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

Software Engineering Student Guide

http://www.ccse.kfupm.edu.sa/~swe/

March 4, 2012

Version 3.0

Introduction

The Department of Information and Computer Science offers a BS in Software Engineering. The current program was revised and approved in April 2008. The program is in full compliance with IEEE/ACM Software Engineering SE2004 guidelines and meets the Engineering Accreditation Criteria (EAC).

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.

Software Engineering Program Goal

Our goal has been, and continues to be, a high quality degree program in Software Engineering that prepares students for lifelong learning as they undertake professional careers in computing. The program prepares students to work as requirements engineer, software architect, software design engineer, software quality engineer, software developer, software test engineer, or software engineering project manager.

Software Engineering Program Mission

To bring forth competent Software Engineers with a strong understanding of computer science bodies of knowledge and theories, who can apply sound engineering principles and methods to the cost-effective creation, development, operation, and maintenance of high-quality software and are prepared for lifelong learning.

Software Engineering Program Objectives

The graduates of the software engineering program shall be able to:

1. **Contributing Citizens**
   Graduates of the SWE program at KFUPM will meet the needs of local software engineering industry and will be contributing members of the society.

2. **Leadership**
   Graduates of the SWE program at KFUPM will exhibit leadership in technical and business environment.

3. **Self-Professional Development**
   Graduates of the SWE program at KFUPM will be adapting and adjusting to the rapid advancements and technological changes in the Software Engineering discipline.

Software Engineering Program Learning Outcomes:

The software engineering program enables students, by the time of graduation, to achieve the ability to:

1. Apply their knowledge of mathematics, sciences, and computer science to the modeling, analysis, and measurement of software artifacts.
2. Work effectively as leader/member of a development team to deliver quality software artifacts.
3. Analyze, specify and document software requirements for a software system.
4. Develop alternative design solutions to a given problem and recommend the best one within limitations of cost, time, knowledge, existing systems, and organizations.
5. Implement a given software design using sound development practices.
6. Verify, validate, assess and assure the quality of software artifacts.
7. Design, select and apply the most appropriate software engineering process for a given project, plan for a software project, identify its scope and risks, and estimate its cost and time.
8. Express and understand the importance of negotiation, effective work habits, leadership, and good communication with stakeholders, in written and oral forms, in a typical software development environment.
9. Understand the impact of computing solutions in a global and societal context.
10. Recognize and be guided by the social, professional, legal, ethical issues involved in the use and development of computer & software technology.
11. Keep abreast of current developments in the discipline to continue their own professional development and life-long learning.
12. Employ appropriate methods and tools for the specification, design, implementation, and evaluation of software systems.

The Program Requirements

a. General Education Requirements (52 credits)

Basic Science	CHEM 101(4),	PHYS 101(4),	PHYS 102(4)	
Mathematics	MATH 101(4),	MATH 102(4),	MATH 201(3),	
Statistics	STAT 319(3)			
Isla. & Ara. Stu.	IAS 101(2),	IAS 111(2),	IAS 201(2),	IAS 212(2),
	IAS 301(2),	IAS 322(2)		
English	ENGL 101(3),	ENGL 102(3),	ENGL 214(3)	
SE	ISE 307(3)			
Physical Edu.	PE 101(1),	PE 102(1)		

b. Core Requirements (65 credits)

SWE	SWE 205(3),	SWE 215(3),	SWE 312(3),	SWE 316(3),
	SWE 326(3),	SWE 363(3)	SWE 387(3)	SWE 417(3),
	SWE 418(2)			
ICS	ICS 102(3),	ICS 201(4),	ICS 202(4),	ICS 233(4),
	ICS 253(3),	ICS 254(3),	ICS 324(4),	ICS 343(4)
	ICS 353(3),	ICS 431(4)		
COE	COE 202(3)			

c. Elective (15 credits)

SWE/ICS Electives	SWE/ICS xxx(3),	SWE/ICS xxx(3),	SWE/ICS xxx(3),
Free Electives	XE xxx(3),	XE xxx(3)	

d. Summer Training (Pass/Fail grade; No credits)
The prerequisites for summer training:

- Student is currently enrolled in the university.
- Student has completed 65 credits or more (including current semester)
- Students has completed or currently doing ENGL 214 and SWE 363.
- Summer training is not in the last semester for the student at the university.

Every student is required to participate in a summer training program of real practical experience, submit a formal written report and make a presentation.

e. Total Requirements
The total required credits for the BS degree in Software Engineering are 132 semester-credit-hours.

Curriculum

BS (Software Engineering) Program

Course		Title	LT	LB	CR	Course		Title	LT	LB	CR
First Year (Preparatory)											
ENGL	001	Preparatory English I	15	5	8	ENGL	002	Preparatory English II	15	5	8
MATH	001	Preparatory Math I	3	1	4	MATH	002	Preparatory Math II	3	1	4
ME	003	Preparatory Engg. Tech.	0	2	1	PYP	001	Prep Physical Science	2	0	2
PYP	002	Prep Computer Science	0	2	1	PYP	003	University Study Skill	0	2	1
PE	001	Prep Physical Educ. I	0	2	1	PE	002	Prep Physical Educ. II	0	2	1
			18	**12**	**15**				**20**	**10**	**16**
Total Credit required in Preparatory Program: 31											
Second Year (Freshman)											
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 Physics II	3	3	4
ENGL	101	An Intro to Academic Discourse	3	0	3	ENGL	102	Intro to Report Writing	3	0	3
CHEM	101	General Chemistry I	3	4	4	ICS	102	Intro. To Computing I	2	3	3
IAS	101	Practical Grammar	2	0	2	IAS	111	Belief & its Consequences	2	0	2
PE	101	Physical Education I	0	2	1	PE	102	Physical Education II	0	2	1
			15	**9**	**18**				**14**	**8**	**17**
Third Year (Sophomore)											
SWE	205	Introduction to SW Eng.	3	0	3	ICS	202	Data Structures	3	3	4
ICS	201	Intro. To Computing II	3	3	4	SWE	215	SW Requirements Eng.	2	3	3
COE	202	Digital Logic Design	3	0	3	ICS	233	Comp. Arch.& As. Lang	3	3	4
MATH	201	Calculus III	3	0	3	ICS	254	Discrete Structures II	3	0	3
ICS	253	Discrete Structures I	3	0	3	IAS	201	Writing for Prof. Needs	2	0	2
			15	**3**	**16**				**13**	**9**	**16**
Fourth Year (Junior)											
SWE	312	User-Interface Design	3	0	3	SWE	326	SW Testing & QA	3	0	3
SWE	316	SW Design and Arch.	3	0	3	SWE	363	Web Eng. & Development	3	0	3
ICS	324	Database Systems	3	3	4	SWE	387	Software Project mgt.	3	0	3
STAT	319	Prob.& Stat. for Engrs	2	3	3	ICS	343	Fund. of Comp NW	3	3	4
IAS	212	Professional Ethics	2	0	2	IAS	322	Human Rights in Islam	2	0	2
						ENGL	214	Academic & Prof Comm	3	0	3
			13	**6**	**15**				**17**	**3**	**18**
Fifth Year (Senior)											
SWE	417	SWE Project I	1	6	3	SWE	418	SWE Project II	0	6	2
XE	xxx	(Elective I)	3	0	3	ICS	431	Operating Systems	3	3	4
ICS	353	Design and Anal of Algo.	3	0	3	SWE	xxx	(SWE/ICS Elective II)	3	0	3
ISE	307	Eng. Economics Analysis	3	0	3	SWE	xxx	(SWE/ICS Elective III)	3	0	3
SWE	xxx	(SWE/ICS Elective I)	3	0	3	IAS	301	Oral Comm. Skills	2	0	2
						XE	xxx	(Elective II)	3	0	3
			13	**6**	**15**				**14**	**9**	**17**
Total credits required in Degree Program: 132											

SWE Courses Summary

A. Core

A.1: SWE Courses

1.	SWE 205	Introduction to Software Engineering	3	0	3
2.	SWE 215	Software Requirement Engineering	2	3	3
3.	SWE 312	User-Interface Design	3	0	3
4.	SWE 316	Software Design and Architecture	3	0	3
5.	SWE 326	SW Testing & Quality Assurance	3	0	3
6.	SWE 363	Web Engineering & Development	3	0	3
7.	SWE 387	Software Project management	3	0	3
8.	SWE 417	Software Engineering Project I	1	6	3
9.	SWE 418	Software Engineering Project II	0	6	2
		SUB TOTAL:	**26 Credits**		

A.1: CS Courses

1.	ICS 102	Introduction to Computing I	2	3	3
2.	ICS 201	Introduction to Computing II	3	3	4
3.	ICS 202	Data Structures	3	3	4
4.	ICS 233	Computer Architecture and Assembly Language	3	3	4
5.	ICS 253	Discrete Structures I	3	0	3
6.	ICS 254	Discrete Structures II	3	0	3
7.	ICS 324	Database Systems	3	3	4
8.	ICS 343	Fundamentals of Computer Networks	3	3	4
9.	ICS 353	Design and Analysis of Algorithms	3	0	3
10.	ICS 431	Operating Systems	3	3	4
		SUB TOTAL:	**36 Credits**		

A.2: COE Courses

1.	COE 202	Digital Logic Design	3	0	3
		SUB TOTAL:	**3 Credits**		

B. Electives

ICS 300 - ICS 499 and SWE 300 - SWE 499 courses

SUB TOTAL (3 SWE/ICS Electives): **9 Credits**

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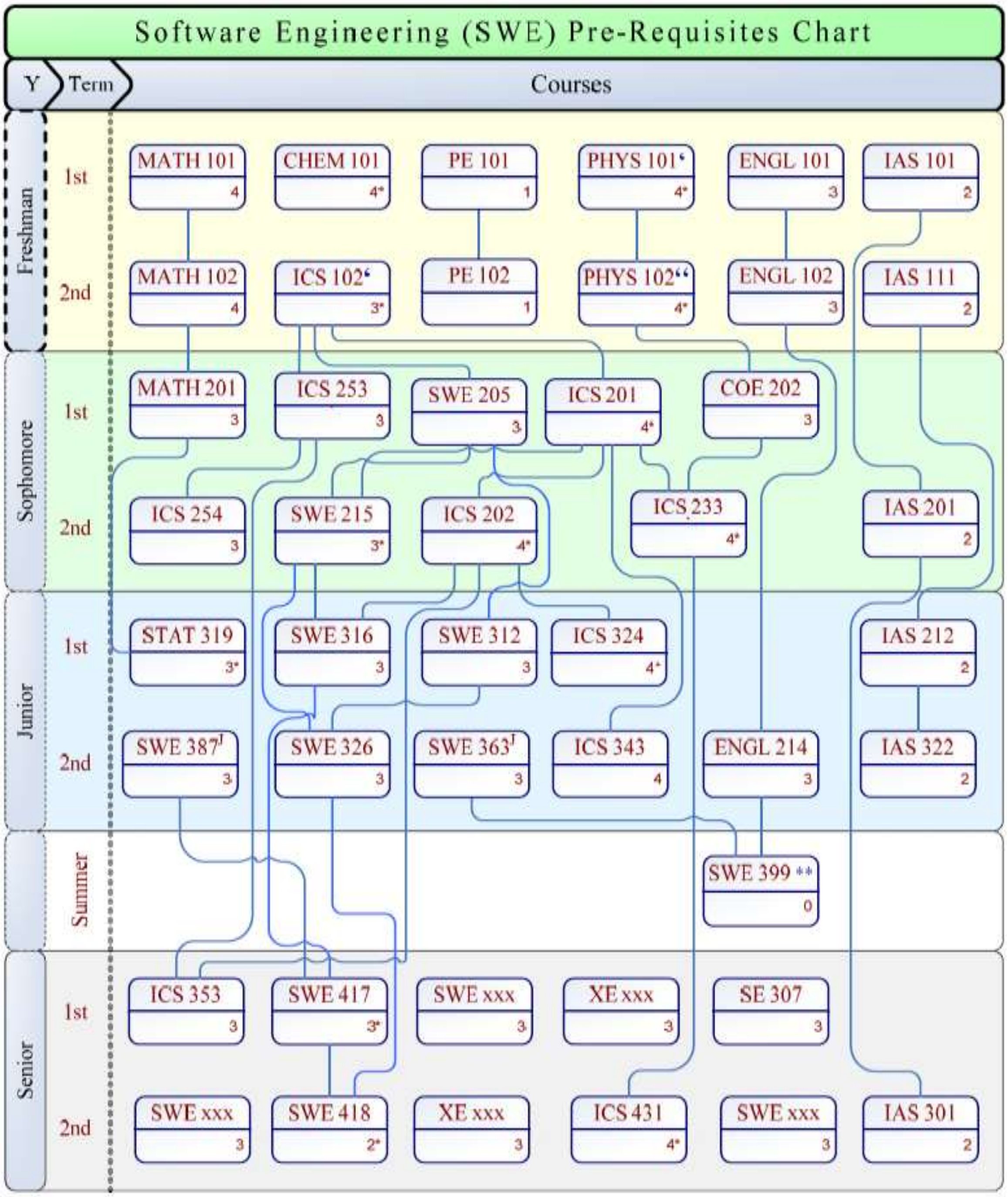
جامعة الملك فهد للبترول والمعادن
كلية علوم وهندسة الحاسب الآلي
قسم علم الحاسب الآلي والمعلومات

Software Engineering (SWE) Pre-Requisites Chart



Y	Term	Courses					
Freshman	1st	MATH 101 4	CHEM 101 4*	PE 101 1	PHYS 101‘ 4*	ENGL 101 3	IAS 101 2
	2nd	MATH 102 4	ICS 102‘ 3*	PE 102 1	PHYS 102‘‘ 4*	ENGL 102 3	IAS 111 2
Sophomore	1st	MATH 201 3	ICS 253 3	SWE 205 3	ICS 201 4*	COE 202 3	
	2nd	ICS 254 3	SWE 215 3*	ICS 202 4*	ICS 233 4*		IAS 201 2
Junior	1st	STAT 319 3*	SWE 316 3	SWE 312 3	ICS 324 4*		IAS 212 2
	2nd	SWE 387^{J} 3	SWE 326 3	SWE 363^{J} 3	ICS 343 4	ENGL 214 3	IAS 322 2
	Summer					SWE 399 ** 0	
Senior	1st	ICS 353 3	SWE 417 3*	SWE xxx 3	XE xxx 3	SE 307 3	
	2nd	SWE xxx 3	SWE 418 2*	XE xxx 3	ICS 431 4*	SWE xxx 3	IAS 301 2

** Pre-requisites for Summer Training (SWE 399): ENGL 214 and SWE 363 and Department Approval

❖ Key:
‘ Co-requisite: Math 101
* Requires Lab work
‘‘ Co-requisite: Math 102
J Junior Standing

Designed By: Azam!
Updated By: Dr. Sajjad Mahmood

Approved Free Electives for the Software Engineering Program

#	Course #	Course Name
1	ACCT 201	Principles of Accounting I
2	ACCT 202	Principles of Accounting II
3	AE 220	Introduction to Aerospace Engineering
4	AE 313	AE Systems and Control
5	AE 325	Gas Dynamics I
6	AE 333	Aerodynamics I
7	AE 403	Aerospace Materials
8	AE 410	Astronautics
9	AE 414	Flight and Air Traffic Control
10	AE 415	Flight and Aviation Safety
11	AE 416	Flight and Aviation Management
12	AE 417	Flight and Aviation Law
13	AE 418	Flight and Aviation Economics
14	AE 426	Flight Dynamics I
15	AE 427	Aerospace System Design
16	ARC – 124	Computer Aided Architectural Design
17	ARC – 225	Virtual Reality in Architecture
18	ARE – 211	Building Materials
19	ARE 212	Construction Systems
20	ARE 413	Construction Management
21	ARE 431	Building Economy
22	CE 201	Statics
23	CE 203	Structural Mechanics I
24	CE 215	Computer Graphics
25	CE 230	Engineering Fluid Mechanics
26	CE 318	Numerical & Statistical Methods in Civil Engineering
27	CE 330	Environmental Engineering Principles
28	CE 332	Engineering Hydrology and Hydraulics
29	CE 341	Transportation Engineering
30	CE 420	Construction Engineering
31	CHE 203	Chemical Engineering Thermodynamics I
32	CHE 201	Introduction to Chemical Engineering
33	CHEM 431	Chemistry of the Environment
34	CISE 301	Numerical Methods
35	COE 308	Computer Architecture
36	COE 344/COE 442	Computer Networks
37	COE 402	Computer System Performance Evaluation
38	COE 403	Advanced Microprocessor Architecture
39	COE 405	Design and Modeling Digital Systems
40	COE 420	Parallel Computing
41	COE 443	High Speed Networks
42	COE 484	Introduction to Robotics

#	Course #	Course Name
43	COE 488	Data Acquisition Interfacing
44	COE341/COE 342	Data & Computer Communication
45	ECON 101	Principles of Economics I (MICRO)
46	ECON 202	Principles of Economics II (MACRO)
47	EE 200	Digital Logic Circuit Design
48	EE 201	Electric Circuits I
49	EE 204	Fundamentals of Electrical Circuits
50	EE 205	Electric Circuits II
51	EE 208	Electrical Systems
52	EE 390	Digital Systems Engineering
53	GEOL 202	Applied Geosciences for Scientists and Engineers
54	GEOP 202	Introduction to Geophysics
55	GS 420	Personality Psychology
56	GS 423	International Relations
57	GS 424	Planning and Social Development
58	GS 427	Human and Environment
59	ISE 303	Operations Research
60	ISE 304	Principles of Industrial Costing
61	ISE 320	Quality Control and Industrial Statistics
62	ISE 323	Work and Process Improvements
63	ISE 405	Stochastic Systems and Simulations
64	ISE 420	Quality Improvement Methods
65	ISE 421	Operation Research II
66	ISE 443	Human Factors Engineering
67	ISE 447	Decision Making
68	ISE 460	Industrial Process Re-Engineering
69	ISE 464	Industrial Information Systems
70	ISE 480	Reliability and Maintainability
71	MATH 232	Introduction to Sets and Structures
72	MATH 260	Introduction to Differential Equations & Linear Algebra
73	MATH 280	Introduction to Linear Algebra
74	MATH 301	Methods of Applied Mathematics
75	MATH 302	Engineering Maths
76	MATH 305	Development of Mathematics
77	MATH 311	Advanced Calculus I
78	MATH 321	Introduction to Numerical Computing
79	MATH 330	Euclidean and Non-Euclidean Geometry
80	MATH 335	Linear Algebra
81	MATH 345	Modern Algebra I
82	MATH 411	Advanced Calculus II
83	MATH 425	Graph Theory
84	MATH 440	Differential Geometry
85	MATH 480	Linear & Nonlinear Programming

#	Course #	Course Name
86	ME 203	Thermodynamics I
87	ME 204	Thermodynamics II
88	ME 215	Materials Science for Mechanical Engineers
89	MGT 210	Business Communication
90	MGT 301	Principles of Management
91	MGT 311	Legal Environment
92	MGT 410	Human Resources Management
93	MGT 410	Organization Behavior and Design
94	MIS 345	Information Technology in Society
95	PHYS 211	Optics
96	PHYS 212	Modern Physics
97	PHYS 301	Classical Mechanics I
98	STAT 301	Introduction to Probability Theory
99	STAT 302	Statistical Inference
100	STAT 320	Statistical Quality Control
101	STAT 460	Time Series

Catalog Description of Courses

ICS 102 Introduction to Computing I **(2-3-3)**

Overview of computers and computing. Introduction to a typical object-oriented programming language. Basic data types and operators. Basic object-oriented concepts. Wrapper classes. Console input/output. Logical expressions and control structures. Classes and methods. Arrays and strings.

Co-requisite: MATH 101 or MATH 132

ICS 201 Introduction to Computing II **(3-3-4)**

Advanced object-oriented programming; inheritance; polymorphism; abstract classes and interfaces, container and collection classes, packages, object-oriented design, software modeling, event-driven programming, recursion, use of stacks, queues and lists from API, searching and sorting.

Prerequisite: ICS 102

ICS 202 Data Structures **(3-3-4)**

Review of object-oriented concepts; Introduction to design patterns; Basic algorithms analysis; Fundamental data structures - implementation strategies for stacks, queues and linked lists; Recursion; Implementation strategies for tree and graph algorithms; Hash tables; Applications of data structures (e.g. data compression and memory management).

Prerequisite: ICS 201

ICS 233 Computer Architecture and Assembly Language **(3-3-4)**

Machine organization; assembly language: addressing, stacks, argument passing, arithmetic operations, decisions, modularization; Input/Output Operations and Interrupts; Memory Hierarchy and Cache memory; Pipeline Design Techniques; Super-scalar architecture; Parallel Architectures.

Prerequisite: COE 202, ICS 201

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

Propositional Logic, Predicate Logic, Sets, Functions, Sequences and Summation, Proof Techniques, Mathematical induction, Inclusion-exclusion and Pigeonhole principles, Permutations and Combinations (with and without repetitions), The Binomial Theorem, Recurrence Relations; Graphs terminology and applications, Connectivity, Isomorphism, Euler and Hamilton Paths and Circuits, Planarity and Coloring; Trees terminology and applications.

Prerequisite: ICS 102

ICS 254 Discrete Structures II **(3-0-3)**

Number Theory: Modular Arithmetic, Integer Representation, Fermat's Little Theorem, Chinese Remainder Theorem, RSA.; Proof Techniques: Methods of Proofs, Applications from Number Theory, Recursive Definitions; Algorithm Correctness; Relations: Closures and Equivalence Relations, Partial Orderings and Lattices, Hasse Diagrams; Recurrence Relations and Generating Functions; Automata Theory: Finite State Machines, Regular Expressions, DFA, NDFA and their equivalence, Grammars and Chomsky Hierarchy, Introduction to Turing Machines.; Abstract Algebra: Groups, Homomorphisms and Lagrange's Theorem, Applications.

Prerequisite: ICS 253

ICS 324 Database Systems **(3-3-4)**

Basic database concepts, conceptual data modeling, relational data model, relational theory and languages, database design, SQL, introduction to query processing and optimization, and introduction to concurrency and recovery.

Prerequisite: 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, socket programming and network security; Transport layer: TCP and UDP, congestion control; Network layer: internetworking, addressing and routing algorithms and protocols; Data link layer: framing, flow and error control protocols, PPP, MAC and LANs; Physical layer: principles of data communications, circuit switching, coding, multiplexing and transmission media.
Prerequisite: ICS 201
Note: This course cannot be taken for credit with COE 344.

ICS 353 Design and Analysis of Algorithms (3-0-3)
Algorithms and Problem Solving; Basic Algorithmic Analysis; Advanced algorithmic analysis; Advanced Data Structures; Algorithmic strategies & Analysis of fundamental computing algorithms; Basic computability; The complexity classes P and NP.
Prerequisites: ICS 202 and ICS 253

ICS 431 Operating Systems (3-3-4)
This course introduces the fundamentals of operating systems design and implementation. Topics include history and evolution of operating systems; Types of operating systems; Operating system structures; Process management: processes, threads, CPU scheduling, process synchronization; Memory management and virtual memory; File systems; I/O systems; Security and protection; Distributed systems; Case studies.
Prerequisite: ICS 233.

SWE 205 Introductions to Software Engineering (3-0-3)
Introduction to software engineering and software processes. Construction techniques and principals. Concepts of Programming Languages: Syntax and semantics. Analysis and Design Modes. Ethical and professional responsibilities.
Prerequisites: ICS 102

SWE 215 Software Requirements Engineering (2-3-3)
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. Students participate in a group project on software requirements.
Prerequisites: ICS 201 and SWE 205

SWE 312 User Interface Design (3-0-3)
Study of both theoretical and practical issues in human-computer interfaces. User interface design process. Usability engineering. Development, programming, and evaluating interface designs. Design of windows, and menus. Commands and natural languages I/O. Visual prototyping. User manuals, online help and tutorials. Students participate in a group project on software user interface design.
Prerequisites: SWE 205

SWE 316 Software Design and Architecture (3-0-3)
Study of design concepts and notations. Architecture, middleware architectures, design patterns, frameworks and components. Designing for qualities such as performance, security, reusability, reliability. Metrics and measurement. Basics of software evolution, reengineering, and reverse engineering. Students participate in a group project on software design.
Prerequisites: ICS 202 and SWE 215

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 and Quality Assurance (3-0-0)
Concept of software quality, and software quality metrics. Software quality assurance planning & implementation. Quality process standards. Validation & verification. Reviews, walkthroughs, & inspections. Mechanisms for validating software systems. Techniques for generating and validating test data. Students participate in a group project on software validation and verification.
Prerequisites: SWE 215 and SWE 312

SWE 344 Internet Protocols and Client-Server Programming (2-3-3)
Principles of inter-network architecture and communication protocols. Open systems and interoperability. Case studies of particular protocols from network layer and above. Socket programming. Remoting. Selected examples of networked client-server applications such as e-mail, news, file-transfer, HTTP. Client-Server Programming Project(s). Using APIs. Software tools and environments.
Prerequisites: ICS 202

SWE 363 Web Engineering and Development (3-0-3)
Web Engineering fundamentals: requirements, analysis modeling, design modeling, testing. Internet basics for web applications. Technologies and tools for developing web applications: markup languages, styling, data description and transformation, client and server side programming. Web services. Advances in web engineering.
Prerequisites: Junior Standing

SWE 387 Software Project Management (3-0-3)
Introduction project management concepts, tools, and techniques: integration management and project planning, scope management, scheduling, budget control, human resource management, communication management, risk analysis and management, project quality management, and procurement management.
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 computer science related activities and use his time to get acquainted with the computer science 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. The student receives a zero-credit Pass/Fail grade.
Prerequisites: SWE 363, ENGL 214, and Department Approval

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 417 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, software requirement specification and software design document.
Prerequisites: SWE 316 and SWE 387

SWE 418 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 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 implement the design they produced in SWE 417, test their code, and evaluate their final product.
Prerequisites: SWE 417 and SWE 326

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 469 Software Metrics **(3-0-3)**
Overview of software metrics, basics of measurement theory, goal-based framework for software measurement, empirical investigation in software engineering. Measuring internal product attributes, measuring external product attributes, measuring cost and effort, measuring software reliability, software test metrics, and object-oriented metrics.
Prerequisites: SWE 316 and STAT 319

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 326

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

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