


# King Fahd University of Petroleum & Minerals
# College of Computing and Mathematics
# Information and Computer Science Department

# BS Program in Computer Science – 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:<br>1. Removed MATH 371 from the Technical Elective Courses. CIE 301 is already listed in the Technical Elective Courses | Farag Azzedin |
| Apr 12, 2026 | | 1- Added a mutual exclusion note of MATH 210 for ICS 253. | Wasfi Al-Khatib |
| Feb 22, 2026 | | 1- Replaced STAT 319 with STAT 201 in the degree plans.<br>2- Replaced STAT 319 with STAT 201 in the prerequisite charts.<br>3- Replaced STAT 319 with STAT 201 in the prerequisites of catalog descriptions of related courses. | Wasfi Al-Khatib |
| Jan 14, 2025 | | 1- Updated the prerequisite of ICS 483 to become ICS 485 instead of Senior Standing.<br>2- Added MATH 202 as a prerequisite to ICS 471 and ICS 485, in accordance with the registrar website. | Wasfi Al-Khatib |
| Oct 28, 2024 | | 1- Updated the technical elective list. | Farag Azzedin and Wasfi Al-Khatib |
| Feb 17, 2024 | | 1- Updated the prerequisite charts to have IAS 111 prerequisite to IAS 212.<br>2- Updated the prerequisite of ICS 440 (adding MATH 202 as an option for the first prerequisite course, according to the registrar's website) | Wasfi Al-Khatib |
| Nov 2, 2023 | 1.4 | 1- Added 1 credit to ICS 399 and updated the summer training degree plan and updated the total number of credit hours.<br>2- Added ICS 413 and 414 (Senior Project I and II) to both, summer training and internship degree plans.<br>3- Updated the prerequisite charts of the summer training and internship degree plans to reflect the new changes. | Wasfi Al-Khatib |
| Oct 9, 2022 | 1.3 | 1- Updated and added all concentrations that CS students following the summer training options can take.<br>2- Added the course title, description and prerequisites of SWE 455.<br>3- Removed SWE 497 from the major elective list.<br>4- Updated the title and description of ICS 471.<br>5- Updated the description and prerequisites of ICS 485.<br>6- Updated the description and prerequisites of ICS 472.<br>7- Updated the prerequisites of ICS 440. | Wasfi Al-Khatib |
| Sep 1, 2022 | 1.22 | Added MATH 405 as a technical elective | Wasfi Al-Khatib |
| Sep 1, 2022 | 1.22 | Updated the degree plans and the prerequisite charts after introducing ENGL 214 as a prerequisite to CGS392. | Wasfi Al-Khatib |

| | | | |
|---|---|---|---|
| Oct 25, 2021 | 1.21 | Fixed typo "ICS 398: Internship" instead of "ICS 398: Summer Training" on Page 7 | Wasfi Al-Khatib |
| Sep 22, 2021 | 1.2 | Updated the NCAAA classification of student outcomes. Added missing course descriptions ICS 398, ICS 399, ICS 411, ICS 439, ICS 445 and ICS 487. Updated the list of ICS Electives. Updated the prerequisites of ICS 471. Updated the course description and prerequisites for ICS 474. Updated the titles in both plans of study of the courses: IAS 111, IAS 212, IAS XXX, GS XXX, ISE 291, COE 292, CHEM 101 and PE 101. | Wasfi Al-Khatib |
| Feb 20, 2021 | 1.1 | Added concentration details. | Wasfi Al-Khatib |
| August 27, 2020 | 1.0 | Prepared student guide based on the new program. | Wasfi Al-Khatib |

# 1. Introduction

The Information and Computer Science (ICS) department offers a BS degree in Computer Science, either with summer training or with internship. The current program was revised and approved in 2020. The program has been developed taking into consideration the IEEE/ACM Computing Curricula guidelines and in compliance with the Computing Accreditation Criteria (CAC) of ABET for Computer Science programs.

## *1.1 ICS Department Vision*

The vision of the ICS department is to be a regional leader that is recognized worldwide in education, research and professional development in the areas of Computer Science and Software Engineering.

## *1.2 ICS Department Mission*

The mission of the ICS department is to:

a. provide high quality undergraduate and graduate educational programs in Computer Science and Software Engineering,
b. contribute significantly to the research and the discovery of new knowledge and methods in computing,
c. offer expertise, resources, and services to the community, and
d. keep its faculty members current by providing opportunities for professional development.

## *1.3 Computer Science Program Mission*

The mission of the computer science program is to provide high quality education in computer science that prepares students for professional careers and postgraduate education, with emphasis on data science and information security.

## *1.4 Computer Science Program Education Objectives*

Computer science graduates will:

1. Have a successful career or pursue an advanced degree in a computing-related area.
2. Work as individuals with minimum guidance and as leaders or members in teams.
3. Follow appropriate professional practices and maintain currency through self-learning or other professional development.

## *1.5 Computer Science Student Learning Outcomes*

By the time of graduation, it is expected that graduates of the program will have an ability to:

**Knowledge and Understanding**

1. Analyze a complex computing problem and to apply principles of computing and other relevant disciplines to identify solutions.

**Skills**

2. Design, implement and evaluate a computing-based solution to meet a given set of computing requirements in the context of the program's discipline.
3. Communicate effectively in a variety of professional contexts.

**Values**

4. Recognize professional responsibilities and make informed judgments in computing practice based on legal and ethical principles.
5. Function effectively as a member or leader of a team engaged in activities appropriate to the program's discipline.

**Skills**

6. Apply computer science theory and software development fundamentals to produce computing-based solutions.

# 2 Degree Plans

The ICS department is offering the BS in Computer Science with two options:

Option I: Summer Training.

Option II: Internship.

**Degree Requirements of Option I: B. S. in Computer Science (Summer Training)**

| **(a) General Education Requirements (49 credit hours)** | | **Credit Hours** |
|---|---|---|
| Natural Sciences | PHYS 101, 102, CHEM 101 | 12 |
| Mathematics and Statistics | MATH 101, 102, 201, 208, STAT 201 | 17 |
| Business and Entrepreneurship | BUS 200 | 3 |
| English | ENGL 101, 102, 214 | 9 |
| Physical Education | PE 101 | 1 |
| Global and Social Studies | CGS 392 | 1 |
| Islamic and Arabic Studies | IAS 111, 121, 212 | 6 |
| | | **49** |

| **(b) Core Requirements (59 credit hours)** | | **Credit Hours** |
|---|---|---|
| Programming in Python and C | ICS 104 | 3 |
| Object-oriented Programming | ICS 108 | 4 |
| Data Structures and Algorithms | ICS 202 | 4 |
| Discrete Structures | ICS 253 | 3 |
| Data Science and Database Systems | ISE 291, ICS 321 | 6 |
| Computer Networks | ICS 343 | 4 |
| Information Security | ICS 344 | 3 |
| Design and Analysis of Algorithms | ICS 353 | 3 |
| Artificial Intelligence | COE 292, ICS 381 | 6 |
| Programming Languages | ICS 410 | 3 |
| Senior Project | ICS 413, ICS 414 | 3 |
| Operating Systems | ICS 433 | 3 |
| Digital Logic and Digital Logic Laboratory | COE 202, COE 203 | 4 |
| Computer Organization | COE 301 | 4 |
| Software Engineering | SWE 206 | 3 |
| Web Engineering and Development | SWE 363 | 3 |
| | | **59** |

| **(c) Electives (20 credit hours)** | | **Credit Hours** |
|---|---|---|
| Computer Science Electives | Four ICS/SWE 3/4xx Courses | 12 |
| Global & Social Studies | One GS xxx Course | 3 |
| Islamic and Arabic Studies | One IAS xxx Course | 2 |
| Technical Elective | XE xxx | 3 |
| | | **20** |

| **(d) Summer Training (1 credit hour)** | | **Credit Hours** |
|---|---|---|
| Summer Training | ICS 399 | 1 |
| | | **1** |

**Total number of credit hours required is 129**

## Degree Plan of Option I: B. S. in Computer Science (Summer Training)

| COURSE | TITLE | LT | LB | CR | COURSE | TITLE | LT | LB | CR |
|---|---|---|---|---|---|---|---|---|---|
| **Preparatory Year** | | | | | | | | | |
| ENGL 01-xx | Prep. English I (First Quarter) | 15 | 5 | 4 | ENGL 03-xx | Prep. English III (Third Quarter) | 15 | 5 | 4 |
| ENGL 02-xx | Prep. English II (Second Quarter) | | | 4 | ENGL 04-xx | Prep. English IV (Fourth Quarter) | | | 4 |
| MATH 001 | Prep. Math I | 3 | 1 | 4 | MATH 002 | Prep. Math II | 3 | 1 | 4 |
| PYP 001 | Prep. Physical Science | 2 | 0 | 2 | PYP 002 | Prep. Computer Science | 0 | 2 | 1 |
| PYP 003 | University Study Skills | 0 | 2 | 1 | PYP 004 | Prep. Eng. Technology | 0 | 2 | 1 |
| PE 001 | Prep. Health and Physical Educ. I | 0 | 2 | 1 | PE 002 | Prep. Health and Physical Educ. II | 0 | 2 | 1 |
| | | **20** | **10** | **16** | | | **18** | **12** | **15** |
| **First Year (Freshman)** | | | | | | | | | |
| ENGL 101 | Intro. to Academic Discourse | 3 | 0 | 3 | ENGL 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 | Intro. to Programming in Python and C | 2 | 3 | 3 | ICS 108 | Object Oriented Programing | 3 | 3 | 4 |
| MATH 101 | Calculus I | 4 | 0 | 4 | MATH 102 | Calculus II | 4 | 0 | 4 |
| PE 101 | Health and Physical Education I | 0 | 2 | 1 | PHYS 102 | General Physics II | 3 | 3 | 4 |
| PHYS 101 | General Physics I | 3 | 3 | 4 | | | | | |
| | | **14** | **8** | **17** | | | **15** | **6** | **17** |
| **Second Year (Sophomore)** | | | | | | | | | |
| COE 202 | Digital Logic Design | 3 | 0 | 3 | CHEM 101 | Principles of Chemical Science I | 3 | 3 | 4 |
| COE 203 | Digital Logic Laboratory | 0 | 3 | 1 | COE 301 | Computer Organization | 3 | 3 | 4 |
| ISE 291 | Intro. to Data Science | 3 | 0 | 3 | COE 292 | Intro. to Artificial Intelligence | 3 | 0 | 3 |
| ICS 202 | Data Structures & Algorithms | 3 | 3 | 4 | ICS 253 | Discrete Structures | 3 | 0 | 3 |
| MATH 208 | Intro. to Diff. Eq. & Linear Algebra | 3 | 0 | 3 | MATH 201 | Calculus III | 3 | 0 | 3 |
| SWE 206 | Intro. To Software Engineering | 2 | 3 | 3 | | | | | |
| | | **14** | **9** | **17** | | | **15** | **6** | **17** |
| **Third Year (Junior)** | | | | | | | | | |
| ENGL 214 | Academic & Professional Comm. | 3 | 0 | 3 | BUS 200 | Business & Entrepreneurship | 3 | 0 | 3 |
| ICS 321 | Database Systems | 3 | 0 | 3 | CGS 392 | Career Essentials | 1 | 0 | 1 |
| ICS 343 | Fundamentals of Cmpter. Networks | 3 | 3 | 4 | IAS 212 | Ethics and Governance | 2 | 0 | 2 |
| STAT 201 | Prob. and Stat. for Eng. & Scientists | 3 | 2 | 3 | ICS 344 | Information Security | 3 | 0 | 3 |
| SWE 363 | Web Eng. & Development | 3 | 0 | 3 | ICS 353 | Design and Analysis of Algorithms | 3 | 0 | 3 |
| | | | | | ICS 381 | Principles of Artificial Intelligence | 3 | 0 | 3 |
| | | **15** | **5** | **16** | | | **15** | **0** | **15** |
| **Summer Session** | | | | | ICS 399 | Summer Training | **0** | **0** | **1** |
| **Fourth Year (Senior)** | | | | | | | | | |
| ICS 410 | Programming Languages | 3 | 0 | 3 | GS XXX | GS Elective | 3 | 0 | 3 |
| ICS 413 | Senior Project I | 0 | 0 | 0 | IAS XXX | Islamic/Arabic Elective | 2 | 0 | 2 |
| ICS 433 | Operating Systems | 3 | 1 | 3 | ICS 414 | Senior Project II | 0 | 9 | 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 |
| XE XXX | Technical Elective | 3 | 0 | 3 | | | | | |
| | | **15** | **1** | **15** | | | **11** | **9** | **14** |
| **Total credit hours required in Degree Program: 129** | | | | | | | | | |

**Degree Requirements for Option II: B. S. in Computer Science (Internship)**

| (a) General Education Requirements (49 credit hours) | | Credit Hours |
|---|---|---|
| Natural Sciences | PHYS 101, 102, CHEM 101 | 12 |
| Mathematics and Statistics | MATH 101, 102, 201, 208, STAT 201 | 17 |
| Business and Entrepreneurship | BUS 200 | 3 |
| English | ENGL 101, 102, 214 | 9 |
| Physical Education | PE 101 | 1 |
| Global and Social Studies | CGS 392 | 1 |
| Islamic and Arabic Studies | IAS 111, 121, 212 | 6 |
| | | **49** |

| (b) Core Requirements (59 credit hours) | | Credit Hours |
|---|---|---|
| Programming in Python and C | ICS 104 | 3 |
| Object-oriented Programming | ICS 108 | 4 |
| Data Structures and Algorithms | ICS 202 | 4 |
| Discrete Structures | ICS 253 | 3 |
| Data Science and Database Systems | ISE 291, ICS 321 | 6 |
| Computer Networks | ICS 343 | 4 |
| Information Security | ICS 344 | 3 |
| Design and Analysis of Algorithms | ICS 353 | 3 |
| Artificial Intelligence | COE 292, ICS 381 | 6 |
| Programming Languages | ICS 410 | 3 |
| Senior Project | ICS 413, ICS 414 | 3 |
| Operating Systems | ICS 433 | 3 |
| Digital Logic and Digital Logic Laboratory | COE 202, COE 203 | 4 |
| Computer Organization | COE 301 | 4 |
| Software Engineering | SWE 206 | 3 |
| Web Engineering and Development | SWE 363 | 3 |
| | | **59** |

| (c) Electives (14 credit hours) | | Credit Hours |
|---|---|---|
| Computer Science Electives | Three ICS/SWE 3/4xx Courses | 9 |
| Global & Social Studies | One GS xxx Course | 3 |
| Islamic and Arabic Studies | One IAS xxx Course | 2 |
| | | **14** |

| (d) Internship (6 credit hours) | | Credit Hours |
|---|---|---|
| Internship | ICS 398 | 6 |
| | | **6** |

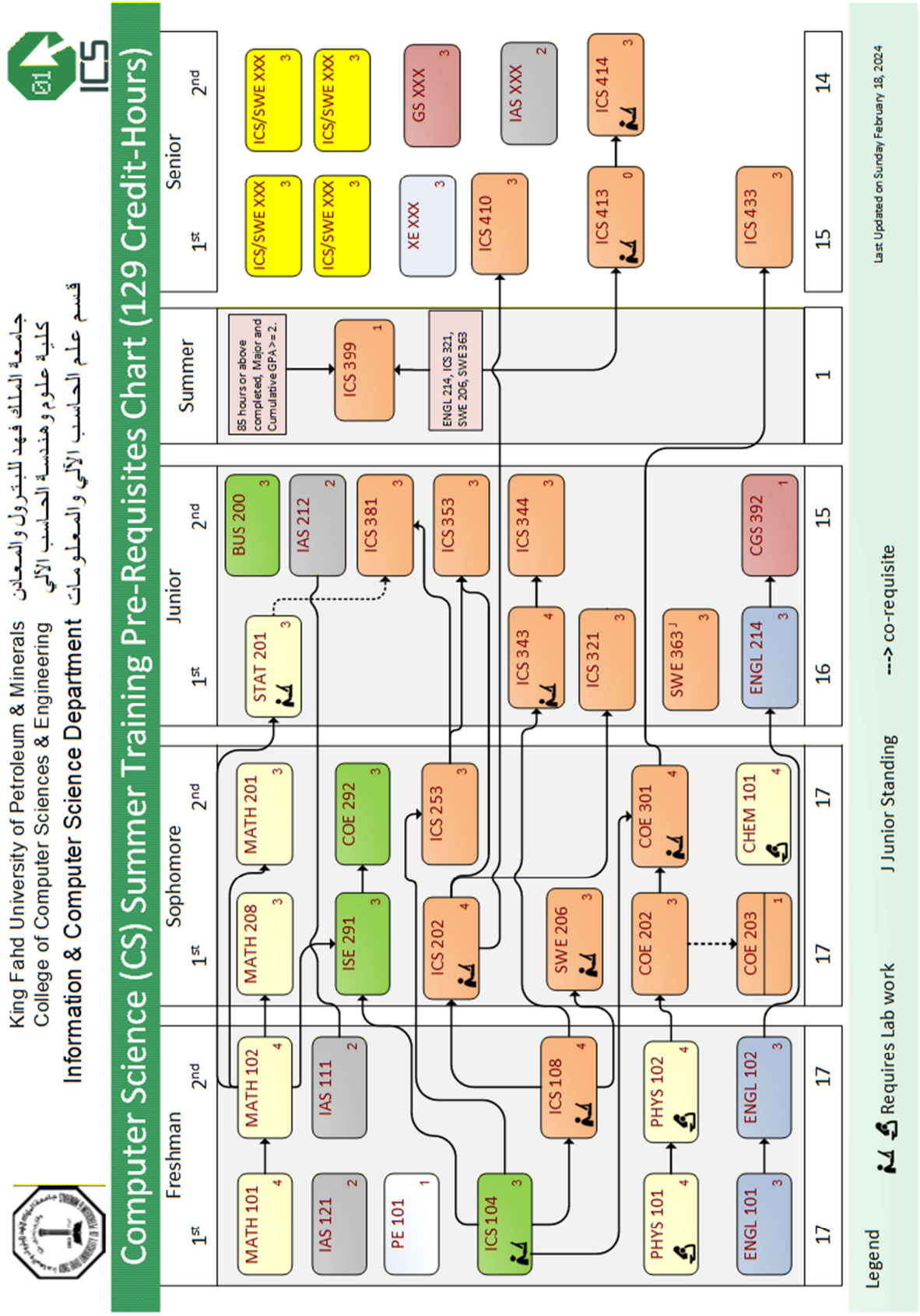
**Total number of credit hours required is 128**

## Degree Plan of Option II: B. S. in Computer Science (Internship)

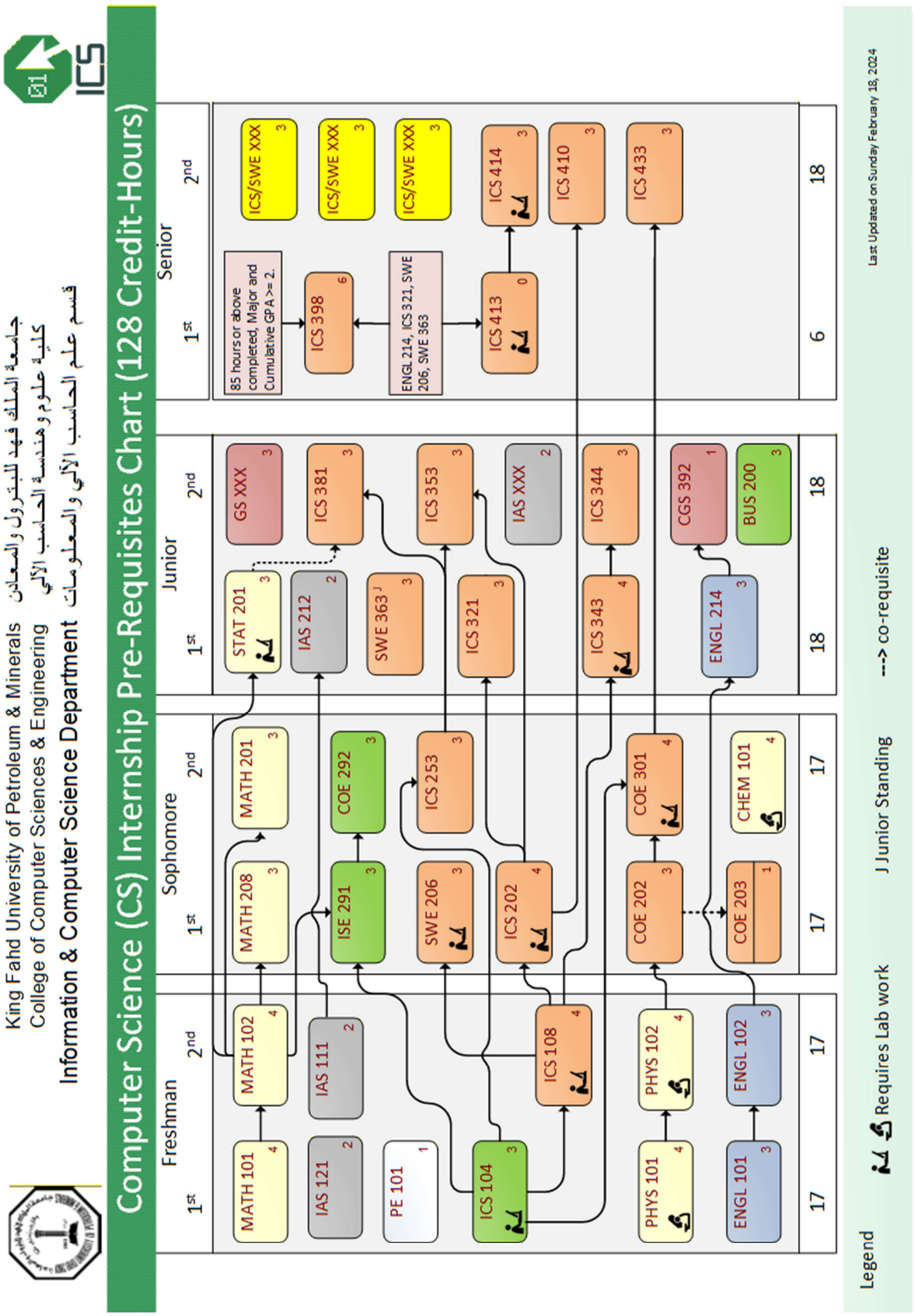
| COURSE | TITLE | LT | LB | CR | COURSE | TITLE | LT | LB | CR |
|---|---|---|---|---|---|---|---|---|---|
| **Preparatory Year** | | | | | | | | | |
| ENGL 01-xx | Prep. English I (First Quarter) | 15 | 5 | 4 | ENGL 03-xx | Prep. English III (Third Quarter) | 15 | 5 | 4 |
| ENGL 02-xx | Prep. English II (Second Quarter) | | | 4 | ENGL 04-xx | Prep. English IV (Fourth Quarter) | | | 4 |
| MATH 001 | Prep. Math I | 3 | 1 | 4 | MATH 002 | Prep. Math II | 3 | 1 | 4 |
| PYP 001 | Prep. Physical Science | 2 | 0 | 2 | PYP 002 | Prep. Computer Science | 0 | 2 | 1 |
| PYP 003 | University Study Skills | 0 | 2 | 1 | PYP 004 | Prep. Eng. Technology | 0 | 2 | 1 |
| PE 001 | Prep. Health and Physical Educ. I | 0 | 2 | 1 | PE 002 | Prep. Health and Physical Educ. II | 0 | 2 | 1 |
| | | **20** | **10** | **16** | | | **18** | **12** | **15** |
| **First Year (Freshman)** | | | | | | | | | |
| ENGL 101 | Intro. to Academic Discourse | 3 | 0 | 3 | ENGL 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 | Intro. to Programming in Python and C | 2 | 3 | 3 | ICS 108 | Object Oriented Programing | 3 | 3 | 4 |
| MATH 101 | Calculus I | 4 | 0 | 4 | MATH 102 | Calculus II | 4 | 0 | 4 |
| PE 101 | Health and Physical Education I | 0 | 2 | 1 | PHYS 102 | General Physics II | 3 | 3 | 4 |
| PHYS 101 | General Physics I | 3 | 3 | 4 | | | | | |
| | | **14** | **8** | **17** | | | **15** | **6** | **17** |
| **Second Year (Sophomore)** | | | | | | | | | |
| COE 202 | Digital Logic Design | 3 | 0 | 3 | CHEM 101 | Principles of Chemical Science I | 3 | 3 | 4 |
| COE 203 | Digital Logic Laboratory | 0 | 3 | 1 | COE 301 | Computer Organization | 3 | 3 | 4 |
| ISE 291 | Intro. to Data Science | 3 | 0 | 3 | COE 292 | Intro. to Artificial Intelligence | 3 | 0 | 3 |
| ICS 202 | Data Structures & Algorithms | 3 | 3 | 4 | ICS 253 | Discrete Structures | 3 | 0 | 3 |
| MATH 208 | Intro. to Diff. Eq. & Linear Algebra | 3 | 0 | 3 | MATH 201 | Calculus III | 3 | 0 | 3 |
| SWE 206 | Intro. To Software Engineering | 2 | 3 | 3 | | | | | |
| | | **14** | **9** | **17** | | | **15** | **6** | **17** |
| **Third Year (Junior)** | | | | | | | | | |
| ENGL 214 | Academic & Professional Comm. | 3 | 0 | 3 | BUS 200 | Business & Entrepreneurship | 3 | 0 | 3 |
| IAS 212 | Ethics and Governance | 2 | 0 | 2 | CGS 392 | Career Essentials | 1 | 0 | 1 |
| ICS 321 | Database Systems | 3 | 0 | 3 | GS XXX | GS Elective | 3 | 0 | 3 |
| ICS 343 | Fundamentals of Cmpter. Networks | 3 | 3 | 4 | IAS XXX | Islamic/Arabic Elective | 2 | 0 | 2 |
| STAT 201 | Prob. and Stat. for Eng. & Scientists | 3 | 2 | 3 | ICS 344 | Information Security | 3 | 0 | 3 |
| SWE 363 | Web Eng. & Development | 3 | 0 | 3 | ICS 353 | Design and Analysis of Algorithms | 3 | 0 | 3 |
| | | | | | ICS 381 | Principles of Artificial Intelligence | 3 | 0 | 3 |
| | | **17** | **5** | **18** | | | **18** | **0** | **18** |
| **Summer Session** | | | | | | | | | |
| **Fourth Year (Senior)** | | | | | | | | | |
| ICS 398 | Internship | 0 | 0 | 6 | ICS 410 | Programming Languages | 3 | 0 | 3 |
| ICS 413 | Senior Project I | 0 | 0 | 0 | ICS 414 | Senior Project II | 0 | 9 | 3 |
| | | | | | ICS 433 | Operating Systems | 3 | 1 | 3 |
| | | | | | ICS XXX | Major Elective I | 3 | 0 | 3 |
| | | | | | ICS XXX | Major Elective II | 3 | 0 | 3 |
| | | | | | ICS XXX | Major Elective III | 3 | 0 | 3 |
| | | **0** | **0** | **6** | | | **15** | **10** | **18** |
| **Total credit hours required in Degree Program: 128** | | | | | | | | | |

## *2.1 Degree Flow Charts*

### a) B. S. in Computer Science (Summer Training)



## b) B. S. in Computer Science (Internship)



## *2.2 Concentration Details*

A concentration is comprised of a sequence of four courses in a specific area related to a given program. Concentrations provide students who take them with in-depth knowledge and expertise in that area. The Computer Science program (Summer Training) allows students to take an approved concentration by mapping its courses to the program's four major elective courses. The following concentrations are available for students following the summer training option:

### 1. Artificial Intelligence and Machine Learning

This interdisciplinary concentration provides the students with the required knowledge to develop intelligent techniques and systems. Students are exposed to topics such as machine learning, deep learning, computer vision, and natural language processing. Furthermore, it also covers classification, regression, clustering, dimensionality reduction, perception, motion and manipulation, reinforcement learning, and various types of neural networks. It promotes interdisciplinary education where computer science intersects with mathematics and engineering. The applications of this concentration are wide-ranging and include automatic image and video processing, healthcare, financial data and trading, speech recognition, facial identification, and seismic survey processing.

| **Concentration Course** | **Mapped to** |
|---|---|
| ICS471: Deep Learning | ICS XXX: Major Elective I |
| ICS485: Machine Learning | ICS XXX: Major Elective II |
| ICS483: Computer Vision | ICS XXX: Major Elective III |
| ICS472: Natural Language Processing | ICS XXX: Major Elective IV |

### 2. Cybersecurity and Blockchain

This interdisciplinary program covers topics related to secure and trusted computing, including data and information assurance, identification of cyber assets and related security risks and threats, measurement of system resilience against cyber-attacks, and security policy compliance and governance. Students learn the fundamental pillars of computer security and data privacy and how they affect complex engineering systems (e.g. manufacturing plants). Topics include cryptology, access control models and mechanisms, intrusion detection systems, and integrity verification mechanisms. Students also learn the fundamentals of Blockchain technology, including record and hash replication, and types of blockchains (public, private, and hybrid), as well the applications in cryptocurrency and various other scientific, engineering, and business use cases.

| **Concentration Course** | **Mapped to** |
|---|---|
| COE426: Data Privacy | ICS XXX: Major Elective I |
| ICS440: Cryptography and Blockchain Applications | ICS XXX: Major Elective II |
| ICS442: Penetration Testing and Ethical Hacking | ICS XXX: Major Elective III |
| SWE445: Secure Software Development | ICS XXX: Major Elective IV |

### 3. Cloud Computing

This interdisciplinary program focuses on the development of Internet-scale applications that can serve millions of users at the same time. The program includes topics that span the disciplines of computer engineering, computer science, and software engineering. These topics include Cloud architectures and enabling technologies, Cloud services and deployment models, software-defined infrastructures, principles of distributed systems, distributed programming models, Web applications, and Cloud-native applications. The program also covers the modern software engineering practices for Cloud applications development and deployment, software architectures for Cloud applications, and design patterns and tools for performance, dependability, and security. This program is distinguished by its hands-on approach to teaching. Students will come out of the program with the motivation, tools, and confidence they need to successfully apply Cloud computing to create business value.

| **Concentration Course** | **Mapped to** |
|---|---|
| COE452: Principles of Cloud-based Systems | ICS XXX: Major Elective I |
| COE427: Distributed Computing | ICS XXX: Major Elective II |
| COE453: Cloud and Edge Computing | ICS XXX: Major Elective III |
| SWE455: Cloud Applications Engineering | ICS XXX: Major Elective IV |

### 4. Computer Networks

Computer networks are the backbone that interconnects different networks and provides a path for exchange of data around the world. This multidisciplinary program is designed to prepare students to enter the field of computer networks and equip them with knowledge and skills to design, manage and secure computer networks. The program also enables students to utilize tools and technologies in computer networks.

The program covers subjects related to wired and wireless networks, network design and management, network security, and internet cloud engineering. Topics include computer network OSI layers, radio frequency propagation models, multiple access techniques, quality of service, 5/6 G networks, interVLAN routing protocols, interior and Exterior for routing for IPv4 and IPv6, multicasting, software-defined network, Internet and web protocols and technologies (HTTP), basics of web development: frontend, backend, and full-stack (HTML, CSS, JavaScript, Node.js), utility computing: Cloud and Edge computing, Cloud Service-oriented architecture and microservice, XaaS pyramid, serverless computing, cloud resource management, virtualization and containerization, cloud data storage, BigTable, Dynamo, and Cassandra, Network Management Standards, Models, and protocols, applications, tools, and systems, remote monitoring and management (RMM), security of LANs, wireless LANs, and cellular networks, authentication, authorization, accountability, and access controls of computer networks, 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 design, management and security.

| **Concentration Course** | **Mapped to** |
|---|---|
| COE444: Network Design | ICS XXX: Major Elective I |
| COE446: Mobile Computing | ICS XXX: Major Elective II |
| COE453: Cloud and Edge Computing | ICS XXX: Major Elective III |
| ICS445: Network Management and Security | ICS XXX: Major Elective IV |

## 5. Data Science and Analytics

This interdisciplinary program focuses on the analysis and handling of data from multiple sources and for various applications in order to draw inferences from it, combining topics from mathematics, statistics, and computer science. These topics include probability theory, inference, least-square estimation, maximum likelihood estimation, finding local and global optimal solutions (gradient descent, genetic algorithms, etc.), and generalized additive models. It also covers machine learning topics such as classification, conditional probability estimation, clustering, and dimensionality reduction (e.g. discriminant factor and principal component analyses), and decision support systems. The program also covers big data analysis, including big data collection, preparation, preprocessing, warehousing, interactive visualization, analysis, scrubbing, mining, management, modeling, and tools such as Hadoop, Map-Reduce, Apache Spark, etc.

| **Concentration Course** | **Mapped to** |
|---|---|
| ICS474: Big Data Analytics | ICS XXX: Major Elective I |
| MATH405: Learning from Data | ICS XXX: Major Elective II |
| STAT413: Statistical Modeling | ICS XXX: Major Elective III |
| ISE487: Predictive Analytics Techniques | ICS XXX: Major Elective IV |

## 6. Decision Analytics

The interdisciplinary field of Decision Analytics (DA) seeks to understand and improve the judgment and decision making of individuals, groups, and organizations. Decision Analytics is grounded in theories and methods drawn from mathematics, probability and statistics, operations research, optimization, and artificial intelligence-based tools such as machine learning. The knowledge of this multidisciplinary area can be applied almost everywhere including government, manufacturing, design, health care, transportation, city planning, and business. The Systems Engineering department proposes a concentration in DA with the aim to equip students with the knowledge and skills for scientific decision making. The concentration consists of four courses taught by the systems Engineering Department, Mathematics and Information and Computer Sciences. The courses are Decision Making, Intelligent Decision Support Systems, Applied Game Theory and Cases in Decision Analytics.

| **Concentration Course** | **Mapped to** |
|---|---|
| ISE447: Decision Making | ICS XXX: Major Elective I |
| ICS487: Intelligent Decision Support Systems | ICS XXX: Major Elective II |
| MATH407: Applied Game Theory | ICS XXX: Major Elective III |
| ISE455: Applied Models for Optimal Decisions | ICS XXX: Major Elective IV |

## 7. Internet of Things (IoT)

This interdisciplinary program covers smart applications built using smart systems capable of sensing, actuation, computing, and communication. In this concentration, students learn how to use smart systems to develop fascinating applications such as those used in smart homes, smart cities, intelligent transportation systems, and more. Topics covered include IoT applications, embedded systems and sensing, IoT communication protocols, Industrial Internet of Things (IIoT), cloud and edge computing, big data analytics, and IoT security. Students are introduced to embedded systems programming and interfacing. Students also learn how to connect smart things to each other, as well as to the cloud. Through learning big data analytics, students can use advanced analytics and machine learning to process sensor data and build innovative applications. Students are also exposed to how IIoT is used in industrial applications using state-of-the-art use cases.

| **Concentration Course** | **Mapped to** |
|---|---|
| COE450: Introduction to Smart Systems | ICS XXX: Major Elective I |
| ICS474: Big Data Analytics | ICS XXX: Major Elective II |
| CISE464: Industrial Internet of Things (IoT) Technology | ICS XXX: Major Elective III |
| COE454: Internet of Things | ICS XXX: Major Elective IV |

### 8. Quantum Information & Computing

This interdisciplinary program covers an emerging discipline in computing that utilizes quantum theory and how to apply it in the fields of computing and communication. The program covers the concepts of qubits, superposition, entanglement, quantum gates, and quantum algorithms in order to understand the difference between classical and quantum computing. Other topics include quantum electrodynamics, including cavity and circuit qubits, quantum superconductivity, non-linear harmonic oscillators, etc. Students are introduced to quantum computing concepts such as quantum hardware, processors, circuits, instruction sets, quantum programming languages, quantum error correction, algorithms, and quantum cryptography. Students learn how to design, simulate, and test the core parts of a superconducting Qubit.

| **Concentration Course** | **Mapped to** |
|---|---|
| COE466: Quantum Architecture and Algorithms | ICS XXX: Major Elective I |
| PHYS471: Introduction to Quantum Information and Computing | ICS XXX: Major Elective II |
| ICS439: Cryptography in Quantum Era | ICS XXX: Major Elective III |
| PHYS472: Qubits and Circuit Quantum Electrodynamics | ICS XXX: Major Elective IV |

# 3 Summary of ICS and SWE Courses

## *3.1 ICS 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 381 | Principles of Artificial Intelligence | 3 | 0 | 3 |
| ICS 398 | Internship | 0 | 0 | 6 |
| ICS 399 | Summer Training | 0 | 0 | 1 |
| ICS 410 | Programming Languages | 3 | 0 | 3 |
| ICS 413 | Senior Project I | 0 | 0 | 0 |
| ICS 414 | Senior Project II | 0 | 9 | 3 |
| ICS 433 | Operating Systems | 3 | 1 | 3 |

## *3.2 SWE Core Courses*

| | | | | |
|---|---|---|---|---|
| SWE 206 | Introduction to Software Engineering | 2 | 3 | 3 |
| SWE 363 | Web Engineering and Development | 3 | 0 | 3 |

## *3.3 ICS/SWE Elective Courses*

| | | | | |
|---|---|---|---|---|
| ICS 355 | Theory of Computing | 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 439 | Cryptography in Quantum Era | 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 | 2 | 3 | 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 |
| ICS 497 | Directed Undergraduate Research | 3 | 0 | 3 |
| | | | | |
| SWE 302 | Game Programming | 3 | 0 | 3 |
| SWE 316 | Software Design and Construction | 3 | 0 | 3 |
| SWE 321 | Formal Methods and Models in Software Engineering | 3 | 0 | 3 |
| SWE 326 | Software Testing | 3 | 0 | 3 |
| SWE 387 | Software Project Management | 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 439 | Software Quality Engineering | 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 |

## *3.4 Technical Elective Courses*

Following is a list of recommended technical electives for the CS program. A written approval from the ICS department is needed for courses outside this list.

| List of Course Numbers and Titles | List of Course Numbers and Titles |
|---|---|
| ACCT 201: Principles of Accounting I | GS 355: Cultural Anthropology |
| AE 220: Introduction to Aerospace Engineering | GS 420: Personality Psychology |
| AE 403: Aerospace Materials | GS 424: Business Psychology |
| AE 410: Astronautics | GS 426: Social Psychology |
| AE 414: Flight and Air Traffic Control | GS 434: Mass Media and Society |
| AE 415: Flight and Aviation Safety | GS 447: Globalization |
| AE 416: Flight and Aviation Management | GS 454: Anthropology of Travel |
| AE 417: Flight and Aviation Law | GS 457: Social Networks |
| AE 418: Flight and Aviation Economics | HRM 301: Human Resources Management |
| ARC 124: Computer Aided Architectural Design | ISE 303: Operations Research |
| ARE 211: Building Materials | ISE 307: Engineering Economic Analysis |
| ARE 413: Construction Management | ISE 429: Maintenance Planning and Control |
| ARE 431: Building Economy | MATH 225: Introduction to Linear Algebra |
| CE 201: Statics | MATH 302: Engineering Maths |
| CE 318: Numerical & Statistical Methods in Civil Eng. | MATH 315: Development of Mathematics |
| CE 422: Construction Management and Economy | MATH 333: Methods of Applied Mathematics I |
| CIE 301: Numerical Methods | MATH 341: Advanced Calculus I |
| COE 241: Data & Computer Communications | MATH 405: Learning from Data |
| COE 402: Computer System Performance Evaluation | MATH 451: Differential Geometry |
| COE 403: Computer Architecture | MATH 467: Graph Theory |
| COE 405: Design and Modeling Digital Systems | MATH 474: Linear & Nonlinear Programming |
| COE 420: Parallel Computing | ME 424: Maintenance Engineering |
| COE 422: Real Time Systems | MGT 210: Business Communication |
| COE 443: High Speed Networks | MGT 301: Principles of Management |
| COE 445: Internet Engineering and technologies | MGT 310: Organization Behavior |
| COE 446: Mobile Computing | MIS 300: Fundamentals of Electronic Commerce |
| COE 484: Introduction to Robotics | MKT 250: Principles of Marketing |
| COE 488: Data Acquisition Interfacing | MSE 207: Materials Science for CHE |
| ECON 101: Principles of Economics I (MICRO) | PHYS 203: Electrical & Magnetic Prop. of Materials |
| ECON 403: Engineering Economics | PHYS 204: General Physics III |
| EE 202: Electric Circuits I | PHYS 211: Optics |
| EE 204: Fundamentals of Electrical Circuits | PHYS 212: Modern Physics |
| EE 206: Intro. to Electrical Systems & Computations | PHYS 215: Introduction to Astronomy |
| EE 390: Digital Systems Engineering | PHYS 261: Energy |
| GEOL 202: Applied Geosciences for Scientists & Eng. | PHYS 271: Introduction to Special Relativity |
| GEOL 303: Sustaining the Earth | PHYS 301: Classical Mechanics I |
| GEOP 202: Introduction to Geophysics | PHYS 305: Electricity and Magnetism I |
| GS 318: World Civilization | STAT 301: Introduction to Probability Theory |
| GS 321: Principles of human behavior | STAT 310: Regression Analysis |
| GS 332: Principles of Sociology | STAT 320: Statistical Quality Control |
| GS 336: Work and Society | |
| GS 342: International Relations | |

# 4 Catalog Description of ICS and SWE Courses

## *4.1 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.
**Note: This course cannot be taken for credit with MATH 210.**
**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 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 201**

**ICS 398: Internship (0-0-6)**
A continuous period of 16 weeks spent as a normal "new" employee in industry, business, or government agencies with the purpose of familiarizing students with the real world of work and enabling them to integrate their learning to a real work environment. During this period, a student is exposed to a real-life work in the field and work as a normal employee. Each student is required to participate with at least one project. Students are required to submit progress reports during the work period. Students are also required to give a presentation and submit a final report on their experience and the knowledge they gained during their work.
**Prerequisites: ENGL 214, ICS 321, SWE 206, and SWE 363, Completion of at least 85 hours, Major and Cumulative GPA of at least 2.0.**

**ICS 399: Summer Training (0-0-1)**
A continuous period of 8 weeks spent as a normal employee in industry, business, or government agencies with the purpose of familiarizing students with the real world of work and enabling them to integrate their classroom learning to a real work environment. During this period, a student is exposed to a real-life work in the field. Students are required to submit progress reports during

the work period. Students are also required to give a presentation and submit a final report on their experience and the knowledge they gained during their Training.
**Prerequisites: ENGL 214, ICS 321, SWE 206, SWE 363, Completion of at least 85 hours, Major and Cumulative GPA of at least 2.0.**

**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 413: Senior Project I (0-0-0)**
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: ENGL 214, ICS 321, SWE 206, SWE 363**

**ICS 414: Senior Project II (0-9-3)**
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: ICS 413**

**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 439: Cryptography in Quantum Era (3-0-3)**
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.
**Note: Not to be taken for credits with COE 440**
**Prerequisites: COE 466**

**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 202 or MATH 208 or MATH 260 or ICS 254) and 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 202 or MATH 208 or MATH 260 or ICS 254) and 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 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 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 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**

**ICS 497: Directed 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 Instructor**

## *4.2 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 411 Software Engineering Project I (1-6-3)**
This is the first part of a two-semester senior-year capstone project. Student teams employ knowledge gained from courses throughout the program such as development of requirements, design, implementation, and quality assurance to develop a software solution to a real-world problem from conception to completion. In this part, students develop project plan and software requirements specification. Next, students' teams can either develop complete design document or follow agile like methodology to develop design document and implementation for 30% of system features.
**Prerequisites: SWE 316 and SWE 387**

**SWE 412 Software Engineering Project II (0-6-2)**
This is the second part of a two-semester senior-year capstone project. Student teams employ knowledge gained from courses throughout the program to develop a software solution to a real-world problem from conception to completion. In this part, students review and refine documents prepared in SWE 411; finalize design, complete implementation of the application, test their code, and evaluate their final product.
**Prerequisites: SWE 326 and SWE 411**

**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 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 455 Cloud Applications Engineering (3-0-3)**
Cloud computing and service models. Software development for the Cloud. Software architectures: monoliths, service-oriented, microservice, and serverless. Trade-offs between architectural patterns and Cloud services. Development lifecycle for Cloud-native SaaS applications. Design patterns for SaaS applications, Cloud service level agreements, and Cloud infrastructures. Software engineering practices and tools for the Cloud: Agile. CI/CD, DevOps, ArchOps, DataOps, MLOps, and DevSecOps. Business processes to implement cloud solutions, Cloud migration processes, and issues, Case studies.
**Prerequisite: COE 344 or ICS 343**

**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**