About the Program

The Computer and Information Science Ph.D. program prepares a student to undertake independent research leading to science and engineering advances in computer and information sciences. The program is structured around the Ph.D. dissertation, with coursework and seminars designed to attain the requisite quality of the dissertation. An important criterion for the dissertation is that it be publishable in a recognized journal and presentable at international conferences.

Time Limit for Degree Completion: 7 years

Campus Location: Main

Full-Time/Part-Time Status: Students complete the degree program through classes offered after 4:30 p.m. The degree program can be completed on a full- or part-time basis.

Areas of Specialization: The Ph.D. program focuses on four research tracks:

1. Artificial Intelligence and Applications, which is concerned with systems that exhibit intelligent behavior;
2. Computer and Network Systems, which covers systems programming, operating systems, and system architectures, including networks and distributed systems;
3. Information Systems, which focuses on systems that provide information to improve the performance of organizations; and
4. Software Systems, which is dedicated to the creation of software and its associated methodologies.

Job Prospects: Graduates typically find employment in universities, industry, or government agencies.

Non-Matriculated Student Policy: Non-matriculated students are permitted to take a maximum of two graduate-level CIS courses.

Financing Opportunities: Teaching Assistants teach two undergraduate laboratory sections each term under the direction of a faculty lecturer. Assistantships provide a stipend and full-time tuition.

Admission Requirements and Deadlines

Application Deadline:

Fall: December 15
Spring: August 1

Applications are reviewed as they are received. Late applications will be considered for admission.

APPLY ONLINE to this graduate program.

Letters of Reference:

Number Required: 3

From Whom: Letters of recommendation should be obtained from Computer Science faculty and professionals.

Coursework Required for Admission Consideration: The applicant is required to have a solid background in Computer and Information Science and related disciplines. In addition, acceptance by a Ph.D. Graduate Faculty member in at least one open track is required. To find a faculty advisor, prospective students should contact Graduate Faculty whose research interests are similar to their own. The list of faculty can be found at http://www.temple.edu/cis/directory/.

Master's Degree in Discipline/Related Discipline: A master's degree is not required.

Bachelor's Degree in Discipline/Related Discipline: A baccalaureate degree in Computer Science, Information Science, Mathematics, Science, or Engineering is required. The applicant's undergraduate program must include a considerable amount of coursework in Computer and Information Science.

Statement of Goals: Approximately 500-1,000 words include your specific interest in Temple's program; your research goals; your future career goals; and your academic and research achievements.

Standardized Test Scores:
GRE: Required. Scores should minimally be in the 75th percentile on the quantitative section and 25th percentile on the verbal section for a combined total score of at least 297.

For applicants whose native language is not English, the TOEFL, IELTS, or PTE Academic exam is required:

TOEFL: 85 iBT or 563 PBT minimum

IELTS: 7.0 minimum

PTE Academic: 58 minimum

A score of 45 or greater on the Test of Spoken English (TSE) or a score of 28 or greater on the TOEFL iBT Speaking section is required for international applicants who wish to be considered for a Teaching Assistantship.

Resume: Current resume required.

Advanced Standing: Advanced standing credit is determined by the CIS Graduate Committee. Requests for, and decisions on, advanced standing are normally not made until after the student has satisfactorily completed the CIS Ph.D. Qualifying Examination and formed a Doctoral Advisory Committee. The maximum number of advanced standing credits awarded is 24.

Program Requirements

General Program Requirements:
Number of Credits Required to Earn the Degree: 48

Required Courses:

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<th>Track-Specific Courses ¹</th>
<th>24</th>
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<tbody>
<tr>
<td>Other CIS Courses ²</td>
<td>24</td>
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<tr>
<td>CIS 9182</td>
<td>Independent Study</td>
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<td>or CIS 9282</td>
<td>Independent Study</td>
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<td>CIS 9991</td>
<td>Project in Computer Science</td>
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<td>CIS 9994</td>
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<td>CIS 9998</td>
<td>Pre-Dissertation Research</td>
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<tr>
<td>CIS 9999</td>
<td>Dissertation Research</td>
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Total Credit Hours 48

¹ Required and elective courses are identified in the course lists below for each of the four tracks: Artificial Intelligence and Applications, Computer and Network Systems, Information Systems, and Software Systems.

² Select no more than 8 courses from those identified. Note that at least 1 credit of coursework (or research experience) outside of the Department of Computer and Information Sciences is required. To fulfill this 1-credit minimum requirement, students enroll in CIS 9182 or CIS 9282, an Independent Study course. This requirement can be waived for students with adequate work experience.

Artificial Intelligence and Applications Track

Core Courses

All are required for the Qualifying Exam:

| CIS 5511 | Programming Techniques |
| CIS 5526 | Machine Learning       |
| CIS 5603 | Artificial Intelligence|

Didactic Courses

Select five, choosing at most four for inclusion in the Qualifying Exam:

| CIS 5513 | Automata and Formal Languages |
| CIS 5525 | Neural Computation           |
| CIS 5527 | Data Warehousing, Filtering and Mining |
| CIS 5538 | Text Mining and Language Processing |
| CIS 5543 | Computer Vision              |
| CIS 5617 | Computer Networking and Communication |
| CIS 9590 | Seminar in Advanced Topics in Computer Science |
| CIS 9601 | Computer Graphics and Image Processing |
CIS 9615  Design and Analysis of Algorithms  
CIS 9618  Web Applications Development  
CIS 9651  Artificial Intelligence, Heurisitic Models, and Education  
CIS 9664  Knowledge Discovery and Data Mining  
CIS 9665  Advanced Topics in Data Base Systems

**Computer and Network Systems Track**

**Core Courses**  
Select at least two for inclusion in the Qualifying Exam:  
- CIS 5511  Programming Techniques  
- CIS 5512  Operating Systems  
- CIS 5513  Automata and Formal Languages  
- CIS 5617  Computer Networking and Communication  
- CIS 5642  Computer Architecture

**Didactic Courses**  
Select at most five for inclusion in the Qualifying Exam:  
- CIS 5526  Machine Learning  
- CIS 5603  Artificial Intelligence  
- CIS 5616  Ad Hoc Networks  
- CIS 5636  Network & Information Security  
- CIS 5639  Wireless Network and Communication  
- CIS 5644  Distributed Systems  
- CIS 9615  Design and Analysis of Algorithms  
- CIS 9618  Web Applications Development  
- CIS 9664  Knowledge Discovery and Data Mining  
- CIS 9665  Advanced Topics in Data Base Systems  
- CIS 9666  Advanced Networks and Client-Server Computing  
- CIS 9669  Distributed and Parallel Computer Systems

**Total Credit Hours**  
24

**Information Systems Track**

Select a minimum of one and up to three theory area topics for inclusion in the Qualifying Exam:  
- CIS 5511  Programming Techniques  
- CIS 9615  Design and Analysis of Algorithms  
- STAT 8003  Statistical Methods I

Select a minimum of one and up to three systems area topics for inclusion in the Qualifying Exam:  
- CIS 5512  Operating Systems  
- CIS 5516  Principles of Data Management  
- CIS 5617  Computer Networking and Communication  
- CIS 5644  Distributed Systems  
- CIS 9666  Advanced Networks and Client-Server Computing

Select a minimum of two and up to four track-specific topics for inclusion in the Qualifying Exam:  
- CIS 5525  Neural Computation  
- CIS 5526  Machine Learning  
- CIS 5527  Data Warehousing, Filtering and Mining  
- CIS 5603  Artificial Intelligence  
- CIS 9590  Seminar in Advanced Topics in Computer Science  
- CIS 9618  Web Applications Development  
- CIS 9664  Knowledge Discovery and Data Mining  
- CIS 9665  Advanced Topics in Data Base Systems

**Total Credit Hours**  
24
CIS 9668  Design and Development of E-Commerce Systems

Total Credit Hours  24

Software Systems Track

Core Courses

All CIS courses are required for the Qualifying Exam:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
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</thead>
<tbody>
<tr>
<td>CIS 5511</td>
<td>Programming Techniques</td>
<td>3</td>
</tr>
<tr>
<td>CIS 5512</td>
<td>Operating Systems</td>
<td>3</td>
</tr>
<tr>
<td>CIS 5513</td>
<td>Automata and Formal Languages</td>
<td>3</td>
</tr>
<tr>
<td>CIS 5516</td>
<td>Principles of Data Management</td>
<td>3</td>
</tr>
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<td>CIS 5617</td>
<td>Computer Networking and Communication</td>
<td>3</td>
</tr>
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<td>Design and Analysis of Algorithms</td>
<td>3</td>
</tr>
<tr>
<td>CIS 9618</td>
<td>Web Applications Development</td>
<td>3</td>
</tr>
<tr>
<td>Elective</td>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>

Total Credit Hours  24

1  Elective requires approval of the Software Systems Track Chair.

Additional Requirements:

Ph.D. Qualifying Examination:
The Qualifying Examination tests the student on the fundamentals of Computer and Information Science and the basic body of knowledge in a track. It consists of a written exam on theory and algorithms, systems, and track-specific material. The Qualifying Exam is offered twice a year, usually in late January and late June.

Culminating Events:

Preliminary Examinations:
The goal of the preliminary examinations is to test the research skills and knowledge of the student and the appropriateness and feasibility of the proposed research. The exams are completed in two stages:

- Prelim I consists of written and oral components testing advanced track knowledge and in-depth knowledge of the research area. It includes a literature review of the area. This preliminary exam is used to determine whether the student needs to take additional courses in order to support research in the chosen area. Prelim I is open only to the Doctoral Advisory Committee and members of the department. It is to be taken within one year of passing the Ph.D. Qualifying Examination.
- Prelim II consists of written and oral components to assess the appropriateness of the research, including approach and methodology. It is designed to ensure that the selected research problem is of reasonable scope and significance and that the proposed dissertation is feasible. The written portion of Prelim II should be of sufficient quality to be publishable as a department technical report. This exam is open to the public.

The Doctoral Advisory Committee evaluates the preliminary examinations. Each member votes to pass or fail the student. In order to pass, a majority of the committee members must agree that the exam has been satisfactorily completed. The successful completion of the preliminary examinations produces a written understanding among the student, faculty advisor, and Doctoral Advisory Committee, specifying the work to be done to obtain final approval of the dissertation.

Students who are preparing to do their preliminary examinations should confirm a time and date with the Chair of their Doctoral Advisory Committee and register with the Administrative Coordinator one month prior to the date. The student and Chair receive confirmation of the time, date, and room of the examination.

Dissertation Proposal:
The dissertation proposal demonstrates the student's knowledge of and ability to conduct the proposed research. The proposal should consist of:

1. the context and background surrounding a particular research problem;
2. an exhaustive survey and review of literature related to the problem; and
3. a detailed methodological plan for investigating the problem.

The proposal should be finished and approved no more than one year after completing coursework. Upon approval, a timeline for completing the investigation and writing process are established.

Dissertation:
The doctoral dissertation is an original empirical study that makes a significant contribution to the field of Computer and Information Science. It should expand the existing knowledge and demonstrate the student's knowledge of research methods and a mastery of her/his primary area of interest. Dissertations should be rigorously investigated; uphold the ethics and standards of the Computer and Information Science field; demonstrate an
understanding of the relationship between the primary area of interest and the broader field of Computer and Information Science; and be prepared for publication in a professional journal.

The Doctoral Advisory Committee is formed to oversee the student's doctoral research and is comprised of at least three Graduate Faculty members. Two members, including the Chair, must be from the Department of Computer and Information Sciences. Committee compositions must be approved by the CIS Graduate Committee. The Chair is responsible for overseeing and guiding the student's progress, coordinating the responses of the committee members, and informing the student of her/his academic progress.

The Dissertation Examining Committee evaluates the student's dissertation and oral defense. This committee is comprised of the Doctoral Advisory Committee and at least one additional Graduate Faculty member from outside the Department of Computer and Information Sciences. The Outside Examiner should be identified no later than the beginning of the term in which the student will defend the dissertation. The committee evaluates the student's ability to express verbally her/his research question, methodological approach, primary findings, and implications. The committee votes to pass or fail the dissertation and the defense at the conclusion of the public presentation.

If a student needs to change a member of a committee, the new member must be approved by the CIS Graduate Committee and registered with the Administrative Coordinator and the Graduate School.

Students who are preparing to defend their dissertation should confirm a time and date with their Doctoral Advisory Committee and register with the Administrative Coordinator at least 30 days before the defense is to be scheduled. The student and Chair receive confirmation of the time, date, and room for the examination.

The Administrative Coordinator sends the Graduate School a completed "Announcement of Dissertation Defense" form, found at http://www.temple.edu/grad/forms/, at least 10 days before the defense. The department posts flyers announcing the defense.

Contacts

Program Web Address:
http://www.temple.edu/cis/graduate/

Department Information:
Dept. of Computer and Information Sciences
SERC, 3rd Floor
1925 N. 12th Street
Philadelphia, PA 19122-1801
cisadmit@temple.edu
215-204-8450

Mailing Address for Application Materials:
Dept. of Computer and Information Sciences
SERC, 3rd Floor (035-10)
1925 N. 12th Street
Philadelphia, PA 19122-1801

Department Contacts:
Administrative Coordinator:
Julie Skrocki
julie.skrocki@temple.edu
215-204-1614

Artificial Intelligence and Applications Track Chair:
Longin Jan Latecki
latecki@temple.edu

Information Systems Track Chair:
Zoran Obradovic
obradovic@temple.edu

Graduate Chairperson:
Justin Y. Shi
Software Systems Track Chair
shi@temple.edu
215-204-6437
Courses

CIS 5001. Comp-Based Appl Prog. 3 Credit Hours.
The course emphasizes component-based application programming using the Microsoft Visual Studio Integrated Development Environment (IDE).
Students will learn (and practice using) the VB .NET programming language, object-oriented software design techniques, and the principles of good user interface design. Topics include building quality software, including user interfaces to databases (using ADO.NET), sequential files, and graphics tools. Object-oriented concepts such as inheritance, polymorphism, static and dynamic binding, and interface (abstract class) components will be covered. The use of ASP.NET for client-server systems development is also elaborated.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CIS 5002. Database Design & Programming. 3 Credit Hours.
This course provides an in-depth understanding of the modeling, design and implementation of database systems. Students develop an appreciation of the role of data, files and databases in information systems, gain an understanding of database development activities as part of the System Development Life Cycle (SDLC), and become familiar with data modeling concepts. Students are expected to be able to create databases and pose complex SQL queries of relational databases using Oracle and Microsoft Access. Topics include the relational model, E-R and Class Diagrams, normalization, advanced SQL, Oracle Enterprise system transaction processing, concurrency control, and recovery. Also covered are aspects of database administration, data integrity, security and authorization, stored procedures and triggers, the embedding of SQL in procedural languages and scripting languages, multi-tiered architectures, middleware, ODBC web-based databases, and web application integration. Students work in teams to implement large scale information system using a DBMS. CASE tools are used for data modeling.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CIS 5003. Networking & Operating Systems. 3 Credit Hours.
This course covers the essentials of operating systems and computer networks. Topics include: the processor, data and program representation, computer memory systems, software system support for I/O including support for networking, and a thorough introduction to the TCP/IP protocol suite.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CIS 5011. Programming and Data Structure. 3 Credit Hours.
Preparatory course for CIS graduate students who have an insufficient background in data structures, and need a stronger foundation before taking the required core course, Programming Techniques 5511 (formerly 8511). Note: Graduate credit will not apply for CIS MS/PHD programs.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CIS 5012. System Software and Operating Systems. 3 Credit Hours.
Preparatory course for CIS graduate students who have an insufficient background in operating systems, and need a stronger foundation before taking the required core course, Operating Systems 5512. Note: Graduate credit will not apply for CIS MS/PHD programs.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CIS 5013. Discrete Structure of Computer Science. 3 Credit Hours.
Preparatory course for CIS graduate students who have an insufficient background in discrete structures, and need a stronger foundation before taking the required core course, Automata & Formal Languages 5513. Note: Graduate credit will not apply for CIS MS/PHD programs.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CIS 5105. IT Process Management. 3 Credit Hours.
An introduction to essential techniques for successfully creating, organizing and managing IT projects. The course provides the foundation for more advanced studies in process management and software engineering. Enterprise-wide requirements, long-range planning and managing all aspects of the development process will be emphasized. The course will stress the use of appropriate software tools and process modeling throughout the development lifecycle. Quality assurance techniques are introduced at the outset to guide IT processes and decision making. Note: This is an MS/IST course. No credit for Graduate CS programs.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.
CIS 5106. System Development Processes. 3 Credit Hours.
Methods and tools for the technical development of IT systems are presented and used in case projects. The course follows the normal development lifecycle, starting with the recognition and justification of the need for either a new system or an upgrade to an existing system. It then proceeds through analysis, specification, design, implementation, testing (quality assurance), client training and turnover, and maintenance. The importance of each development stage will be taught within the framework of systems reliability, effectiveness, security, scalability, and development cost. Note: This is an MS/IST course. No credit for Graduate CS programs.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CIS 5107. Comp Systems Security&Privacy. 3 Credit Hours.
Computer systems security and information privacy has become a critical area of computer science development and research. This course involves an analysis of the technical difficulties of producing secure computer information systems that provide guaranteed controlled sharing and privacy. Emphasis is on software modeling and design to better ensure the protection of resources (including data and programs) from accidental or malicious modification, destruction, or disclosure. Current systems and methods will be examined and critiqued. The possible certification of such systems will also be investigated. Note: This is an MS/IST course. No credit for Graduate CS programs.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CIS 5108. Emerging Technologies. 3 Credit Hours.
The purpose of this course is to provide students with an understanding of maturing and emerging technologies and their likely impact on the networked information paradigm and enterprise management. Both hardware and software technologies will be covered. Students will be introduced to advanced software tools that demonstrate how agency enterprises make use of vast information flows and interconnectivity. Note: This is an MS/IST course. No credit for Graduate CS programs.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CIS 5206. System Development Processes. 3 Credit Hours.
Methods and tools for the technical development of IT systems are presented and used in case projects. The course follows the normal development lifecycle, starting with the recognition and justification of the need for either a new system or an upgrade to an existing system. It then proceeds through analysis, specification, design, implementation, testing (quality assurance), client training and turnover, and maintenance. The importance of each development stage will be taught within the framework of systems reliability, effectiveness, security, scalability, and development cost. Note: This is an MS/IST course. No credit for Graduate CS programs.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CIS 5208. Knowledge Management. 3 Credit Hours.
Principles of knowledge management (KM) and their use in locating, evaluating, disseminating, and using information and knowledge. Application of these principles and techniques. Knowledge management incorporates data acquisition, information integrity, and management of knowledge and is crucial to everyone working in any field where information is stored, processed, and used. It places a premium on an IT-intensive organization to invest, cultivate, and fully utilize the intellect and knowledge of all staff.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CIS 5210. Seminar in Information Science and Technology. 3 Credit Hours.
An intermediate level graduate special topics course in current and emerging developments in information systems and technology. Note: This is an MS/IST course. No credit for Graduate CS programs. This course is repeatable for credit.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may be repeated for additional credit.

CIS 5301. Advanced Database Management Systems. 3 Credit Hours.
This course provides an in-depth understanding of the modeling, design and implementation of database systems. Topics include the relational model, E-R Diagramming and Class Diagrams, normalization, advanced SQL, Oracle Enterprise system transaction processing, concurrency control, and recovery. Also covered are aspects of database administration, security and authorization, stored procedures and triggers, the embedding of SQL in procedural languages and scripting languages, multi-tiered architectures, middleware, ODBC web-based databases, and web application integration. Students work in teams to implement large scale information system using a DBMS. CASE tools are used for data modeling. Note: This is an MS/IST course. No credit for Graduate CS programs.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CIS 5303. Usability Engineering. 3 Credit Hours.
This course focuses on the principles of usability engineering to design effective interfaces. In parallel with functional specification development, usability engineering identifies the usability specifications of the system, which includes information and interface design. In some modern day information systems, usability can be paramount and require as much or more effort and programming as functional requirements, i.e., information systems may provide relevant functionality, but if the system is not easy to learn and use, it may fail. Using theories and principles from software engineering and psychology, students learn to analyze usability requirements to improve user interface development. Note: This is an MS/IST course. No credit for Graduate CS programs.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.
CIS 5304. Network Technologies. 3 Credit Hours.
Focusses on the design, construction and use of modern networks and inter-networks, including Internet, intranet, firewalls, VPN, e-mail, and wireless technologies. Prepares students to successfully create and operate modern secure networks. Key concepts and technologies include LAN design and construction, Internet architecture, internetworking (with an emphasis on the Internet), WAN connectivity, firewalls, Application Layer protocols, virtual private networks, wireless and network operation in real-world environments. Note: This is an MS/IST course. No credit for Graduate CS programs.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CIS 5306. Software Engineering. 3 Credit Hours.
A project-based course focusing on current methodologies employed in software design and development. The core material covers the key components of software engineering, including requirements analysis, specification development, detailed design, program development, quality control (verification and validation), configuration management, testing, and post-development maintenance. Emerging software development techniques - security engineering, service-oriented architecture (SOA), and aspect-oriented development are also introduced. Note: This is an MS/IST course. No credit for Graduate CS programs.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CIS 5306. Software Engineering. 3 Credit Hours.
A project-based course focusing on current methodologies employed in software design and development. The core material covers the key components of software engineering, including requirements analysis, specification development, detailed design, program development, quality control (verification and validation), configuration management, testing, and post-development maintenance. Emerging software development techniques - security engineering, service-oriented architecture (SOA), and aspect-oriented development are also introduced. Note: This is an MS/IST course. No credit for Graduate CS programs.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CIS 5306. Software Engineering. 3 Credit Hours.
A project-based course focusing on current methodologies employed in software design and development. The core material covers the key components of software engineering, including requirements analysis, specification development, detailed design, program development, quality control (verification and validation), configuration management, testing, and post-development maintenance. Emerging software development techniques - security engineering, service-oriented architecture (SOA), and aspect-oriented development are also introduced. Note: This is an MS/IST course. No credit for Graduate CS programs.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CIS 5410. Advanced Seminar in Information Science and Technology. 3 Credit Hours.
An advanced level graduate special topics course in current and emerging developments in the field of information systems and technology. Note: This is an MS/IST course. No credit for Graduate CS programs. This course is repeatable for credit.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may be repeated for additional credit.

CIS 5511. Programming Techniques. 3 Credit Hours.
Prerequisites: CIS 2168 and CIS 3223.
A more formalized view of data structures. Stacks, trees, tables, lists, multilinked structures, strings and files are considered. These are viewed in terms of their general usefulness in the construction of algorithms and in their efficient implementation. Both theoretical results and programming techniques will be stressed.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CIS 5512. Operating Systems. 3 Credit Hours.
Prerequisites: CIS 3207 and CIS 3223.
Basic principles of operating systems; multi-tasking systems; control and coordination of tasks; deadlocks; synchronization, mutual exclusion, sharing; memory management, virtual memories, segmentation, paging; protection; file systems; resource management; evaluation and prediction of performance; design and implementation of operating systems in high-level languages.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CIS 5513. Automata and Formal Languages. 3 Credit Hours.
Prerequisites: CIS 2166 and CIS 3242.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CIS 5516. Principles of Data Management. 3 Credit Hours.
Prerequisites: CIS 5511 (or 8511) and CIS 5512 (or 8512).
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.
CIS 5524. Analysis and Modeling of Social and Information Systems. 3 Credit Hours.
Prerequisites: Basic knowledge in database systems; programming skills; basic statistics, graph theory, and linear algebra.
This course will include methods for analyzing and modeling the following aspects of social networks: the small-world network models, centralized and decentralized social network search algorithms, power-laws and preferential attachment, diffusion and information propagation in social networks, influence maximization in social networks, community detection in social networks, models of network cascades, models of evolving social networks, links and attributes prediction.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CIS 5525. Neural Computation. 3 Credit Hours.
Prerequisites: STAT 8003/8103 and undergraduate-level understanding of probability, statistics, and linear algebra.
Neural networks provide powerful techniques to model and control nonlinear and complex systems. The course is designed to provide an introduction to this interdisciplinary topic. The course is structured such that students from computer science, engineering, physics, mathematics, statistics, cognitive sciences, and other disciplines learn the main principles of this area as well as have an opportunity to explore promising research topics through hands-on experience with neural network simulators applied to classification and prediction problems ranging from biomedical sciences to finance and business.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CIS 5526. Machine Learning. 3 Credit Hours.
Prerequisites: STAT 8003 or 8103, and undergraduate-level understanding of probability, statistics, and linear algebra.
The goal of the field of machine learning is to build computer systems that learn from experience and are able to adapt to their environments. This introductory machine learning course will give an overview of many techniques and algorithms in machine learning, beginning with topics such as simple concept learning and ending up with more recent topics such as boosting, support vector machines, and reinforcement learning. The objective of the course is not only to present the modern machine learning methods but also to give the basic intuitions behind the methods as well as a more formal understanding of how and why they work.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CIS 5527. Data Warehousing, Filtering and Mining. 3 Credit Hours.
Prerequisites: CIS 5511 (or CIS 8511) and an undergraduate course in databases.
The course is devoted to information system environments enabling efficient indexing and advanced analyses of current and historical data for strategic use in decision making. Data management will be discussed in the context of data warehouses/data marts; Internet databases; Geographic Information Systems, mobile databases, temporal and sequence databases. Constructs aimed at an efficient online analytic processing (OLAP) and those developed for nontrivial exploratory analysis of current and historical data will be discussed in detail. The theory will be complemented by hands-on applied studies of problems in such fields as financial engineering, e-commerce, geosciences, and bioinformatics.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CIS 5535. Probabilistic Graph Models. 3 Credit Hours.
Prerequisites: CIS 2033 and CIS 3223.
Probabilistic graphical models are very important machine learning tools for knowledge representation and reasoning under uncertainty. They have been widely used in machine learning and related fields, such as computer vision, natural language processing, data mining, bioinformatics and even computer network research. This course aims to make a comprehensive introduction over the most important theories, algorithms, and applications of probabilistic graphical models, and facilitate the advanced research within the computer & information sciences department and related disciplines outside.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CIS 5538. Text Mining and Language Processing. 3 Credit Hours.
Prerequisites: CIS 2033.
This course will cover a broad overview of problems and techniques in text mining and natural language processing. It will also provide in-depth coverage of the latest natural language processing research in selected topics. The in-depth part of the course will focus on the latest research in unsupervised information extraction. This part of the course will cover such techniques as pointwise mutual information, pattern-matching, bootstrapping, Hidden Markov Models, Conditional Random Fields, and language modeling techniques, among others.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.
CIS 5543. Computer Vision. 3 Credit Hours.
Prerequisites: CIS 2033 and CIS 3219 and CIS 3223.

The objective of the course is to introduce the theory and application of computer vision. The theoretic part introduces the analysis of visual patterns and the generative models behind them. The application part uses real world tasks to help students to learn practical computer vision technologies. The course covers the following topics: image formation (camera model, color space, illumination model, etc.), low level vision processing (edge detection, intensity based segmentation, etc.), popular research tools in computer vision, visual matching and registration, visual recognition, image and category classification, scene understanding, object detection, visual tracking, activity and action analysis, and selected advanced topics. In addition to course lectures, the course uses homework assignments, in-class discussions and course projects.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CIS 5590. Topics in Computer Science. 3 Credit Hours.
Prerequisites: Special authorization required.

Current topics and issues in Computer Sciences are covered. This course is repeatable for credit.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may be repeated for additional credit.

CIS 5603. Artificial Intelligence. 3 Credit Hours.
Prerequisites: CIS 2166 or MATH 3098, and CIS 2168 and CIS 2033.

Since today's AI is mostly learning and inference, we will focus on both subjects. This course is designed as the first graduate course in learning and inference. It introduces the basic concepts by focusing on their intuitive understanding and algorithmic perspective. It is intended to prepare beginning graduate students for further graduate courses in machine learning, data mining, robotics, and computer vision. The course project will focus on programming and practical experiments with our high end robot Pekeell from Wany Robotics.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CIS 5617. Computer Networking and Communication. 3 Credit Hours.
Prerequisites: CIS 5511 (or 8511) and CIS 5512 (or 8512).

Introduction to the design and analysis of computer networks and communications systems, including the Physical, Data Link, Network, Transport and Application layers. The Internet (TCP/IP) model will be emphasized and compared and contrasted with other current technologies. Major themes include the distinction between service and protocol, performance metrics, analysis techniques, and fundamental performance tradeoffs.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CIS 5618. Energy Management in Data Centers and Beyond. 3 Credit Hours.

Students are expected to have a background in data structures and algorithms as well as computer architecture and operating systems. Comprehensive coverage of energy management in data centers: essential concepts in data center architecture, including the computing core, data center network, and storage systems; energy management in computing elements, caches, “in-the-box” interconnects, primary memory, storage systems, and data center network; data center level issues including power, thermal, and cooling management at data center level and interaction of data centers with smart grid. Other issues covered include design of energy efficient software, virtualization and energy management of VMs, energy issues in cloud computing, and modeling of energy-performance interplay.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CIS 5636. Ad Hoc Networks. 3 Credit Hours.
Prerequisites: CIS 3223, and CIS 4319 or 4329.

A comprehensive approach to fundamentals of ad hoc networks including media access protocols, routing protocols, implementation and communication performance analysis.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CIS 5637. Network & Information Security. 3 Credit Hours.
Prerequisites: CIS 4319 or 4329.

This course introduces fundamental knowledge of cryptography and its applications to network and information security.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CIS 5639. Wireless Network and Communication. 3 Credit Hours.
Prerequisites: CIS 3207 and CIS 3223.

This course introduces the fundamental design and performance issues of wireless networks and communications.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.
CIS 5642. Computer Architecture. 3 Credit Hours.
Prerequisites: CIS 2168 and CIS 3207.
Since 1951, there have been thousands of new computers using a wide range of technologies and having widely varying capabilities. Dramatic changes that have occurred in just over 50 years. After adjusting for inflation, price/performance has improved by almost 100 billion in 55 years, or about 58% per year. Another way to say it is we've seen a factor of 10,000 improvement in cost and a factor of 10,000,000 improvement in performance. This course covers the recent developments in modern computer architectures and the emerging design methods for high performance computing.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CIS 5644. Distributed Systems. 3 Credit Hours.
Prerequisites: CIS 2166 and CIS 2168 and CIS 5512 (or 8512).
We consider a distributed computer system that consists of multiple autonomous processors that do not share primary memory but cooperate by sending messages over a communication network. Discussion of special problems related to distributed control such as election and mutual exclusion, routing, data management Byzantine agreement, and deadlock handling.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CIS 9182. Independent Study. 1 to 6 Credit Hour.
Independent research supervised by a Computer and Information Sciences faculty member. NOTE: Only one independent study towards MS.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may be repeated for additional credit.

CIS 9190. Seminars in Computer and Information Science. 1 Credit Hour.
Throughout the semester, various guest lecturers will discuss their area of research. Students are required to attend at least five lectures and submit five short papers on the topics presented. This course counts in the same category as independent study when it comes to program requirements (MS and/or PhD degree). This course is recommended for PhD students who have passed the qualifying exam, to broaden their research interests. This course is recommended for MS students who are interested in CIS research and want to take 10 credits per semester.
Department restrictions: Must be enrolled in one of the following Departments: CST:Computer & Info Sci
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
College Restrictions: Must be enrolled in one of the following Colleges: Science & Technology
Repeatability: This course may be repeated for additional credit.

CIS 9282. Independent Study. 1 to 6 Credit Hour.
Independent research supervised by a Computer and Information Sciences faculty member. NOTE: Only one independent study towards MS.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may be repeated for additional credit.

CIS 9590. Seminar in Advanced Topics in Computer Science. 3 Credit Hours.
Prerequisites: Permission of instructor.
Topics to be decided individually.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may be repeated for additional credit.

CIS 9601. Computer Graphics and Image Processing. 3 Credit Hours.
Prerequisites: CIS 5511 or 8511.
An analysis of techniques used in computer manipulation of two- and three-dimensional images. Although elements of computer graphics are covered (e.g., two- and three-dimensional transforms), the main focus is on image processing techniques. We will also gain insight into basic techniques in computer vision. Topics covered include image filters, image segmentation, similarity of images, object detection, object recognition, and shape representation and similarity. Nowadays it is an easy task to transfer visual input of a camera to a computer's memory. However, image and video understanding belong still to unsolved problems of computer science. The main objective of the course is to convey basic intuitions behind the unsolved and solved problems and to introduce some of the techniques that provided solutions to some of the problems.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CIS 9602. User Interface Design and Systems Integration. 3 Credit Hours.
Prerequisites: CIS 5511 or 8511.
This course focuses on the principles of usability engineering to design effective interfaces and as the basis for integrating existing systems to form new systems. The course builds on knowledge of networking, databases, and programming. The course outline is partly based on the recommendations of the ACM Special Interest Group on Computer-Human Interaction for an introductory graduate course on user interface design.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.
CIS 9615. Design and Analysis of Algorithms. 3 Credit Hours.
Prerequisites: CIS 5511 (or 8511) and CIS 5513 (or 8513).
General techniques for developing algorithms. Divide and conquer Greedy dynamic programming, Search and traverse, Backtracking, Branch and Bound, Some theoretical results will be discussed, for example, those relating to NP-completeness.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CIS 9618. Web Applications Development. 3 Credit Hours.
Prerequisites: CIS 5511 (or 8511) and CIS 5512 (or 8512).
This course takes a technology-based approach to software engineering of networked application systems design and programming. It draws on new Microsoft .NET technology, together with former object-oriented design and programming, for its theoretical, architectural, and system design foundations. The course bridges software engineering principles in their most abstract and conceptual sense, with programming technique in its most concrete and pragmatic sense. It demonstrates how to optimize productivity of the software engineer, integrate the best that open technologies have to offer, and build large-scale systems that operate most efficiently on the internet. The course is divided into three parts: 1) theory that flows from .NET and object-oriented methodologies, including Application System Architectures, Design Methodologies, Quality Assurance, Scalability, and Security; 2) development of a working skill set in two .NET languages: ASP.NET and VB.NET and its major development tool, VS.NET; and 3) design and programming of a small but complete web-deployed application.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CIS 9651. Artificial Intelligence, Heuristic Models, and Education. 3 Credit Hours.
Prerequisites: CIS 5603 or 8603.
Introduction to how artificial intelligence and heuristic models are used to build better computer-based educational systems. Current as well as past models are explored (e.g., PROUST, GUIDON, SOAR, etc.). Key issues to be examined include student models, interfaces, pedagogical expertise, domain expertise, and collaborative learning systems.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CIS 9664. Knowledge Discovery and Data Mining. 3 Credit Hours.
Prerequisites: Basic knowledge in Data Base Systems (CIS 5516 or 9616); programming skills, basic statistics, graph theory, and linear algebra.
Basic concepts and techniques for the automated extraction of interesting patterns in large databases. Topics covered include association-rule mining, sequence mining, web and text mining, data warehousing, information filtering, classification and clustering analysis, Bayesian and neural networks, classification and regression trees, hypotheses evaluation, feature extraction, dimensionality reduction, singular value decomposition, data compression and reconstruction, visualization of large data sets, fractals in databases, and indexing methods that support efficient data mining and queries by content. Special emphasis is given in multimedia, business, scientific, and medical databases.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CIS 9665. Advanced Topics in Data Base Systems. 3 Credit Hours.
Prerequisites: CIS 5516 or 9616.
Survey of recent developments in database systems with an emphasis on object-oriented databases (OODB’s). Prototype and operational OODB systems will be analyzed. Applications of OODB’s to computer-aided software engineering (CASE) environments, integrated application development environments, and geographical information systems.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

CIS 9666. Advanced Networks and Client-Server Computing. 3 Credit Hours.
Prerequisites: CIS 5617 or 9617.
Computer networks, network technology, protocols, routing algorithms, reliability and design issues. Data transmission and transmission media, data communications fundamentals, transmission efficiency, wide-area networks, local area networks, wireless networks, TCP/IP and other protocol architectures, client/server computing, network management, and network security
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.
CIS 9668. Design and Development of E-Commerce Systems. 3 Credit Hours.

Prerequisites: CIS 9618.

This course teaches the technical aspects of developing a commercial website, including the business-to-consumer and business-to-business models. This process combines a number of integrated technologies: Web page and style sheet design; dynamic web pages that access data from relational and XML databases; server side transaction processing; client/server and distributed processing; principles of internet security, scalability, and database reliability; and .NET programming. Students develop a site as a course project using custom coding using .NET and Microsoft's web site development system Commerce Server 2000. Other tools to be used are Dreamweaver or FrontPage for web design, VS for .NET program development, and the Microsoft Enterprise Manager for the management of SQL Server databases.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate

Repeatability: This course may not be repeated for additional credits.

CIS 9669. Distributed and Parallel Computer Systems. 3 Credit Hours.

Prerequisites: CIS 5617 or 9617.

Intended for students interested in the advances of scalable parallel computing systems. The main goal is to apply distributed and parallel computing theories to practical scalable parallel application development and new parallel programming tool construction.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate

Repeatability: This course may not be repeated for additional credits.

CIS 9991. Project in Computer Science. 1 to 3 Credit Hour.

Project to be carried out under the direction of a faculty member.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate

Repeatability: This course may be repeated for additional credit.

CIS 9994. Preliminary Examination Preparation. 1 to 6 Credit Hour.

Preparation for the Preliminary Examinations after coursework completion.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate

Repeatability: This course may be repeated for additional credit.

CIS 9995. Master Research in IS&T. 3 Credit Hours.

This is a required capstone elective course for the MS in IS&T program. It is designed to ensure that all MS in IS&T graduates have had a one semester group learning project experience implementing of an information system for an external client. In special, approved cases, special projects and/or a research paper may be substituted for the project. The course may be counted at most once toward the MS in IS&T degree.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate

Repeatability: This course may be repeated for additional credit.

CIS 9996. Thesis in Computer Science. 1 to 6 Credit Hour.

Thesis to be carried out under the direction of a Graduate Faculty member. Total of 6 credits required.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate

Repeatability: This course may be repeated for additional credit.

CIS 9998. Pre-Dissertation Research. 1 to 6 Credit Hour.

Following coursework and passing of the Preliminary Examinations, students work with their advisors on the dissertation proposal.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate

Repeatability: This course may be repeated for additional credit.

CIS 9999. Dissertation Research. 1 to 6 Credit Hour.

All Ph.D. candidates must enroll in this course for at least one to three credit hours each semester until the successful completion of the dissertation. Minimum of 6 credits of CIS 9999 are required.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate

Student Attribute restrictions: Must be enrolled in one of the following Student Attributes: Dissertation Writing Student

Repeatability: This course may be repeated for additional credit.