**Software Breadth COURSES**

Graduate students following the Software Track of the Informatics Concentration must complete three graduate courses outside of software (“Software Breadth”) drawn from this list. This list is not intended to be exclusive, however. If you have identified a course not on this list that you think would add value to your program, we encourage you (with your advisor’s approval, for Ph.D. students) to propose that it satisfy the Software Breadth requirement; check with the Student Affairs Office for details on the process.

**Bren School COURSES - Computer Science**

**CompSci 201 Foundations of Cryptographic Protocols (4).** Overview of modern cryptography; security threats and countermeasures; secret and public key cryptography; digital signatures and non-repudiation; cryptographic strength; block ciphers and stream ciphers; computer and network security; data privacy and data integrity; authentication and identification; freshness and timeliness. Prerequisites: ICS 161, 162, 260, 261, 262, 263, or equivalent; consent of instructor.

**CompSci 202 Applied Cryptography (4).** Algorithms and data structures for performing computer security services. Network security, digital certificates and credentials, authenticated dictionaries, dynamic coalition management, and techniques for authorization and non-repudiation. Prerequisites: ICS 161, 163, 260, 261, 262, 263, or equivalent.

**CompSci 203 Network and Distributed Systems Security (4).** Overview of modern computer and networks security: attacks and countermeasures. Authentication, identification, data secrecy, data integrity, authorization, access control, computer viruses, network security. Group communication and multicast security techniques. Also covers secure e-commerce and applications of public key methods, digital certificates, and credentials. Prerequisite: ICS 243A. Same as Networked Systems 240.

**CompSci 206 Principles of Scientific Computing (4).** Overview of widely used principles and methods of numerical and scientific computing, including basic concepts and computational methods in linear algebra, optimization, and probability. Prerequisites: basic courses in multivariate calculus, linear algebra, and probability. ICS 282 and Statistics 230 may not both be taken for credit.

**CompSci 212 Multimedia Systems and Applications (4).** Organization and structure of modern multimedia systems; audio and video encoding/compression; quality of service concepts; scheduling algorithms for multimedia; resource management in distributed and multimedia systems; multimedia protocols over high-speed networks; synchronization schemes; multimedia applications and teleservices. Prerequisites: undergraduate degree in computer science or ICS 143 and 161. ICS 148, 153, and 156 are also recommended. Undergraduates may enroll with consent of instructor.

**CompSci 221 Information Retrieval, Filtering, and Classification (4).** Algorithms for the storage, retrieval, filtering, and classification of textual and multimedia data. The vector space model, Boolean and probabilistic queries, and relevance feedback. Latent semantic indexing; collaborative filtering; and relationship to machine learning methods. Prerequisites: B.S. degree in computer science, or ICS 161, 171; Mathematics 3A or 6C; and a course in basic probability.

**CompSci 222 Principles of Data Management (4).** Covers fundamental principles underlying data management systems. Content includes key techniques including storage management, buffer management, record-oriented file system, access methods, query optimization, and query processing. Prerequisites: ICS 143, 148, 152, and 184. Formerly ICS 214.

**CompSci 223 Transaction Processing and Distributed Data Management (4).** Covers fundamental principles underlying transaction processing including database consistency, concurrency control, database
recovery, and fault-tolerance. Includes transaction processing in centralized, distributed, parallel, and client-server environments. Prerequisite: ICS 214A.

**CompSci 224 Advanced Topics in Data Management (4).** Selected advanced topics in data management. Content differs in each offering and with instructor's interests. Intended for students interested in data management with focus on reading and critiquing recent research papers, presentations, and substantial research projects. Prerequisites: ICS 143, 152, 161, 214A, 214B, or consent of instructor.

**CompSci 230 Distributed Computer Systems (4).** Principles of distributed computing systems. Topics covered include message-passing, remote procedure calls, distributed shared memory synchronization, resource and process/thread management, distributed file systems, naming and security. Prerequisite: consent of instructor. Formerly ICS 247.

**CompSci 232 Internet (4).** A broad overview of basic networking concepts. Layered network architecture and network protocols. Internet architecture and operation, including addressing, routing, and flow control. Local area networks. Telephone network architecture. Integrated services architectures, including Asynchronous Transfer Mode. Prerequisite: an introductory course in probability or consent of instructor. Same as EECS248A and Networked Systems 201.

**CompSci 233 Networking Laboratory (4).** A laboratory-based introduction to basic networking concepts such as addressing, sub-netting, bridging, ARP, and routing. Network simulation and design. Structured around weekly readings and laboratory assignments. Prerequisite: ICS 243A. Same as Networked Systems 202.

**CompSci 234 Advanced Networks (4).** Advanced network protocols, potentially including ATM, advanced addressing, advanced routing, streaming, QoS, optical networks. Prerequisite: ICS 243A. Same as Networked Systems 210.

**CompSci 235 Internet Technology (4).** Application layer Internet protocols, potentially including client/server, WWW, file sharing, group communications, Internet programming. Prerequisite: ICS 243A. Same as Networked Systems 220.

**CompSci 236 Wireless and Mobile Networking (4).** Introduction to wireless networking. The focus is on layers 2 and 3 of the OSI reference model, design, performance analysis, and protocols. Topics covered include: an introduction to wireless networking, digital cellular, next generation cellular, wireless LANs, and mobile IP. Prerequisites: ICS 243A, and an introductory course in probability or consent of instructor. Same as Networked Systems 230.

**CompSci 237 Middleware for Networked and Distributed Systems (4).** Discusses concepts, techniques, and issues in developing distributed systems middleware that provides high performance and Quality of Service for emerging applications. Also covers existing standards (e.g., CORBA, DCOM, Jini, Espeak) and their relative advantages and shortcomings. Prerequisite: undergraduate-level course in operating systems and networks or consent of instructor. Same as Networked Systems 260.

**CompSci 241 Advanced Compiler Construction (4).** Advanced study of programming language implementation techniques: optimizations such as common sub-expression elimination, register allocation, and instruction scheduling. Implementation of language features such as type-directed dispatch, garbage collection, dynamic linking, and just-in-time code generation. Prerequisite: ICS 142 or equivalent.

**CompSci 244/In4matx 244 Introduction to Embedded and Ubiquitous Systems (4).** Embedded system technologies including processors, DSP, memory, and software. System interfacing basics; communication strategies; sensors and actuators; mobile and wireless technology. Using pre-designed hardware and software components. Design case studies in wireless, multimedia, and/or networking domains. Prerequisites: B.S. degree in computer science; or ICS 51, 152; Mathematics 3A or 6C or ICS 6A; ICS 161.
CompSci 245 Software for Embedded Systems (4). Embedded computing elements, device interfaces, time-critical IO handling. Embedded software design under size, performance, and reliability constraints. Software timing and functional validation. Programming methods and compilation for embeddable software. Embedded runtime systems. Case studies of real-time software systems. Prerequisites: B.S. degree in computer science; or ICS 51, 152; Mathematics 3A or 6C or ICS 6A; ICS 161.


CompSci 248A/In4matx 241 Introduction to Ubiquitous Computing (4). The "disappearing computer" paradigm. Differences to the desktop computing model: applications, interaction in augmented environments, security, alternate media, small operating systems, sensors, and embedded systems design. Evaluation by project work and class participation.


CompSci 260 Fundamentals of the Design and Analysis of Algorithms (4). Covers fundamental concepts in the design and analysis of algorithms and is geared toward non-specialists in theoretical computer science. Topics include: deterministic and randomized graph algorithms, fundamental algorithmic techniques like divide-and-conquer strategies and dynamic programming, and NP-completeness. Prerequisite: ICS 161 or equivalent undergraduate algorithms course.

CompSci 261 Data Structures (4). An in-depth treatment of data structures and their associated management algorithms including resource complexity analysis. Prerequisite: ICS 23 and 161.

CompSci 262 Computational Complexity (4). Advanced course in computational models and complexity classes. Covers the fundamentals of Turing Machines, Decidability, and NP-completeness. Includes discussion of more advanced topics including polynomial hierarchy, randomized complexity classes, #P-completeness and hardness of approximation. Prerequisite: ICS 162.

CompSci 263 Analysis of Algorithms (4). Analysis of correctness and complexity of various efficient algorithms; discussion of problems for which no efficient solutions are known. Prerequisites: ICS 161 and 261.

CompSci 265 Graph Algorithms (4). Graph definitions, representation methods, graph problems, algorithms, approximation methods, and applications. Prerequisites: ICS 161 and 261.

CompSci 266 Computational Geometry (4). An overview of some of the basic problems in computational geometry and of some algorithmic and data-structuring techniques appropriate to their solution. Prerequisites: ICS 161 and 261.
CompSci 267 Data Compression (4). An introduction to the theory and practice of modern data compression techniques. Topics include codes, coding, modeling, text compression, lossless and lossy image compression standards and systems, audio compression. Prerequisite: ICS 161, 260, or 261.

CompSci 271 Introduction to Artificial Intelligence (4). The study of theories and computational models for systems which behave and act in an intelligent manner. Fundamental subdisciplines of artificial intelligence including knowledge representation, search, deduction, planning, probabilistic reasoning, natural language parsing and comprehension, knowledge-based systems, and learning.

CompSci 273A Machine Learning (4). Computational approaches to learning algorithms for classifications, regression, and clustering. Emphasis is on discriminative classification methods such as decision trees, rules, nearest neighbor, linear models, and naive Bayes. Prerequisites: ICS 270A and ICS 282. Formerly ICS 273.

CompSci 273B Kernel-Based Learning (4). Principles of kernel methods, support vector machines, and related machine learning methods. Applications to regression, classification, prediction, and other data analysis problems. Typical areas of application range from bioinformatics, to image analysis, to pattern recognition. Prerequisites: ICS 271 and ICS 273A, or consent of instructor.

CompSci 274A Probabilistic Learning: Theory and Algorithms (4). An introduction to probabilistic and statistical techniques for learning from data, including parameter estimation, density estimation, regression, classification, and mixture modeling. Prerequisite: ICS 282 or consent of instructor. Formerly ICS 274.

CompSci 274B Learning in Graphical Models (4). Models for data analysis are presented in the unifying framework of graphical models. The emphasis is on learning from data but inference is also covered. Real world examples are used to illustrate the material. Prerequisite: ICS 274A or consent of instructor.

CompSci 275 Network-Based Reasoning/Constraint Networks (4). Study of the theory and techniques of constraint network model. Covers techniques for solving constraint satisfaction problems: backtracking techniques, consistency algorithms, and structure-based techniques. Tractable subclasses. Extensions into applications such as temporal reasoning, diagnosis, and scheduling. Prerequisite: a basic course in algorithm design and analysis, or consent of instructor.

CompSci 276 Network-Based Reasoning/Belief Networks (4). Focuses on reasoning with uncertainty using "Bayes Networks" that encode knowledge as probabilistic relations between variables, and the main task is, given some observations, to update the degree of belief in each proposition. Prerequisite: a basic course in probability or consent of instructor.

CompSci 277 Data Mining (4). Introduction to the general principles of inferring useful knowledge from large data sets (commonly known as data mining or knowledge discovery). Relevant concepts from statistics, databases and data structures, optimization, artificial intelligence, and visualization are discussed in an integrated manner. Prerequisite: ICS 273 or 274 or consent of instructor.


Bren School COURSES - Informatics

In4matx 203 Qualitative Research Methods in Information Systems (4). Introduction to qualitative research methods used to study computerization and information systems, such as open-ended interviewing, participant observation, and ethnography. Studies of the methods in practice through examination of research literature. Prerequisite: ICS 230 or 233.

In4matx 205 Quantitative Research Methods in Information Systems (4). Quantitative research methods used to study computerization and information systems. Design of instruments, sampling, sample sizes, and data analysis. Validity and reliability. Longitudinal versus cross-sectional designs. Analysis of
secondary data. Studies of the methods through examination of research literature. Prerequisites: basic knowledge of elementary statistics; ICS 230 or 233.

**In4matx 207 Descriptive Multivariate Statistics I (4).** Mathematical tools to organize and illuminate the multivariate methods. Multiple regression analysis. Multi-dimensional scaling and cluster analysis. Statistical computing via MDS(x), DMDP, and SPSS. Students must enroll in the laboratory section which meets on Wednesdays. Satisfactory/Unsatisfactory grading only. Prerequisite: Social Science 100A-B-C or equivalent. Same as Social Ecology 290A, Social Science 201A, and Management 290X.

**In4matx 251 Computer-Supported Cooperative Work (4).** The role of information systems in supporting work in groups and organizations. Examines various technologies designed to support communication, information sharing, and coordination. Focuses on behavioral and social aspects of designing and using group support technologies.

**In4matx 263 Computerization, Work, and Organizations (4).** Selected topics in the influence of computerization and information systems in transforming work and organizations. Theories of organization and organizational change. Processes by which diverse information technologies influence changes in work and organizations over short and long time periods. Prerequisite: ICS 230 or 233.

**In4matx 265 Theories of Computerization and Information Systems (4).** Social and economic conceptions of information technology. Macrosocial and economic conditions that foster changes in information technologies. Social construction of information and computer technology in professional worlds. Theories of information technology and large-scale social change. Prerequisite: ICS 230 or 233.

**In4matx 267 Computing and Cyberspace (4).** Selected topics in Internet-level computerization and systems, including electronic communities, distributed information services, electronic commerce, and digital libraries. Surveys systems and architectures. Theories of social interaction, computer-mediated communication, and social-technical system design. Examines social studies of cyberspace use and impacts. Prerequisite: ICS 230 or 233.

**In4matx 269 Computer Law (4).** The American legal system and its provisions affecting computer systems, computer networks, and information processing. Intellectual property, contracts, privacy, liability for malfunction, computer crime, constitutional issues, transborder data flow, computer-based evidence, and litigation. Prerequisite: graduate standing or consent of instructor. Formerly Informatics 264.

**ACE COURSES**

(each of these may count only once towards the breadth requirement of the Software track)

**I&C SCI 270 Arts Computation Engineering Interdisciplinary Theory Seminar: Special Topics (4).** Counterposes technological discourses with fine arts discourses and practices, with a focus on historical contextualization, utilizing critical theory and science and technology studies perspectives. Topics vary and are not repeated in any three-year period. May be repeated for credit as topics vary. Same as Engineering 270 and Arts Interdisciplinary 270.


**I&C SCI 272 Arts Computation Engineering Studio/Laboratory: Games and Algorithmic Systems in Literature and the Arts (4).** Explores the cultural tradition of the game and game play with particular reference to the automation of games in computational systems and the close relation between gaming,
improvisation, hypertext, and interactive art. Game programming techniques and projects. May be taken twice for credit. Same as Engineering 272 and Arts Interdisciplinary 272.


I&C SCI 274 Arts Computation Engineering Studio/Laboratory: Real Space Interaction (4). Designing and building machine artworks, motion control, mechatronic, animatronic, and mobile robotic projects. Mechanics, electromechanics, electronics, microcontrollers, motor control. Aesthetico-critical as well as technical aspects subject to assessment. Same as Engineering 274 and Arts Interdisciplinary 274.


I&C SCI 277 Arts Computation Engineering Studio/Laboratory: Special Topics (4). Focuses on currently emerging technologies, techniques, and cultural and critical issues. May be repeated for credit as topics vary. Same as Engineering 277 and Arts Interdisciplinary 277.

EECS COURSES

EECS205 Advanced Scientific Visualization (4). Introduces advanced visualization techniques for various types of measured or computer-simulated data. Typical applications for these visualization techniques include the study of airflows around car bodies, medical data, and molecular structures. Prerequisite: EECS105 or consent of instructor. Formerly ECE205.

EECS208 Principles of Virtual Reality (4). Introduces cutting-edge virtual reality technology. Provides an introduction to the physical principles, technological challenges, possibilities, and limitations for the creation of virtual environments. Programming projects emphasize the visualization, exploration, and modification of scientific data in virtual environments. Prerequisite: EECS104 or consent of instructor. Formerly ECE208.

EECS242 Information Theory (3). Fundamental capabilities and limitations of information sources and information transmission systems. An analytical framework for modeling and evaluating communication systems: entropy, mutual information asymptotic equipartition property, entropy rates of a stochastic process, data compression, channel capacity, differential entropy, the Gaussian channel. Prerequisite: EECS240. Formerly ECE225.

School of Business COURSES

MGMT MBA207 Information Technology for Management (4). Focuses on the technological and managerial issues surrounding the development and use of IT in organizations. Examines role of technology in organizations, how technology can be used to execute an organization's business strategy, and to enable new, innovative business strategies.
MGMTMBA216 Management of High-Technology Companies (4). Focuses on the unique array of managerial problems that derive from operating in high-velocity, high-change environments. Methods include rigorous case analyses, readings, and visiting experts to enhance knowledge.

MGMTFE271 Systems Analysis and Design (4). Systems analysis and design is a complex, organizational process a team of business and technical professionals uses to identify, design, and create information-based solutions to business challenges. Explores the concepts, methodologies to create business value for the organization. Prerequisite: Management 207.

MGMTFE272 Critical IT Decisions for Business Executives (4). Develops frameworks to help business executives make critical IT decisions. Examples include how much to invest in IT, determining management practices to maximize return on IT investment, sourcing strategies for IT and business process outsourcing, strategies for digital environments. Prerequisite: Management 207.

MGMTFE274 Database Management and Applications (4). Examines contemporary business applications of databases including CRM, segmentation, data-warehousing, data-mining, and business intelligence. Also covers the database design process with a focus on enabling business decision making including capturing the linkages among data, querying, and data administration. Prerequisite: Management 207.

MGMTFE275 Strategic Information Systems (4). Focuses on the strategic and competitive implications of IT, the Internet, and e-business for firms, industries, and countries. Topics include: globalization; IT alignment with business strategy; value of IT; business transformation; national IT policy; strategy and IT in the network era. Prerequisite: Management 207.

MGMTFE278 Information Systems Project Management (4). Concentrates on project management techniques in the context of information systems projects: organizing, planning, budgeting, scheduling, management, leadership, and control. Special emphasis is placed on issues of system implementation and management of organizational change. Prerequisite: Management 207.

MGMTFE287 Project Management (4). Examines the fundamental components of project management and its role in the modern corporation. Emphasis is on how to initiate, implement, control, and terminate a project. Use of computer package for project management.

SOCIAL SCIENCE COURSES

SocSci201G Analysis of Relational Data (4). A practicum in social networks data analysis focusing on the special problems raised by data sets that embody relations. Log-linear and quadratic assignment procedures are stressed along with multidimensional scaling and other representational models. Prerequisites: graduate standing; consent of instructor. Same as Anthropology 222A, Social Science 241C and 256A, and Sociology 225A.