in Python and C	2	3	3	ICS	108	Object Oriented Programming	3	3	4
MATH	101	Calculus I	4	0	4	MATH	102	Calculus II	4	0	4
PHYS	101	General Physics I	3	3	4	PHYS	102	General Physic II	3	3	4
PE	101	Health and Physical Educ. I	0	2	1						
			14	8	17				15	6	17
Third Year (Sophomore)											
ICS	202	Data Structure & Algorithms	3	3	4	COE	233	Digital Logic & Computer Organization	3	0	3
ISE	291	Introduction to Data Science	3	0	3	COE	292	Introduction to Artificial Intelligence	3	0	3
MATH	201	Calculus III	3	0	3	IAS	212	Ethics and Governance	2	0	2
SC	XXX	Science Elective	3	0	3	ICS	253	Discrete Structures	3	0	3
SWE	206	Intro. to Software Engineering	2	3	3	MATH	208	Intro. to Diff. Eq.& Linear Algebra	3	0	3
						SWE	216	Requirements Engineering	3	0	3
			14	6	16				17	0	17
Fourth Year (Junior)											
ENGL	214	Academic & Professional Com.	3	0	3	BUS	200	Business & Entrepreneurship	3	0	3
ICS	321	Database Systems	3	0	3	CGS	392	Career Essentials	0	2	1
ICS	343	Fundamentals of Computer Networks	3	3	4	ICS	344	Information Security	3	0	3
STAT	201	Prob. And Stat. for Eng. & Scientists	3	1	3	SWE	326	Software Testing	3	0	3
SWE	316	Software Design & Construction	3	0	3	SWE	363	Web Eng. & Development	3	0	3
						SWE	387	Software Project Management	3	0	3
			15	4	16				15	2	16
Summer Training (0-0-1)											
Fifth Year (Senior)											
IAS	XXX	Islamic/Arabic Elective	2	0	2	GS	XXX	Global & Social Studies Elective	3	0	3
ICS	353	Design & Analysis of Algorithms	3	0	3	ICS	433	Operating Systems	3	1	3
ICS/SWE	XXX	Major Elective I	3	0	3	ICS/SWE	XXX	Major Elective III	3	0	3
ICS/SWE	XXX	Major Elective II	3	0	3	ICS/SWE	XXX	Major Elective IV	3	0	3
SWE	413	Senior Design Project I	0	1	0	SWE	414	Senior Design Project II	0	6	3
SWE	439	Software Quality Eng.	3	0	3						
			14	1	14				12	7	15
Total credits required in Degree Program: 129											

2.3 Concentration Details

Students can use their four major elective courses to register in one of the concentrations as follows:

1. Artificial Intelligence and Machine Learning

Course		Title	LT	LB	CR
ICS	471	Deep Learning	3	0	3
ICS	472	Natural Language Processing	3	0	3
ICS	483	Computer Vision	3	0	3
ICS	485	Machine Learning	3	0	3

2. Cyber Security & Blockchain

Course		Title	LT	LB	CR
ICS	440	Cryptography & Blockchain Applications	3	0	3
ICS	442	Pen. Testing & Ethical Hacking	3	0	3
SWE	445	Secure Software Development	3	0	3
COE	426	Data Privacy	3	0	3

3. Cloud Computing

Course		Title	LT	LB	CR
COE	427	Distributed Computing	3	0	3
COE	452	Principles of Cloud-Based Systems	3	0	3
COE	453	Cloud and Edge Computing	3	0	3
SWE	455	Cloud Applications Engineering	3	0	3

4. Computer Networks

Course		Title	LT	LB	CR
ICS	445	Network Management and Security	3	0	3
COE	444	Network Design	3	0	3
COE	446	Mobile Computing	3	0	3
COE	453	Cloud and Edge Computing	3	0	3

5. Internet of Things

Course		Title	LT	LB	CR
COE	450	Introduction to Smart Systems	3	0	3
COE	454	Internet of Things	3	0	3
CISE	464	Industrial Internet of Things Technology	3	0	3
ICS	474	Big Data Analytics	3	0	3

6. Decision Analytics

Course		Title	LT	LB	CR
ISE	447	Decision Making	3	0	3
ISE	455	Applied Models for Optimal Decisions	3	0	3
ICS	487	Intelligent Decision Support Systems	3	0	3
MATH	407	Applied Game Theory	3	0	3

3 Summary of SWE & ICS Courses

3.1 SWE Core Courses

SWE 206	Introduction to Software Engineering	2	3	3
SWE 216	Requirements Engineering	3	0	3
SWE 316	Software Design and Construction	3	0	3
SWE 326	Software Testing	3	0	3
SWE 363	Web Engineering and Development	3	0	3
SWE 387	Software Project Management	3	0	3
SWE 399	Summer Training	0	0	0
SWE 413	Senior Design Project I	0	1	0
SWE 414	Senior Design Project II	0	6	3
SWE 439	Software Quality Engineering	3	0	3

3.2 CS Core Courses

ICS 104	Introduction to Programming in Python and C	2	3	3
ICS 108	Object-oriented Programming	3	3	4
ICS 202	Data Structures and Algorithms	3	3	4
ICS 253	Discrete Structures	3	0	3
ICS 321	Database Systems	3	0	3
ICS 343	Fundamentals of Computer Networks	3	3	4
ICS 344	Information Security	3	0	3
ICS 353	Design and Analysis of Algorithms	3	0	3
ICS 433	Operating Systems	3	1	3

3.3 SWE/CS Elective Courses

SWE 302	Game Programming	3	0	3
SWE 321	Formal Methods and Models in Software Engineering	3	0	3
SWE 416	Software Architecture	3	0	3
SWE 422	Usability Engineering	3	0	3
SWE 436	Object-Oriented Design Patterns	3	0	3
SWE 440	Information Security Management	3	0	3
SWE 445	Secure Software Development	3	0	3

SWE 455	Cloud Applications Engineering	3	0	3
SWE 463	Mobile Application Development	3	0	3
SWE 487	Software Processes and Process Improvements	3	0	3
SWE 490	Special Topic I	3	0	3
SWE 491	Special Topic II	3	0	3
SWE 497	Undergraduate Research	3	0	3
ICS 355	Theory of Computing	3	0	3
ICS 381	Principles of Artificial Intelligence	3	0	3
ICS 410	Programming Languages	3	0	3
ICS 412	Compiler Construction Techniques	3	0	3
ICS 415	Computer Graphics	3	0	3
ICS 424	Advanced Database Systems	3	0	3
ICS 437	Distributed Systems	3	0	3
ICS 440	Cryptography and Blockchain Applications	3	0	3
ICS 441	Digital Forensics Techniques	3	0	3
ICS 442	Penetration Testing and Ethical Hacking	3	0	3
ICS 443	Network Design & Management	3	0	3
ICS 445	Network Management and Security	3	0	3
ICS 446	Cluster Computing	3	0	3
ICS 447	Computer Network Technologies	3	0	3
ICS 448	Network and Security Administration	3	0	3
ICS 471	Deep Learning	3	0	3
ICS 472	Natural Language Processing	3	0	3
ICS 473	Bioinformatics Mining and Algorithms	3	0	3
ICS 474	Big Data Analytics	3	0	3
ICS 483	Computer Vision	3	0	3
ICS 484	Arabic Computing	3	0	3
ICS 485	Machine Learning	3	0	3
ICS 486	Agent-Based Systems and Swarm Intelligence	3	0	3
ICS 487	Intelligent Decision Support Systems	3	0	3
ICS 488	Knowledge-Based Systems and Soft Computing	3	0	3
ICS 489	Applications of Machine Learning	3	0	3
ICS 490	Special Topics I	3	0	3
ICS 491	Special Topics II	3	0	3

3.4 Science Elective Courses

AS 201	Financial Mathematics	3	0	3
BIOL 233	Biology for Engineers	2	3	3
GEOL 201	Physical Geology	2	3	3
GEOL 202	Applied Geosciences for Scientists and Engineers	2	3	3
GEOL 303	Sustaining The Earth	3	0	3
GEOP 202	Introduction to Geophysics	3	0	3
GEOP 472	Meteorology and Climatology	3	0	3
CIE 301	Numerical Methods	3	0	3
MATH 372	Quantitative Methods for Actuaries	3	0	3
MATH 432	Applied Matrix Theory	3	0	3
MATH 434	Calculus of Variations and Optimal Control	3	0	3
MATH 435	Ordinary Differential Equations	3	0	3
MATH 445	Introduction to Complex Variables	3	0	3
MATH 451	Differential Geometry	3	0	3
MATH 463	Combinatorics	3	0	3
MATH 467	Graph Theory	3	0	3
MATH 474	Linear & Nonlinear Programming	3	0	3
MATH 475	Wavelets and Applications	3	0	3
PHYS 203	Electrical and Magnetic Properties of Materials	3	0	3
PHYS 204	General Physics III	3	0	3
PHYS 213	Modern Physics	3	0	3
PHYS 215	Introduction to Astronomy	3	0	3

4 Catalog Description of SWE and ICS Courses

4.1 SWE Courses

SWE 206 Introduction to Software Engineering (2-3-3)
Introduction to software engineering discipline, software process, requirements analysis and design models. Understanding of ethical and professional issues of software engineering discipline
Prerequisites: ICS 108

SWE 216 Requirements Engineering (3-0-3)
Requirements engineering process. Methods, tools, and techniques for eliciting, organizing, and documenting software requirements. Analysis and validation techniques, including need, goal, and use case analysis. Requirements documentation standards. Traceability. Requirements management. Handling requirements changes. Capturing usability requirements and developing UI prototypes based on requirements. Students participate in a group project on software requirements.
Prerequisites: SWE 206

SWE 302 Game Programming (3-0-3)
Introduction to games; Game programming principles; Game development engines: PyGame and Unity3D; Game data structures; Game intelligence; Simulation; Graphics and animation; Collision detection; Strategy games; Action games; Games research; Application of games to other domains.
Prerequisites: SWE 206

SWE 316 Software Design and Construction (3-0-3)
Study of design concepts and notations. Architecture, construction, and design patterns. Designing for different qualities criteria. Design evolution processes and activities.
Prerequisites: SWE 206

SWE 321 Formal Methods and Models in Software Engineering (3-0-3)
Mathematical foundations for formal methods. Formal languages and techniques for specification and design, including specifying syntax using grammars and finite state machines. Analysis and verification of specifications and designs. Use of assertions and proofs. Automated program and design transformation.
Prerequisites: ICS 202 and ICS 253

SWE 326 Software Testing (3-0-3)
Practical ways to design high quality tests during all phases of software development. Test Planning. Test design. Test coverage criteria. Test automation. Concept of static analysis. Reviews. Walkthroughs. Inspections. Students participate in a group project on software.
Prerequisites: SWE 216

SWE 363 Web Engineering and Development (3-0-3)
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 387 Software Project Management **(3-0-3)**
Introduction to project management concepts, managing time, cost, change, risk, quality, communication, and people; development and management standards and managing software development projects.
Prerequisites: Junior Standing

SWE 399 Summer Training **(0-0-0)**
A summer period of 8 weeks spent as a trainee in industry, business, or government agencies for the purpose of familiarizing the student with the real job world and enabling him to apply and relate his academic knowledge to a real work environment. The student is required to participate in software engineering related activities and use his time to get acquainted with the software engineering related functions and resources used by his employing organization. Besides progress reports, the student is required to submit a final report and do a presentation on his experience and the knowledge he gained during his summer training program.
Prerequisites: SWE 363, ENGL 214 and Department Approval

SWE 413 Senior Design Project I **(0-1-0)**
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.
Prerequisites: SWE 316 and SWE 387

SWE 414 Senior Design Project II **(0-6-3)**
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.
Prerequisites: SWE 413

SWE 416 Software Architecture **(3-0-3)**
Study the concepts, principles, methods, and best practices in software architecture. Different architectural styles, patterns and product lines are presented and compared. Methods to analyze, evaluate and document software architectures are also discussed. Students participate in a group project on software architecture design.
Prerequisites: SWE 316

SWE 422 Usability Engineering **(3-0-3)**
Design, implement and evaluate software system interfaces with focus on usability, interaction paradigms and human computer activities. The lifecycle of an interactive human computer interface is studied from both engineering and end-user perspectives.
Prerequisites: SWE 206

SWE 436 Object-Oriented Design Patterns **(3-0-3)**
A depth study of object-oriented design patterns. How design patterns solve design problems? How to select a design pattern? How to use a design pattern? Detailed study of creational patterns, structural patterns, and behavioral patterns. Case studies.
Prerequisites: SWE 316

SWE 439 Software Quality Engineering **(3-0-3)**
Overview of engineering foundations of software, basics of measurement theory, empirical experimentation in software engineering, software metrics and measuring software quality.
Prerequisite: SWE 316 and (STAT 319 or STAT 201)

SWE 440 Information Security Management (3-0-3)
Introduction to information security management principles, management of threats to and vulnerabilities of information security, risk management, and to apply the knowledge of people and technical security controls.
Prerequisite: Senior Standing

SWE 445 Secure Software Development (3-0-3)
Security in requirements engineering; Secure designs; Risk analysis; The SQUARE Process Model; Threat modeling; Defensive coding; Software protection; Fuzzing; Static analysis and security assessment; Memory leaks, buffer and heap overflow attacks, injection attacks.
Prerequisite: Senior Standing

SWE 463 Mobile Application Development (3-0-3)
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

SWE 487 Software Processes and Process Improvements. (3-0-3)
Software process models. Software process analysis. Life cycle process models and standards. Process implementation at various levels like organization, project, team, or individual. Measurement and analysis of software process. Process improvements.
Prerequisite: SWE 387

SWE 490 Special Topics I (3-0-3)
In-depth study of a selected special topic relevant to software engineering
Prerequisites: Consent of the Instructor

SWE 491 Special Topics II (3-0-3)
In-depth study of a selected special topic relevant to software engineering
Prerequisites: Consent of the Instructor

SWE 497 Undergraduate Research (3-0-3)
The course introduces students to research. Explains the differences between different publications channels like conferences, journals, books, and book chapters. Introduces students to metrics like impact factor and H-index. Teaches how to search and locate relevant literature on a given research topic. Introduces students to research methodology, experimentation design, and ways to conduct experiments and report the results. It also teaches students on how to prepare a research article.
Prerequisites: Consent of the Instructor

4.2 CS Courses

ICS 104: Introduction to Programming in Python and C **(2-3-3)**

Overview of computer hardware and software. Programming in Python with emphasis on basic program constructs: variables, assignments, expressions, decision structures, looping, functions, lists, files, and exceptions; Introduction to objects and classes. Programming in C with emphasis on pointers and functions with output parameters. Simple multidisciplinary problem solving in science, engineering, and business.

Prerequisites: None.

ICS 108: Object-Oriented Programming **(3-3-4)**

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.

Prerequisites: ICS 104

ICS 202: Data Structures and Algorithms **(3-3-4)**

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).

Prerequisites: ICS 108

ICS 253: Discrete Structures **(3-0-3)**

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.

Prerequisites: ICS 104

ICS 321: Database Systems **(3-0-3)**

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.

Prerequisites: ICS 202

ICS 343: Fundamentals of Computer Networks **(3-3-4)**

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.

Note: This course cannot be taken for credit with COE 344.

Prerequisites: ICS 108

ICS 344: Information Security **(3-0-3)**

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.
Prerequisites: ICS 343 or COE 344

ICS 353: Design and Analysis of Algorithms (3-0-3)
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.
Prerequisites: ICS 202, ICS 253

ICS 355: Theory of Computing (3-0-3)
Regular grammars: Equivalence of DFA, NDFA and regular expressions, pumping lemma, emptiness, and membership; Context-Free Grammars: parsing and ambiguity, normal forms, applications, equivalence of PDA's and CFG's, pumping lemma, emptiness and membership; Turing machines: Programming techniques for Turing machines, universal Turing-machine; Undecidability: Recursively enumerable and recursive languages, undecidability, problem reduction, undecidable problems of CFG's, RE's and TM's.
Prerequisites: ICS 253

ICS 355: Theory of Computing (3-0-3)
Regular grammars: Equivalence of DFA, NDFA and regular expressions, pumping lemma, emptiness, and membership; Context-Free Grammars: parsing and ambiguity, normal forms, applications, equivalence of PDA's and CFG's, pumping lemma, emptiness and membership; Turing machines: Programming techniques for Turing machines, universal Turing-machine; Undecidability: Recursively enumerable and recursive languages, undecidability, problem reduction, undecidable problems of CFG's, RE's and TM's.
Prerequisites: ICS 253

ICS 381: Principles of Artificial Intelligence (3-0-3)
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 first-order 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)
Prerequisites: ICS 253
Co-requisites: (STAT 319 or STAT 201)

ICS 410: Programming Languages (3-0-3)
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 412: Compiler Construction Techniques (3-0-3)
Compiler techniques and methodology; Organization of compilers; Lexical and syntax analysis; Parsing techniques; Object code generation and optimization, detection, and recovery from errors; Contrast between compilers and interpreters.
Prerequisites: ICS 202, ICS 253

ICS 415: Computer Graphics **(3-0-3)**

Applications of computer graphics; Graphics systems and devices; Output primitives and their attributes; Geometric transformations; Window to viewport mapping and clipping; Curves and surfaces; Three-dimensional viewing; Hidden surface removal; illumination and color models; Animation.

Prerequisites: ICS 202

ICS 424: Advanced Database Systems **(3-0-3)**

Data preprocessing, data warehousing and OLAP; Security, transaction processing, concurrency control techniques, and backup and recovery of relational databases; Introduction to non-relational database systems such as NoSQL and NewSQL databases.

Prerequisites: ICS 321

ICS 433: Operating Systems **(3-1-3)**

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.

Prerequisites: COE 233 or COE 301

ICS 437: Distributed Systems **(3-0-3)**

Introduction to distributed systems; Distributed systems architecture; Computer networks for distributed systems; Distributed objects and remote invocation; Distributed naming; Distributed file systems; Security and synchronization in distributed systems; Distributed coordination and agreement; Distributed transactions; Distributed replication; Distributed multimedia systems, distributed shared memory; Case studies.

Note: It cannot be taken for credit with COE 423.

Prerequisites: ICS 343 or COE 344

ICS 440: Cryptography and Blockchain Applications **(3-0-3)**

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.

Prerequisites: (MATH 208 or MATH 202 or MATH 260 or ICS 254) and (STAT 319 or STAT 201)

ICS 441 Digital Forensics Techniques **(3-0-3)**

Major phases of digital investigation; Data acquisition of physical storage devices; Study of file systems with a main focus on Microsoft Windows and Linux systems; File system analysis and file recovery; File carving and document analysis; Information hiding and steganography; Time, registry, and password recovery; Email and database forensics; Memory acquisition.

Prerequisites: ICS 253 or Consent of Instructor

ICS 442: Penetration Testing and Ethical Hacking **(3-0-3)**

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.
Prerequisites: ICS 343 or COE 344 or COE 353

ICS 443: Network Design & Management (3-0-3)
Overview of network design and management; Design methodologies; Network management strategies; Network configuration management; Network management protocols: SNMP, and RMON; Network management tools and systems; Network management applications; Desktop and web-based network management; Network troubleshooting.
Note: This course cannot be taken for credit with COE 444.
Prerequisites: ICS 343 or COE 344

ICS 445: Network Management and Security (3-0-3)
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.
Note: Cross-listed with COE 555
Prerequisites: ICS 343 or COE 344 or EE 400

ICS 446: Cluster Computing (3-0-3)
Introduction to high performance computing: Types of parallel computers, system architectures and performance measures; Message passing programming; Complexity analysis of parallel algorithms; Embarrassingly parallel computations; Partitioning and divide-and-conquer strategies; Pipelined computations; Synchronous computations; Load balancing and termination detection; Programming with shared memory; Parallel sorting algorithms; Numerical algorithms; Parallel image processing; Searching and optimization.
Note: It cannot be taken for credit with COE 420.
Prerequisites: ICS 202 and Junior Standing

ICS 447: Computer Network Technologies (3-0-3)
Performance measures and evaluation techniques; Advanced network architectures and differentiated services in IP networks; Switched, fast and gigabit Ethernet; VLANs; Wireless LANs; ISDN and ATM; Frame relay; Mobile computing and mobile IP; VPN and enterprise networks; Emerging network trends and technologies.
Note: It cannot be taken for credit with COE 446.
Prerequisites: ICS 343 or COE 344

ICS 448: Network and Security Administration (2-3-3)
Installing, configuring, securing, and administering network services. Assessing tools for improving data/service protection; Securing remote and local network infrastructures; DNS servers, web servers, network file sharing, and other common network communication components; Practical experience through hands-on lab exercises.
Prerequisites: ICS 344 or Consent of Instructor

ICS 471: Deep Learning (3-0-3)
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), Auto-encoders, Transformers, and Generative adversarial networks.
Prerequisites: (COE 292 or ICS 381) and (MATH 208 or MATH 260 or MATH 202 or ICS 254) and (STAT 319 or STAT 201)

ICS 472: Natural Language Processing (3-0-3)
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).
Prerequisites: ICS 471

ICS 473: Bioinformatics Mining and Algorithms (3-0-3)
Foundations of bioinformatics; Sequence alignment; Sequence motifs/patterns; Protein structures prediction; Microarray data analysis; Biological networks modeling and mining.
Prerequisites: [ICS 202 and ICS 381] or Consent of Instructor

ICS 474: Big Data Analytics (3-0-3)
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: (MATH 101 or MATH 106), (ISE 205 or STAT 201 or STAT 211 or STAT 212 or STAT 319 or EE 315)

ICS 483: Computer Vision (3-0-3)
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.
Prerequisites: ICS 485

ICS 484: Arabic Computing (3-0-3)
Arabic language characteristics; Arabic character sets; Standardization; Unicode; Arabization systems; Arabic software tools; Arabic programming languages and introduction to Arabic computations.
Prerequisites: ICS 108 or Consent of Instructor

ICS 485: Machine Learning (3-0-3)
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
Prerequisites: (COE 292 or ICS 381) and (MATH 202 or MATH 208 or MATH 260 or ICS 254) and (STAT 319 or STAT 201)

ICS 486: Agent-Based Systems and Swarm Intelligence (3-0-3)
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 (3-0-3)
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: ISE 205 or STAT 319 or STAT 201 or EE 315

ICS 488: Knowledge Based System and Soft Computing (3-0-3)
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

ICS 489: Applications of Machine Learning (3-0-3)
This is a multidisciplinary course that covers applications of artificial intelligence (AI) and machine learning (ML) in different domains. Students will use the knowledge earned from AI & ML concentration courses to develop industry-relevant solutions on electrical engineering, computer linguistics, embedded systems, and health domains. Students will work on several programming assignments and mini projects in signal processing, natural language processing and medical imaging. In addition, students will learn how to implement energy-efficient, real-time ML-based solutions.
Prerequisites: ICS 485

ICS 490: Special Topics I (3-0-3)
State-of-the-art topics in Computer Science and Information Systems.
Prerequisites: Senior Standing

ICS 491: Special Topics II (3-0-3)
State-of-the-art topics in Computer Science and Information Systems.
Prerequisites: Senior Standing