Knight Foundation School of Computing and Information Sciences

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The Knight Foundation School of Computing and Information Sciences offers five Master of Science degrees and a Doctor of Philosophy degree. The Master of Science in Computer Science degree provides study in state-of-the-art computer applications as well as an introduction to the theoretical foundations of computer science. The Master of Science in Information Technology is intended to educate students in the technical aspects of information. The Master of Science degree in Telecommunications and Networking is intended to provide study in state-of-the-art telecommunications and networking technologies and management. The Master of Science in Cybersecurity includes student learning outcomes that address cybersecurity from several complementary perspectives. The Master of Science in Data Science provides broad and deep technical training in data science, with specialization in several key application areas of importance to industry. The Doctor of Philosophy in Computer Science is designed to provide study in all major areas of computer science while leading to the frontiers of knowledge in a chosen field of concentration.

Master of Science in Computer Science

Admission

The following are in addition to the University's graduate admission requirements:

1. A Bachelor's Degree or equivalent in Computer Science from an accredited institution. A degree in a related field is acceptable if the applicant shows evidence of computer science background suitable for entry into the master's program as judged by the Graduate Committee.
2. Foreign students whose native language is not English must score at least 550 on the paper-based (or 80 on iBT) in the Test of English as a Foreign Language (TOEFL).

Required Courses

1. Required coursework: 9 credits

COT 5407	Introduction to Algorithms	3
Choose two from the following:		
CEN 5011	Advanced Software Engineering	3
COP 5725	Principles of Database Management Systems	3
COP 5614	Operating Systems	3

2. Elective coursework

a. non-thesis option: 21 credits of elective courses
b. thesis option: 15 credits of elective courses and 6 credits of master's thesis

Elective courses can be selected from SCIS Graduate Course Offerings.

No grade below "C" will be accepted in any course taken to satisfy graduate program requirements.

Thesis Option

CIS 6970	Thesis	6

After completion of the other required courses, the student must conduct a research thesis. The topic must first be approved by the faculty member who will supervise the research and then by the Thesis Committee. The thesis

will be accepted only after being read and approved by a Thesis Committee. An oral defense is required before the Thesis Committee.

Combined BS/MS in Computer Science Degree Pathway

To be considered for admission to the combined bachelor's/master's degree pathway, students must have completed 75 credits in the bachelor's degree program at FIU and meet the admissions criteria for the graduate degree program to which they are applying. Students need only apply once to the combined degree pathway the application is submitted to Graduate Admissions typically before the student starts the last 30 credits of the bachelor's degree program. A student admitted to the combined degree pathway will be considered to have undergraduate status until the student applies for graduation from their bachelor's degree program. Upon conferral of the bachelor's degree, the student will be granted graduate status and be eligible for graduate assistantships. Only 5000-level or higher courses, and no more than the number of credits specified by the program catalog, may be applied toward both degrees.

Admission Requirements

1. Current enrollment in the Bachelor's Degree program in Computer Science at FIU.
2. Completed at least 75 credits of coursework.
3. Current GPA must be 3.3 or higher.
4. Complete the separate Combined Degree Pathway application, including signed approval by the director or designee from the graduate program.

General Requirements

The FIU Bachelor's degree in Computer Science must be awarded before the Master's degree.

Coursework

Required Courses

COT 5407	Introduction to Algorithms	3
Choose two from the following:		
CEN 5011	Advanced Software Engineering	3
COP 5725	Principles of Database Management Systems	3
COP 5614	Operating Systems	3

Elective

7 courses selected from the SCIS Graduate Course Offerings.

No grade below "C" will be accepted in any course taken to satisfy graduate program requirements.

Overlap

Up to 4 courses (12 credits) may be used in satisfying both the Bachelor's and Master's degree requirements. All overlapping courses must be approved by both graduate and undergraduate program directors before students are enrolled in such courses.

The courses must be regular 5000-level computer science graduate courses intended for graduate majors.

Master of Science in Cybersecurity

The MS-Cybersecurity program will include student learning outcomes that address cybersecurity from several complementary perspectives:

1. Students will gain practical, hands-on skills in current "best practices" in cybersecurity, such as configuring firewalls and writing secure web applications, while also understanding their limitations.
2. Students will gain deep knowledge of the principles of the emerging science of cybersecurity, enabling them to understand and even design solutions with rigorously-provable security guarantees.
3. Students will gain understanding of the broader human context of cybersecurity, enabling them to consider and address its social, economic, political, and psychological implications.
4. Students will gain deeper knowledge of specific areas in cybersecurity through their selection of elective courses.

Admission Requirements

The following are in addition to the University's graduate admission requirements.

1. A Bachelor's degree from an accredited institution in Computer Science, Computer Engineering, Information Technology, or a similar discipline.
2. Foreign students whose native language is not English must score at least 550 on the paper-based (or 80 on iBT) in the Test of English as a Foreign Language (TOEFL).

Required Courses

The students are required to earn 30 credits from 10 courses, including 5 core courses and 5 elective courses chosen from an approved set of electives.

Core Courses (15 credits)

CEN 5079	Secure Application Programming	3
CIS 5208	Social, Economic, and Policy Aspects of Cybersecurity	3
CIS 5370	Principles of Cybersecurity	3
CNT 5415	Practical Applied Security	3
COT 5428	Formal Foundations for Cybersecurity	3

Elective Courses (15 credits)

List of courses is maintained by the Knight Foundation School of Computing and Information Sciences and the Department of Electrical and Computer Engineering.

Master of Science in Data Science

The Master of Science in Data Science is an interdisciplinary program that provides broad and deep technical training in data science, drawing on faculty expertise from five different colleges across the FIU campus, allowing for specialization in several key application areas of importance to industry, and training students from a wide variety of disciplines. The program is aimed at students with sound analytical skills holding a Bachelor's degree in Computer Science, Computer Engineering, Statistics, Healthcare Management, Management Information Systems, Hospitality Management, or related disciplines. The program will have a common core involving four courses in Computing and Statistics plus a Capstone course. The Elective courses are offered as separate specialization tracks to prepare students to become data scientists in areas such as Computational Data Analytics, Business Data Analytics,

Hospitality Data Analytics, and Biostatistics Data Analytics. The program will prepare students with professional experience for the marketplace. The Capstone course will pursue a discipline-specific and industry-relevant project in data analytics.

Admissions Requirements

The following requirements are in addition to the University's graduate admission requirements.

1. Bachelor's degree in a discipline appropriate for the specialization sought. For example, a specialization in **Computational Data Analytics** requires a Bachelor's degree in Computer Science, Computer Engineering, Information Technology, Mathematics, Statistics, or a related discipline. Students seeking to specialize in other tracks would require an appropriate Bachelor's degree.
2. GRE general test score with a minimum quantitative score of 148.
3. Three letters of recommendation

Required Courses

Students are required to complete 30 credits of graduate level courses. Included in the program are 12 credits of core courses, 15 credits of elective courses, and 3 credits of a capstone course.

Core Coursework (12 credits)

Students must complete these four courses.

CAP 5768	Introduction to Data Science	3
COP 5771	Principles of Data Mining	3
STA 6244	Data Analysis I (or equivalent)	3
STA 6247	Data Analysis II (or equivalent)	3

Students in the Biostatistics Data Analytics track may replace STA 6244 and 6247 with PHC 6052 and 6091, respectively.

Required Capstone Course (3 credits)

Students in each track must complete three credits of capstone course involving a data analytics project.

IDC 6940	Capstone in Data Science	3
ISM 6930	Topics in Management Information. Systems (for Business track)	3

Specialization Elective Courses (15 credits)
Students must complete any five courses from one of the specialization tracks listed below. The list of courses is maintained by the unit that houses the track.

Computational Data Analytics (Knight Foundation School of Computing and Information Sciences)

Business Analytics (Dept. Information Systems and Business Analytics)

Hospitality Analytics (College of Hospitality and Tourism Management)

Biostatistics Data Analytics (Dept. Biostatistics)

Public Policy Analytics (Dept. of Public Policy and Administration)

Data Science 4+1 Degree Pathway

With their advisor's approval, students from all undergraduate majors including Computer Science, Information Systems and Statistics may apply to the Data Science 4+1 degree pathway. If accepted, students will be allowed to take up to 12 credits of graduate data science courses which will apply towards both their undergraduate degree requirements and the master's degree program in data science.
The admission requirements are:

1. Current enrollment in an approved bachelor's degree program at FIU.
2. Completed 75 credits.
3. Current GPA must be 3.3 or higher.
4. GRE quantitative score of 148 or higher.
5. Completed prerequisites for the master's in Data Science program or demonstrated competencies in the specialization areas (the latter option requires approval by the graduate program director of the appropriate specialization area)
6. Complete the separate 4+1 pathway application, including signed approval by the director or designee from the graduate program.

Master of Science in Information Technology

The Master of Science in Information Technology is intended to educate students in the area of technical aspects of Information. It provides an emphasis on software technology, database technology, and security technology. The program is ideally suited for those who wish to obtain a higher level degree in Information Technology, and seek employment in the IT industry.

Admissions Requirements

The following are in addition to the University's graduate admissions requirements.

1. Bachelor's degree from an accredited institution in Information Technology, Computer Science, Computer Engineering, or a similar field or a Bachelor's degree in any field plus 3 years of Information Technology work experience.
2. Foreign students whose native language is not English must score at least 550 on the paper-based (or 80 on iBT) in the Test of English as a Foreign Language (TOEFL).

A student's GPA and required test scores will be considered as minimum requirements for admission. The academic background of each student shall be analyzed to determine if there is need for remedial courses in addition to the required curriculum. Students are also required to comply with all course prerequisites.

Required Courses

Students in the Master of Science in Information Technology program will be required to take 30 credits of graduate level courses. Included in the program are 9 credits of Information Technology core courses, 6 credits that form a track, and 15 credits of Information Technology elective courses.

Core Coursework (9 credits)

CEN 5087	Software and Data Modeling
CIS 5372	Fundamentals of Computer Security
CIS 5027	Computer Systems Fundamentals

Track Courses (6 credits)

Student must choose one track

Software Track
The software track prepares students with fundamental methods and cutting-edge technologies for developing and maintaining software systems. Students graduating from the software engineering specialization will have a thorough knowledge of the process and major techniques for modeling, designing, and analyzing software systems. The graduates of this track will be well-prepared to undertake major software systems development projects from major software corporations such as Motorola, Siemens, and IBM.

Students must choose two courses from a list of courses maintained by the school.

System Administration Track
The System Administration track prepares the student to be able to install, support, and maintain servers or other computer systems, and planning for and responding to service outages and other problems. Other duties may include scripting and basic programming, setting up custom operating system environments, project management for systems-related projects, supervising or training computer operators, and being the consultant for computer problems beyond the knowledge of technical support staff.

Students must choose two courses from a list of courses maintained by the school.

Security Track
The security track will equip students with fundamental knowledge and skills in information security and privacy, system security, and network security to they become highly qualified workforce in information technology fields.

Students must choose two courses from a list of courses maintained by the school.

Electives (15 credits)
Students must choose any four graduate level courses offered by the Knight Foundation School of Computing and Information Sciences, with the exception of CGS 6834 and COP 6007. Three credits can be earned in either CIS 5900 or CIS 5910, but not both. With the approval of the Graduate Program Director, one course not appearing on this list can be substituted for an elective.

Master of Science in Telecommunications and Networking

The Master of Science in Telecommunications and Networking is intended to educate individuals seeking employment with hardware and/or software companies, service providers, large user organizations, or telecommunications regulatory agencies as well as for those who are employed by these companies/organizations and wish to obtain formal, higher-level, specialized degree in Telecommunications and Networking. Telecommunication and Networking students learn how to lead in the ever changing environment of real-time global information networking, telecommunications, wireless and optical strategies and how to amplify business value through communications, technologies and systems. All courses in the program are categorized under the five following areas. SCIS offers thesis and non-thesis options for the Master's Degree.

Admissions Requirements

1. Bachelor's degree in a related field from an accredited institution.
2. Foreign students whose native language is not English, must score at least 550 on the paper-based (or 80 on iBT) in the Test of English as a Foreign Language (TOEFL).

Graduate Requirements

1. Maintain an overall GPA of at least 3.0. No grade below "C" will be accepted in any course taken to satisfy graduate program requirements.
2. Completion of 30 semester hours of graduate level in three categories:
   - 15 credits of required courses
   - 6 credits of either thesis or courses from any one focus area
   - 9 credits of electives

Required Courses (breadth)
All students must complete the following five courses:

TCN 5030	Computer Communications and Networking Technologies
TCN 6430	Networks Management and Control Standards
TCN 6275	Mobile Computing
TCN 5080	Secure Telecommunications Transactions (or CIS 5372)
TCN 5640	Telecommunications Enterprise Planning and Strategy

One Focus Area (depth)
Students in the non-thesis option must select two courses from one focus area that aligns with their backgrounds and interests. Areas include but are not limited to software, communications, policy/legal issues, wireless and security. These areas are designed to serve a wide constituency of students. The list of focus areas and acceptable courses are maintained by the school.

Electives
Three additional courses offered by the Knight Foundation School of Computing and Information Sciences (to bring to 30 credits), including any above course or TCN-prefix course not otherwise used to the satisfy focus requirement. The list of acceptable courses is maintained by the School.

Combined BS in Electrical Engineering/MS in Telecommunications and Networking Degree Pathway

Students who pursue a BS degree and are in their junior year, with at least a 3.3 GPA on both overall and upper division courses may apply to enroll in the combined BS/MS pathway. To be considered for admission to the combined bachelor's/master's degree pathway, students must have completed at least 75 credits in the bachelor's degree program at FIU and meet the admissions criteria for the graduate degree program to which they are applying. Students need only apply once to the combined degree pathway; the application is submitted to Graduate Admissions typically before the student starts the last 30 credits of the bachelor's degree program. A student admitted to the combined degree pathway will be

considered to have undergraduate status until the student applies for graduation from their bachelor's degree program. Upon conferral of the bachelor's degree, the student will be granted graduate status and be eligible for graduate assistantships. Only 5000-level or higher courses, and no more than the number of credits specified by the program catalog, may be applied toward both degrees. In addition to the admission requirements of the combined BS/MS pathway, students must meet all the of the University's graduate admissions requirements.

Students enrolled in the pathway may count up to six credit hours of Telecommunications and Networking graduate courses as credits for both the BS and MS degrees. The combined BS/MS pathway has been designed to be a continuous enrollment pathway. During this combined BS/MS pathway, upon completion of all the requirements of the undergraduate program, students will receive their BS degrees. Students in this pathway have one year to complete the master's degree after receipt of the bachelor's degree. Students who fail to meet this one year post B.S. requirement or who elect to leave the combined pathway at any time and earn only the BS degree will have the same access requirements to regular graduate programs as any other student, but will not be able to use the six credits in both the bachelor's and master's degrees.

For each of the graduate courses counted as credits for both BS and MS degree, a minimum grade of "B" is required. Students enrolled in the pathway may count up to six credit hours of Telecommunications and Networking graduate courses toward the elective BSEE requirements as well as toward the MS in Telecommunications and Networking degree. Only graduate courses with formal lectures can be counted for both degrees. The students are responsible for confirming the eligibility of each course with the undergraduate advisor.

Students interested in the pathway should consult with the undergraduate advisor on their eligibility to the pathway. The students should also meet the graduate advisor to learn about the graduate program and available courses before completing the application form and submitting it to the undergraduate advisor. Applicants will be notified by the department and the University Graduate School of the decision on their applications.

Doctor of Philosophy in Computer Science

The following are in addition to the University's graduate admission requirements:

1. A baccalaureate or master's degree in Computer Science, or equivalent degree in a related field as judged by the School's Graduate Committee.
2. For students without a Master's degree in a related field: A minimum of a 3.2 average on all upper division work and acceptable courses in Calculus and Statistics.
3. For students with a Master's degree in a related field: A minimum of a 3.0 average on all upper division work and acceptable courses in Calculus and Statistics, and a minimum of a 3.3 average in related graduate work.
4. Foreign students whose native language is not English must score at least 550 on the paper-base (or 80 on iBT) in the Test of English as a Foreign Language (TOEFL). TOEFL within the past two years.
5. GRE (General test) GRE must have been taken within the past five years.
6. Three letters of recommendation from persons in a position to judge the applicant's potential for advanced graduate study in computer science.

Required Courses

All students must complete the following three courses and receive a grade of 'B' or higher in each.

COP 5614	Operating Systems	3
	or	
TCN 5445	Telecommunication Network Programming	3
COT 5310	Theory of Computation I	3
	or	
TCN 5421	Theory of Network Computation	3
COT 6405	Analysis of Algorithms	3

No grade below "C" will be accepted in any course taken to satisfy graduate program requirements.

Other Requirements

1. The student must pass at least seven elective courses, for a total of 30 semester credit hours of course work. At least four of the seven elective courses must be distinguished and specially marked Ph.D. level courses. The acceptable elective courses and distinguished Ph.D. level courses can be found in a list maintained and published by the School. In addition, the student must also earn at least 15 dissertation credit hours and satisfy the School's seminar attendance requirement. In total, 75 credits beyond the bachelor's degree are required.
2. The student must pass the Qualifying Examination, which is an examination designed to ensure that the student has competency in core computer science topics.
3. The student must pass the Preliminary Examination, which is an oral examination of his or her dissertation proposal.
4. The student must write a dissertation on his or her research and successfully defend it orally in the Dissertation Defense.
5. The student must spend at least one academic year in full-time residence. Normally, this will be after passing the Qualifying Examination.

For additional information and for specific rules and regulations relating to the graduate program, please refer to the web site, (**http://www.cis.fiu.edu/programs/grad/**) or write to:

Graduate Program Director
Knight Foundation School of Computing and Information Sciences,
Florida International University
Modesto A. Maidique Campus
Miami, Florida 33199

Course Descriptions

Definition of Prefixes

CAP-Computer Applications; CDA-Computer Design/Architecture; CEN-Computer Software Engineering; CGS-Computer General Studies; CIS-Computer Science and Information Systems; CNT-

Computer Networks; COP-Computer Programming; COT-Computing Theory; TCN-Telecommunications; IDC-Interdisciplinary Computing

CAP 5011 Multimedia Systems and Applications (3). Course covers organization of multimedia systems, data representation, quality of service, scheduling algorithms, synchronization and tele-communication of multimedia streams. Prerequisite: COP 4610.

CAP 5109 Advanced Human-Computer Interaction (3). Fundamental concepts of human-computer interaction, cognitive models, user-centered design principles, evaluation techniques, and emerging technologies in various contexts and domains.

CAP 5507 Game Theory (3). Game representations, solution concepts, algorithms & complexity, repeated games, learning, auctions, voting application to many disciplines. Familiarity with mathematical proofs would be helpful.

CAP 5510C Introduction to Bioinformatics (3). Introduction to bioinformatics; algorithmic, analytical and predictive tools and techniques; programming and visualization tools; machine learning; pattern discovery; analysis of sequence alignments, phylogeny data, gene expression data, and protein structure. Prerequisites: COP 3530, or equivalent and STA 3033 or equivalent.

CAP 5602 Introduction to Artificial Intelligence (3). Presents the basic concepts of AI and their applications to game playing, problem solving, automated reasoning, natural language processing and expert systems. Prerequisite: COP 3530.

CAP 5610 Introduction to Machine Learning (3). Decision trees, Bayesian learning reinforcement learning as well as theoretical concepts such as inductive bias, the PAC learning, minimum description length principle. Prerequisite: Graduate standing.

CAP 5622 Machine Learning Techniques & Application (3). Practical introduction to Machine Learning: tools for Supervised/Unsupervised Learning, Reinforcement Learning, Best Practices/Practical Applications, Cloud Deployment of ML models. For non-CS majors.

CAP 5627 Affective Intelligent Agents (3). Design and implementation methods using artificial intelligence (AI) techniques, human-computer interaction (HCI) principles, emotion theories; applications, e.g. health informatics, education, games. Prerequisites: Graduate standing or permission of the instructor.

CAP 5640 Graduate Introduction to Natural Language Processing (3). The concepts and principles of computer processing of natural language, including linguistic phenomena, formal methods, and applications. Students will conduct an independent research project. Prerequisites: M.S. or Ph.D. standing or permission of the instructor.

CAP 5701 Advanced Computer Graphics (3). Advanced topics in computer graphics: system architecture, interactive techniques, image synthesis, current research areas. Prerequisites: COP 3530 and CAP 3710 or equivalent, or by permission. This course will have additional fees.

CAP 5738 Data Visualization (3). Advanced class on data visualization principles and techniques. Students propose, implement, and present a project with strong collaborative and visual components.

CAP 5768 Introduction to Data Science (3). Foundations of databases, analytics, visualization and management of data. Practical data analysis with applications. Introduction to Python, SQL, R, and other specialized data analysis toolkits. Prerequisites: STA 3164 or equivalent.

CAP 5769C Practical Data Science (3). Topics will include: data collection and processing, data visualization and presentation, statistical model building using machine learning, and big data techniques for scaling these methods. Prerequisite: M.S. or Ph.D. standing or permission of the instructor. Corequisite: None. M.S.& Ph.D. in CS students may not take this course for their degrees.

CAP 5771 Principles of Data Mining (3). Introduction to data mining concepts, knowledge representation, inferring rules, statistical modeling, decision trees, association rules, classification rules, clustering, predictive models, and instance-based learning. Prerequisites: COP 4710 and STA 3033.

CAP 6619 Advanced Topics in Machine Learning (3). Advanced course on machine learning principles and techniques. Students propose, implement, and present a collaborative project with advanced machine learning techniques. Prerequisite: CAP 5610.

CAP 6736 Geometric Modeling and Shape Analysis (3). Techniques for 2D/3D geometric modeling and analysis, including representation, reconstruction, processing, modeling and shape analysis, and applications in science and engineering. Prerequisites: SCIS graduate standing or by permission of the instructor.

CAP 6776 Advanced Topics in Information Retrieval (3). Information Retrieval (IR) principles including indexing and searching document collections, as well as advanced IR topics such as Web search and IR-style search in databases. Prerequisite: COP 5725.

CAP 6778 Advanced Topics in Data Mining (3). Web, stream data, and relational data mining, graph mining, spatiotemporal data mining, privacy-preserving data mining, high-dimensional data clustering, social network, and linkage analysis. Prerequisite: CAP 5771 or permission of the instructor.

CDA 5655 Virtualized Systems (3). Topics include the concepts and principles of virtualization and the mechanisms and techniques of building virtualized systems, from individual virtual machines to virtualized networked infrastructure. Prerequisites: COP 4610 or permission of the instructor.

CDA 6939 Special Topics: Advanced Topics in Computer Architecture (3). This course deals with selected special topics in computer architecture. Prerequisite: Permission of the instructor.

CEN 5011 Advanced Software Engineering (3). This course deals with the design of large scale computer programs. Included are topics dealing with planning design, implementation, validation, metrics, and the

management of such software projects. Prerequisite: CEN 4010.

CEN 5064 Software Design (3). Study of object-oriented analysis and design of software systems based on the standard design language UML; case studies. Prerequisite: CEN 5011.

CEN 5076 Software Testing (3). Tools and techniques to validate software process artifacts: model validation, software metrics, implementation-based testing, specification-based testing, integration and systems testing. Prerequisites: CEN 4010 or CEN 5011.

CEN 5079 Secure Application Programming (3). Development of applications that are free from common security vulnerabilities, such as buffer overflow, SQL injection, and cross-site scripting attacks. Emphasis is on distributed web applications. Prerequisite: Graduate standing.

CEN 5082 Grid Enablement of Scientific Applications (3). Fundamental principles and applications of high-performance computing and parallel programming using OpenMP, MPI, Globus Toolkit, Web Services, and Grid Services. Prerequisites: Graduate standing or permission of the instructor.

CEN 5087 Software and Data Modeling (3). Essential software and data modeling methods and techniques such as UML, XML, and ER. Prerequisite: Graduate standing.

CEN 5120 Expert Systems (3). Introduction to expert systems, knowledge representation techniques and construction of expert systems. A project such as the implementation of an expert system in a high level AI-language is required. Prerequisites: COP 3530 or permission of the instructor.

CEN 6070 Software Verification (3). Study of formal verification of software systems; verification methods; verification of sequential and concurrent software systems. Prerequisite: CEN 5011.

CEN 6075 Software Specification (3). Study of formal specification in the software development process; specification methods; specification of sequential and concurrent systems. Prerequisite: CEN 5011.

CGS 5166 Introduction to Bioinformatics Tools (2). Introduction to bioinformatics; analytical and predictive tools; practical use of tools for sequence alignments, phylogeny, visualizations, pattern discovery, gene expression analysis, and protein structure. Prerequisites: PCB 6025 or equivalent.

CGS 6834 Programming for the Web (3). Installation and maintenance of servers. Techniques for building secure multimedia interactive web pages. A hands-on project to develop an educational interactive multimedia web site is required. This course is not an elective for Computer Science programs.

CIS 5027 Computer Systems Fundamentals (3). Fundamentals concepts of IT Systems: operating systems, networking, distributed systems, platform technologies, web services and human-computer interaction. Covers design principles, algorithms and implementation techniques. Prerequisite: Graduate standing.

CIS 5208 Social, Economic, and Policy Aspects of Cybersecurity (3). The broader human context of cybersecurity, from the perspective of society, economics, and policy. Prerequisite: Graduate standing.

CIS 5346 Storage Systems (3). Introduction to storage systems, storage system components, storage architecture, devices, trends and applications, performance, RAID, MEMS and portable storage, file-systems, OS storage management. Prerequisite: Graduate standing.

CIS 5370 Principles of Cybersecurity (3). Cybersecurity algorithms, techniques. Mathematical foundations. Symmetric and public key encryption. Authentication, key infrastructure, certificates. Covert channels. Access control. Vulnerabilities. Prerequisite: Graduate standing.

CIS 5372 Fundamentals of Computer Security (3). Information assurance algorithms and techniques. Security vulnerabilities. Symmetric and public key encryption. Authentication and Kerberos. Key infrastructure and certificate. Mathematical foundations. Prerequisite: Graduate standing.

CIS 5373 Systems Security (3). Risk, Trust, and Threat models; Types of Attacks; Safe Programming Techniques; Operating System Mechanisms, Virtual Machine Systems; Hardware Security Enforces; Application Security; Personal Security. Prerequisite: CIS 5372.

CIS 5374 Information Security and Privacy (3). Information Security Planning, Planning for Contingencies, Policy, Security Program, Security Management Models, Database Security, Privacy, Information Security Analysis, Protection Mechanism. Prerequisite: CIS 5372.

CIS 5432 Advanced IT Automation (3). Advanced topics in system/network management including monitoring, help desk, antivirus, anti-malware, backup, disaster recovery, discovery, audit, remote control, automated response, policies, and reports. Prerequisites: CIS 4431 or permission of the instructor.

CIS 5900 Independent Study (1-10). Individual conferences, assigned readings, and reports on independent investigations. Prerequisite: Permission of the department.

CIS 5910 Project Research (1-6). Advanced undergraduate or master's level research for particular projects. Repeatable. Prerequisite: Permission of the department.

CIS 5915 Research Experience for Graduate Students (0-9). Participation in ongoing research in the research centers of the school.

CIS 5931 Special Topics (VAR). A course designed to give groups of students an opportunity to pursue special studies not otherwise offered.

CIS 6612 Special Topics: Advanced Topics in Software Engineering (3). This course deals with selected topics in software engineering. Prerequisite: Permission of the instructor.

CIS 6900 Independent Study (1-10). Individual conferences, assigned readings, and reports on independent investigations. Prerequisite: Permission of the department.

CIS 6930 Advanced Special Topics (3). A course designed to give groups of students an opportunity to pursue special advanced studies not otherwise offered.

CIS 6931 Special Topics: Advanced Topics in Information Processing (3). This course deals with selected special topics in information processing. Prerequisite: Permission of the instructor.

CIS 6933 Computer Science Seminar (1). Regularly scheduled seminar series featuring speakers on computer science related topics. Prerequisite: Graduate standing.

CIS 6970 Thesis (1-10). Prerequisite: Completion of all other requirements for the M.S. Degree in Computer Science.

CIS 7910 Graduate Research (1-25). Doctoral research prior to candidacy. Repeatable. Prerequisite: Permission of the department.

CIS 7980 Ph.D. Dissertation (1-10). Prerequisite: Permission of the Major Professor and Doctoral Candidacy.

CNT 6207 Distributed Processing (3). Study of distributed processing using networking and distributed computing techniques. Investigation of distributed algorithms and models of distributed computing. Prerequisite: Graduate Standing.

CNT 6208 Advanced Topics in Concurrent and Distributed Systems (3). Study of the major aspects of concurrent and distributed systems. Topics include foundations of concurrent computation, languages and tools for concurrent systems, distributed real-time systems, distributed multimedia systems, and concurrent object-oriented systems.

COP 5614 Operating Systems (3). Operating systems design principles, algorithms and implementation techniques: process and memory management, disk and I/O systems, communications and security.

COP 5621 Compiler Construction (3). Basic techniques of compilation; scanning; grammars and LL and LR parsing, code generation; symbol table management; optimization. Prerequisites: MAD 3512 and CEN 4010.

COP 5725 Principles of Database Management Systems (3). Overview of Database Systems, Relational Model, Relational Algebra and Relational Calculus; SQL; Database Applications; Storage and Indexing; Query Evaluation; Transaction Management. Selected database topics will also be discussed.

COP 5949 Cooperative Education in Computer Science (1-3). One semester of full-time work, or equivalent, in an outside organization, limited to students admitted to the CO-OP program. A written report and supervision evaluation is required of each student.

COP 6007 Computer Programming Concepts (3). For non-computer science graduate students. Concepts of object oriented programming, introduction to an object oriented programming language; internet programming; applications of programming to learning technologies. Prerequisite: Permission of the instructor.

COP 6556 Semantics of Programming Languages (3). This course provides an overview of systematic and effective approaches to programming. Abstraction; formal specification techniques; program verification and; semantics of programming languages. Prerequisite: COT 5310.

COP 6611 Advanced Operating Systems (3). Advanced topics in operating system design; microkernel; memory architecture; multi-processor issues; multimedia operating systems; case studies. Prerequisite: Graduate standing.

COP 6727 Advanced Database Systems (3). Design, architecture and implementation aspects of DBMS, distributed databases, and advanced aspects of databases selected by the instructor. Prerequisite: Graduate standing.

COP 6795 Special Topics on Databases (3). Study of selected advanced topics in databases and related areas. Prerequisite: Permission of the instructor.

COT 5310 Theory of Computation I (3). Abstract models of computation; including finite automata, regular expressions, context-free grammars, pushdown automata, Turing machines. Decidability and undecidability of computational problems. Prerequisite: MAD 3512.

COT 5407 Introduction to Algorithms (3). Design of efficient data structures and algorithms; analysis of algorithms and asymptotic time complexity; graph, string, and geometric algorithms; NP-completeness.

COT 5428 Formal Foundations for Cybersecurity (3). Formal models and methods for achieving rigorous security guarantees. Cryptographic indistinguishability properties, reduction proofs. Formal analyses of security APIs. Secure information flow. Prerequisite: CIS 5370.

COT 5432 Applied Parallel Computing (3). This course teaches advance undergrad and graduate students to solve problems from scientific, social and financial domains using parallel computing principles and techniques. Prerequisites: COP 3530 and (CDA 3102 or CDA 4101 or EEL 4709) or permission of the instructor

COT 5443 Optimization Methods for Computing: Theory and Applications (3). Optimization for CS students, including introduction to optimization algorithms, applications in CS, efficient computing, and real-world problems. Prerequisites: MAC 2311 Calculus I or equivalent; MAS 3105 Linear Algebra or equivalent (instructor's permission is acceptable).

COT 5520 Computational Geometry (3). Design and analysis of efficient algorithms to solve geometric problems: geometric searching, convex hull, proximity problem, Voronoi diagram, spanning tree, triangulation, graph drawing applications. Prerequisite: COP 3530 (or equivalents).

COT 6405 Analysis of Algorithms (3). Design of advanced data structures and algorithms; advanced analysis techniques; lower bound proofs; advanced algorithms for graph, string, geometric, and numerical problems; approximation algorithms; randomized and on-line algorithms. Prerequisite: Graduate standing.

COT 6421 Theory of Computation II (3). Verification of program correctness; program schemes; fixed-point theory of programs; resolution and theorem proving. Prerequisite: COT 5310.

COT 6446 Randomized Algorithms (3). Topics include moments and deviations, tail inequalities, random walk

and Markov chains, stochastic processes, the probabilistic method, and applications of these tools and techniques in data structure, geometric algorithms, graph algorithms, secure systems and property testing, etc. Prerequisite: COT 5407.

COT 6930 Special Topics: Advanced Topics in Theory (3). This course deals with selected special topics in computing theory. Prerequisite: Permission of the instructor.

COT 6931 Topics in Cognitive Science (3). A "top-down" view of Computer Science, in particular artificial intelligence, by studying the computational aspects of human cognition. Prerequisite: Permission of the instructor.

COT 6936 Topics in Algorithms (3). Advanced data structures, pattern matching algorithms, file compression, cryptography, computational geometry, numerical algorithms, combinational optimization algorithms and additional topics. Prerequisite: COP 3530.

IDC 5007 Concepts of Artificial Intelligence (3). High-level conceptual survey of artificial intelligence for non-CS graduate students, including techniques, applications, ethics, and philosophical issues. No high-level math or programming required.

IDC 5013 Computer Science for Middle School Teachers (3). Provide teachers with the knowledge to teach Computer Science topics such as programming, physical computing, web development, design, and data, appropriate for middle school students.

IDC 5014 Computer Science for High School Teachers (3). Computer Science topics such as computational thinking, logic, visual programming, social and ethical issues related to computer technologies, appropriate for high school students.

IDC 6940 Capstone Course in Data Science (1-3). Projects course using Python, SQL, R, and/or other specialized analysis toolkits to synthesize concepts from data analytics and visualization as applied to industry-relevant projects. Prerequisite: CAP 5768

TCN 5010 Telecommunications Technology and Applications (3). An in-depth introduction to voice and data networks, signaling and modulation, multiplexing, frequency band and propagation characteristics, special analysis of signals, and traffic analysis. Prerequisite: Permission of the instructor.

TCN 5030 Computer Communications and Networking Technologies (3). Teaches the dynamics related to computer communications, how computers are grouped together to form networks, various networking implementation strategies, and current technologies. Prerequisite: Permission of the instructor.

TCN 5060 Telecommunications Software and Methodologies (3). A high-level look into network architectures and distributed applications, client-server models, network software platforms and advanced techniques for programs specifications through implementation. Prerequisites: TCN 5030 or permission of the instructor.

TCN 5080 Secure Telecommunications Transactions (3). Telecom and information security issues such as: digital signatures, cryptography as applied to telecom transactions, network policing, nested authentication, and improving system trust. Prerequisites: TCN 5030 or permission of the instructor.

TCN 5150 Multimedia Computer Communications (3). Covers multimedia computer communications technologies including, multimedia over networks, videoconferencing, telephone, compression algorithms and techniques for transmitting data efficiently. Prerequisites: TCN 6210 or permission of the instructor.

TCN 5421 Theory of Network Computation (3). Fundamental mathematical models of general and network computation: finite state automata, regular languages, decidability; scholastic processes, Markov chains, queuing theory.

TCN 5440 Software Development for Telecommunication Networks (3). Focuses on the aspects, tools, and techniques of developing software applications for telecommunications networks. Prerequisites: TCN 5030 or equivalent.

TCN 5445 Telecommunications Networking Programming (3). Advanced telecommunications network programming skills including Router and Bridge Software, socket programming and protocol handler. Prerequisite: Permission from instructor.

TCN 5455 Information Theory (3). Entropy and measure of information. Proof and interpretation of Shannon's fundamental theorem for various channels, including noiseless, discrete, time-discrete and time-continuous channels. Prerequisite: Permission of the instructor.

TCN 5640 Telecommunications Enterprise Planning and Strategy (3). Methodologies for re-engineering, project management, strategic planning, change management, RFPs, and life-cycle management within the telecommunications and IT arena. Prerequisite: Permission of the instructor.

TCN 5710 Cyber Sustainability (3). In-depth introduction to sustainable development and optimization of cyber systems, such as mobile networks and data centers, with an emphasis on cost, energy, water and life-cycle assessment.

TCN 6210 Telecommunications Network Analysis and Design (3). A systematic, analytic and descriptive approach to the evaluation of telecommunications networks, networking principles, and control and quality of service. Prerequisite: Permission of the instructor.

TCN 6215 Advanced Network Algorithms (3). This course will cover algorithms that are used in network research and implementation. Prerequisites: TCN 6210 or consent of the instructor.

TCN 6230 Optical Networks (3). Enabling technologies, multiplexing techniques, WDM, broadcast networks, wavelength-routed networks, network architectures, protocols, network algorithms, and device-network interfaces. Prerequisites: TCN 5030 or equivalent.

TCN 6260 Internetworking (3). The course will discuss advanced topics, current trends and control of internetworking. An analytical and descriptive approach will be used to cover the subject of internetworking.

TCN 6270 Mobile and Wireless Networks (3). Techniques in the design and operation of wireless networks; LANs, MANs, and WANs; analytical models; application of traffic and mobility models; mobility control, and wireless ATM. Prerequisites: TCN 5030 or equivalent.

TCN 6275 Mobile Computing (3). Enabling technologies and impediments of mobile computing. It includes mobile architectural design, mobile-aware and transparent adaptation, mobile data access and file systems, and ad-hoc networks. Prerequisite: Permission of the instructor.

TCN 6420 Modeling and Performance Evaluation of Telecommunications Networks (3). Covers methods and research issues in the models and performance evaluation of high-speed and cellular networks. Focuses on the tools from Markov queues, queuing networks theory and applications. Prerequisites: TCN 5030 or equivalent.

TCN 6430 Networks Management and Control Standards (3). Protocols for management of telecom networks, including Simple Network Management Protocol and Common Management Information Protocol. Extension of protocols to optimize network performance. Prerequisites: TCN 5030 or equivalent.

TCN 6450 Wireless Information Systems (3). Enabling technologies and impediments of wireless information systems. Focuses on software architectures, and information and location management in the wireless environment. Prerequisite: Permission of the instructor.

TCN 6820 Industrial Development of Telecommunications (3). This course, from a management perspective, addresses the evolution of the telecom industry, the impact it has on reshaping our world, and the importance of management decisions in telecom.

TCN 6880 Telecommunications Public Policy Development and Standards (3). A concept-oriented examination of the domestic and international telecommunications policy processes and standards setting environment. Prerequisite: Permission of the instructor.

TCN 6935 Graduate Seminar (0). Investigation and report by graduate students on topics of current interest in telecommunication and networking. Prerequisites: Ph.D. classification and approval of instructor.