SICE Bulletin

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Overview

Moore's Law says that computing power doubles every 18 months. Regardless of whether that law is literally correct, it illustrates the rapid changes in information technology that will continue for the foreseeable future. The Luddy School of Informatics, Computing, and Engineering prepares students to meet the continuing demand for information technology professionals who know how to grow and adapt to this environment of rapid technological change.

The Luddy School of Informatics, Computing, and Engineering is focused on the best applications of technologies, and emphasizes the social and psychological aspects of information technology. Some have called informatics "technology with a human face." Luddy prepares professionals to use information technology to solve problems in a variety of settings. The degrees emphasize the development of new uses for technologies, always keeping in mind the needs of people and the best and most appropriate uses for technology.

Luddy students have the following:

- A technical understanding of how computing systems and programs operate
- An ability to adapt/assess and apply new trends in information technology (IT)
- Well-developed problem-solving skills
- Experience working on a team, such as those formed for the senior capstone experience
- Well-developed communications skills to clearly convey solutions and observations to others
- An understanding of social and ethical principles as they relate to IT issues

Degrees from the Luddy School of Informatics, Computing, and Engineering are unique because they involve students in learning how information technology relates to a traditional discipline in the sciences, liberal arts, or professions. In Luddy, a student learns to use technology to solve problems in the chosen area of emphasis and is prepared to use technology to solve problems in a wide variety of career settings.

The undergraduate curriculum looks at information technology from a balanced perspective. It includes a technical core in the areas of mathematical foundations, distributed information, human-computer interaction, social/organization informatics, and new media. In addition to knowledge of core informatics and of informatics in the context of a traditional discipline, students must take a set of general-education courses to ensure that they can communicate clearly in both written and spoken English, read effectively, and reason quantitatively. They must be able to raise and rationally debate ethical concerns suggested by information technologies and their interactions with other people. Students also must have some knowledge of the world; its peoples and their cultural, artistic, and scientific achievements. To this end, the general-education requirement exposes students to the arts and humanities, social and historical studies, and the natural sciences.

The School offers a broad array of B.S., M.S., and Ph.D. programs in informatics, computer science, data science, intelligent systems engineering, and information and library science, undergraduate and graduate certificates, as well as minors and specializations. These are all outlined under the degree programs in the undergraduate and graduate sections of this bulletin.

Information Technology in Today's Learning

When Indiana University was founded in 1820, only Greek and Latin were taught. The curriculum has obviously changed over time, in response to both intellectual and practical needs. The most recent school to be established at Indiana University, the Luddy School of Informatics, Computing, and Engineering, responds to the world's changing needs.

Today, one might say that programming languages and software tools are the Greek and Latin of our times, and no person can be called truly educated without mastery of these "languages." It is not intended to suggest that the classical languages or any natural languages have been supplanted by C++ and Java. Indeed, making available the classical corpus in searchable digital form was one of the first applications of computing to the humanities. The point is to suggest the pervasiveness of information technology in all of civilized life. Much as Greek and Latin opened doors to the scholarship of the nineteenth century, so information technology opens doors to art and science in the twenty-first century.

The development of networks and distributed systems over the past several decades has changed forever the notion of a computer as something that merely "computes." The computer is now an "information processor." Arthur C. Clarke once said that "a sufficiently advanced technology is indistinguishable from magic." Unfortunately, many people see computers and the Internet as magical. The mission of Luddy School of Informatics, Computing, and Engineering is to educate citizens that advanced information technology is indistinguishable (or at least inseparable) from science and the arts.

IU Bloomington

Indiana University Bloomington (IUB) is a residential campus that offers undergraduate, professional, and graduate degrees in more than 70 fields of study. In the fall semester of 2010, the campus had a total enrollment of 42,464, including 31,892 undergraduates and 8,344 students in graduate and professional programs. More than 30 schools and departments at IUB are ranked

among the top 10 nationally, with more than 100 ranked in the top 20 in their respective fields.

University Libraries at IUB

The University Libraries at IUB rank fourth in collection size among the Big Ten universities, fifth in the Committee on Institutional Cooperation (CIC), and thirteenth in the nation among major research libraries. The libraries' collections include 7.8 million bound volumes, 4 million microforms, and more than 70,000 current serials. The Herman B Wells Library houses a core collection especially for undergraduates and extensive graduate research collections—as well as reference services, technical services, government publications, and other essential library services. The Wells Library also is home to the Information Commons, which has more than 350 computer workstations. These facilities are complemented by the 14 campus libraries serving diverse disciplines, such as music, optometry, chemistry, geology, education, business, journalism, and other areas.

University Information Technology Services at IUB

University Information Technology Services (UITS) at IUB supports the application, use, and development of information technology for research, teaching, and learning. UITS makes available more than 1,200 computer workstations, located in 43 Student Technology Centers, for both scheduled instruction and individual study and more than 200 "InfoStations" and other limited-use workstations in locations across campus for access to e-mail and the Web. The Assistive Technology Lab, located in the Wells Library, offers programs and specialized information technology services for students with disabilities. Research computing facilities on campus include two high-performance supercomputers (a 47-processor IBM SP and a 64-processor SGI/Cray Origin2000), a multiterabyte massive data storage system, and a state-of-the-art campus backbone network. Another strength that UITS brings is the Network Operations Centers for both Abilene (Internet 2) and TransPac. More fully described in the next section, they are housed on the IUPUI campus, but scholars and students in Bloomington also benefit from these high-speed communication links.

IUB Hutton Honors College

The Luddy School of Informatics, Computing, and Engineering encourages superior students to take advantage of the variety of opportunities offered through the Hutton Honors College and is pleased to help honors students plan their individual programs.

Grants and Scholarships at IUB

The Luddy School of Informatics, Computing, and Engineering is developing new sources of funding, and students are encouraged to review the Luddy School of Informatics, Computing, and Engineering website.

Grants and scholarships also are available through other IU offices, such as the Hutton Honors College. Students are encouraged to consult with the Office of Student Financial Assistance (www.indiana.edu/~sfa) for additional funding opportunities.

IU East

The Bachelor of Science in Informatics is offered on the East campus. Information on the Informatics degree program can be located on the Web at http://www.iue.edu/informatics/.

One School, Multiple Campuses

The school spans the IU Bloomington (IUB), IU Indianapolis (IUI), IU South Bend (IUSB), IU Kokomo (IUK), IU East (IUEA) and IU Southeast (IUSE) campuses. By combining the strengths of these six campuses, the school is able to create a unique environment that enables students to earn degrees with strong information technology components in arts, humanities, science, and the professions. The expert faculty and excellent technological resources foster a synthesis of academic disciplines and cultures. Faculty from varied disciplines share developments in the fast-moving information technology areas through the school and its degree programs. The school is actively forging cooperative arrangements with employers in the state and region; and creating internships, cooperative education programs, and opportunities for learning through service.

- IU Bloomington
- IU Indianapolis
- IU East
- IU Kokomo
- IU South Bend
- IU Southeast

IU Indianapolis

As the first school of its kind in the United States, the Indiana University Luddy School of Informatics, Computing, and Engineering is an innovator in a fast-paced and dynamic field. Our school on the IUI campus integrates computing, social science, and information systems design in unique ways.

We explore how people use computing and technology to live, work, play, and communicate. At Luddy IUI we apply our insights to developing innovative IT solutions that transform fields like health care, biology, business, law, entertainment, and media.

More than 4,500 students—including over 1,400 at Luddy IUI—study informatics on IU campuses. Our top-notch programs and highly regarded faculty prepare them for the power and possibilities in computing and information technology.

IUI University Library

The IUI University Library is a technology-based learning center that supports teaching and learning in a new Information Commons; at hundreds of workstations in the library; at computers throughout the campus; and in the homes of students, faculty, and staff.

The collection covers a wide range of academic disciplines—from liberal arts to science, engineering, and technology. The collection contains 4,145 subscriptions to electronic and print periodicals, more than 25,000 e-books, more than 1 million print and online volumes, and the Joseph and Matthew Payton Philanthropic Studies Library and Ruth Lilly Special Collections and Archives. The University Library also creates and hosts digital resources about the state of Indiana, including an electronic atlas and image collection.

The University Library information system hosts more than 350 computer workstations, permitting patrons

to search for information through an extensive and sophisticated online research system. Word processing and other electronic applications are also available on these machines. The University Library has more than 500 general and graduate study carrels; 40 group-study rooms with seating for approximately 180; and class and meeting rooms, including a 100-seat auditorium.

University Information Technology Services at IUI

University Information Technology Services (UITS) at IUI supports the application, use, and development of information technology for research, teaching, and learning. Students have access to more than 500 public workstations on campus. UITS partners with academic schools on campus to provide consulting support in 16 student technology centers and operates another 2 centers as campus-wide resources. The network operations center for Abilene, the high-speed Internet2 backbone network, is located on the IUI campus, as is the network operations center for TransPAC, a high-speed network connecting the United States with countries in Asia and the Pacific Rim. The IUI campus also is home to the Cisco Networking Academy Training Center and the Cisco Certified Internetwork Expert (CCIE) Practice Lab. One of two such labs in the nation, the CCIE lab provides a testing environment for networking professionals worldwide who are candidates for certification as Cisco Certified Internetwork Experts.

Because Indiana's government, business, industry, finance, health, service, and nonprofit organizations are centered in Indianapolis, the urban environment plays an important role as a learning resource for students enrolled in the informatics programs. Many of the state's communication industries are concentrated in the capital city, and the larger organizations based here have made commitments to improve their communication and business processes through the use of information and information technology. IUI has established strong working relationships with both industry and government agencies in communications, information technology, and media arts and sciences.

IUI Honors Program

The IUI Honors Program offers special opportunities for academically superior students to do honors work or pursue department or general honors degrees. Undergraduates may enroll in independent study, H-Option courses, graduate courses, or designated honors courses. Students should check the Schedule of Classes for course offerings.

Students who have SAT scores of 1100 or above, rank in the top 10 percent of their high school class, or have a 3.30 grade point average are eligible to enroll in honors courses. For additional information on honors degrees, contact the Honors Office, University College 3140, at (317) 274-2660.

Information on the Informatics degree program can be located on the Web at http://informatics.iupui.edu/.

IU Kokomo

The Bachelor of Science in Informatics is offered on the Kokomo campus under the Science, Mathematics, and Informatics Department. Information on the Informatics degree program can be located on the Web at https://www.iuk.edu/sciences/informatics/index.html.

IU South Bend

Indiana University South Bend provides all the services and opportunities of a large university combined with the advantages and atmosphere of a small college.

Information on the School of Informatics degree programs offered at the IUSB campus can be located on the Web at https://www.iusb.edu/informatics/.

IU Southeast

The Bachelor of Science in Informatics is offered on the Southeast campus under the Department of Natural Sciences. Information on the Informatics degree program can be located on the Web at http://www.ius.edu/informatics/.

Contact Information

Undergraduate Student Services

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Bloomington, IN 47408
@

Graduate Student Services

Luddy Hall, Room 1113
700 N. Woodlawn Avenue
Bloomington, IN 47408
(812) 855-1135
gradvise@indiana.edu

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Disclaimer

While every effort is made to provide accurate and current information, Indiana University reserves the right to change without notice statements in the bulletin series concerning rules, policies, fees, curricula, or other matters.

History

The Luddy School of Informatics, Computing, and Engineering offers a new kind of computing education—one where students not only learn how technology works, but also what it can accomplish. Our interdisciplinary approach to research, as well as our innovative curriculum, is designed to instill a new generation of students with the knowledge, imagination, and flexibility to tackle complex issues from global warming to national security. We are training a new kind of thinker, one who is ready to solve the problems we face today and those that will challenge us tomorrow.

Computing education has a long and storied history at Indiana University. The Department of Computer Science, founded in 1971, has graduated thousands of students

who have gone on to become leaders and innovators in technology development.

Founded in 2000 as the IU School of Informatics, the school added a new dimension to our technology programs. The School of Informatics was the first IT school of its kind—an innovative, interdisciplinary program where technology fuels discoveries in fields as diverse as music and microbiology. We offered the first Ph.D. in Informatics, as well as one of the first master's degrees in cybersecurity.

Recognizing the vital connection between these fields and wanting to provide students with a richer educational experience, the Department of Computer Science and the School of Informatics joined forces in 2005, and the School of Library and Information Science merged with the then-School of Informatics and Computing in 2012.

The intelligent systems engineering program, IU's first engineering program, was established in 2016. It provides a modern vision of engineering through technology with curriculum designed to teach students how to take on the next generation of solutions powered by computing and artificial intelligence. Our data science program prepares students to collect, organize, analyze, and interpret the massive amounts of data generated daily to become valuable data professionals who have the vision and skills to use data to solve problems, unite communities, prevent disasters, transform industries, and most importantly, improve lives.

A transformative, $60 million gift from IU alumnus Fred Luddy in 2019 - the second-largest gift in Indiana University history - expanded support for faculty and students both at the graduate and undergraduate level. The gift also allowed the creation of the Luddy Center for Artificial Intelligence and served as a catalyst for the school. In honor of Luddy's generosity, the school was renamed the Luddy School of Informatics, Computing, and Engineering.

Mission

The Indiana University School of Informatics includes the Luddy School of Informatics, Computing, and Engineering at Indiana University Bloomington, the School of Informatics and Computing at IUPUI and programs at IU East, IU Kokomo, IU South Bend, and IU Southeast.

The mission of the School is to excel and lead in education, research, and outreach spanning and integrating the full breadth of computing and information technology, including the scientific and technical core, a broad range of applications, and human and societal issues and implications.

The School aims to lead the nation in creating a new, broad and interdisciplinary view of computing and information technology, and uses this viewpoint as the foundation of its main areas of emphasis:

Education and Research

The School offers a broad array of B.S., M.S., and Ph.D. programs in informatics, computer science, data science, intelligent systems engineering, and information and library science and conducts research in a wide range of computing and informatics foundations, applications and implications. This range includes:

- foundational areas including algorithms, data and search, networks and systems, and programming languages
- interdisciplinary applications in areas including artificial intelligence, cognitive science and robotics, complex systems, cyber-infrastructure, digital media, health and life sciences, and security and privacy
- human and societal issues including human computer interaction and social informatics

Economic Development and Entrepreneurship

The School aims to provide talented graduates and professional expertise to a wide range of computing and information technology businesses and occupations, and places special emphasis on partnering with information technology businesses and needs in the state of Indiana. It also emphasizes and supports a culture of entrepreneurship in its students, faculty and alumni.

Diversity

The School aims to provide an environment that involves a diverse array of students, staff and faculty, including women and under-represented minorities, and people with a wide range of intellectual interests and talents. The broad view that the School takes of computing and information technology education and research provides a strong foundation for its diversity goals and being recognized as a national exemplar.

Undergraduate Programs

The Luddy School of Informatics, Computing, and Engineering offers a Bachelor of Science in Informatics (INFOBS), a Bachelor of Science in Computer Science (CSCIBS), a Bachelor of Science in Intelligent Systems Engineering (ISENGRBS), and a Bachelor of Science in Data Science (DSCIBS).

The very nature of these degrees, with the changing technologies and applications, requires that the content of each degree be continuously assessed and revised. Therefore, the faculty of Luddy will periodically review and revise the curricula to ensure that students are prepared to meet contemporary workplace and intellectual demands. Please email the Luddy School of Informatics, Computing, and Engineering Student Services Office at siceugrd@indiana.edu or refer to our website.

Academic counseling for each student in Luddy is provided by an academic advisor prior to each semester's enrollment. Although academic counseling is intended to provide effective guidance, students are responsible for planning their own programs and for meeting the following degree requirements for graduation. Students are advised to read bulletin descriptions of all courses selected, paying careful attention to conditions concerning awarding of credit.

Admission

Undergraduate students admitted to the Luddy School of Informatics, Computing, and Engineering (Direct

Admit, Certification, School Changes) are assessed a mandatory school fee.

Direct Admission

Each year, qualified high school seniors are invited to be directly admitted to the Luddy School of Informatics, Computing, and Engineering. To be eligible for Direct Admission, students must have:

- Submitted a complete application to the Office of Admissions by November 1.
- Been admitted to Indiana University with either Computer Science B.S., Data Science B.S., Informatics B.S., Intelligent Systems Engineering B.S., or Cybersecurity & Global Policy B.S. listed as your intended major on your IU Bloomington application.
- A minimum SAT score of 1310 (critical reading and math only) or minimum ACT score of 28. Superscores are accepted for both SAT and ACT.
- A 620 minimum math SAT score or 26 math ACT score if your intended major is Intelligent Systems Engineering.
- A minimum cumulative GPA of 3.75 on a 4.0 scale.

Indiana University Bloomington and the Luddy School of Informatics, Computing, and Engineering accept weighted GPAs if provided on your high school transcript. All GPAs will be converted to a 4.0 scale by the Office of Admissions.

Standard Admission

Students wishing to major in computer science, data science, informatics, or intelligent systems engineering must be admitted to Indiana University and first enter the University Division at IUB. Freshmen should begin to satisfy specific degree requirements in the first year. Computer Science BS, Data Science, Informatics, and Intelligent Systems Engineering majors, after declaring their respective major and completion of the below requirements, will automatically "certify" from University Division in the certification after requirements are completed and they have been in University Division **one full semester**. Certification is 3 times a year: spring, summer, and fall.

Students pursuing a Bachelor of Science degree in informatics must satisfy the following requirements:

- Complete 30 credit hours of course work that can count toward a bachelor of science degree in informatics with a minimum cumulative grade point average of 2.0.
- Complete the English composition requirement (ENG-W 131 or equivalent) with a minimum grade of C.
- Complete INFO-I 101, Introduction to Informatics, with a minimum grade of C.

Students pursuing a Bachelor of Science degree in computer science or data science must satisfy the following requirements:

- Complete 30 credit hours of course work that can count toward a bachelor of science degree in computer science or data science with a minimum cumulative grade point average of 2.0.
- Complete the English composition requirement (ENG-W 131 or equivalent) with a minimum grade of C.

Students pursuing a Bachelor of Science degree in intelligent systems engineering must satisfy the following requirements:

- Complete 30 credit hours of course work that can count toward a bachelor of science degree in intelligent systems engineering with a minimum cumulative grade point average of 3.0 or written consent from the department chair.
- Completion of IU's ENGR-E 101.
- Completion of IU's MATH-M 211.
- Students must meet with the departmental advisor to gain permission to register for ENGR-E 110 and E 111 for their second semester.

Contact the Office of Admissions at (812) 855-0661 or view the website for complete instructions. For specific information on the Luddy School of Informatics, Computing, and Engineering, view the website or email siceugrd@indiana.edu.

Data Science

DSCI-D 321 Data Representation (3 cr.) P: CSCI-A 310 or C 343. This course covers a wide variety of data representations and data processes that are core parts of the data/information ecosystem. The focus is on essential aspects and mechanisms of data engineering to prepare data for data science and machine learning problems and applications.

DSCI-D 351 Big Data Analytics (3 cr.) P: CSCI-C 200 or C 211 This course introduces the fundamentals of data science and big data analysis by focusing on: theoretical aspects, such as their philosophical grounds and implications, and methodological aspects, such as large-scale data processing, statistical analysis and machine learning, data retrieval and recommendation, data representation and semantics, along with several case studies.

DSCI-D 390 Undergraduate Independent Study (1-3 cr.) Department Approval. Independent research based on existing literature or original work. A report, in the style of a department technical report, is required. May be repeated for a maximum of 6 credit hours.

DSCI-D 498 Data Science Capstone I (3 cr.) P: DSCI-D 321, DSCI-D 351, INFO-I 123, and STAT-S 352. This first course of two introduces students to a real-world, group project that includes statement of work, requirements gathering, data science system design and implementation, product delivery, and assessment of work. The first course is devoted to identifying team projects, understanding the customers' needs and preliminary tasks for the project.

DSCI-D 499 Data Science Capstone II (3 cr.) P: DSCI-D 498. This second course of two completes a team-based, real-world project that solves a data science problem. The students develop a project plan, milestones, design and implement solutions, and give a product including a write-

up, code base, and interpretation of results. Students also learn additional elements of data science e.g., ROC.

Data Science

Computer Science

Data Science

Engineering

Informatics

Information and Library Science

Computer Science

CSCI-A courses are non-major courses and are listed first regardless of the course level.

CSCI-A 110 Introduction to Computers and Computing (3 cr.) CASE N&M One year of high school algebra or MATH-M 014 recommended. Basic principles of computers and software. Social and lifestyle effects of information technology. Emphasis on problem-solving techniques. Productivity software skills are taught using real-world projects. Lecture and laboratory. Credit given for only one of CSCI-A 106, A 110, or A 111.

CSCI-A 111 A Survey of Computers and Computing (1.5 cr.) One year of high school algebra or MATH-M 014, and some prior computing experience recommended. Survey of computing concepts, with emphasis on problem-solving techniques. Experience in a variety of popular applications software for tasks such as word processing, Web browsing, spreadsheet calculations, and databases. Lecture and laboratory. An eight-week course. Credit given for only one of CSCI-A 106, A 110, or A 111.

CSCI-A 112 Programming Concepts (1.5 cr.) CSCI-A 110, A 111, or equivalent computing experience recommended. Introduction to programming for users of computer systems. Emphasis on problem-solving techniques. Lecture and laboratory. An eight-week course. Credit not given for both CSCI-A 112 and INFO-I 110.

CSCI-A 113 Data Analysis Using Spreadsheets (1.5 cr.) CSCI-A 110, A 111, or equivalent recommended. An introduction to data analysis using spreadsheets, including both scientific and business applications. Elementary statistical concepts and their applications to data analysis. Emphasis on problem-solving techniques. Lecture and laboratory. An eight-week course.

CSCI-A 114 Introduction to Databases (1.5 cr.) CSCI-A 110, A 111, or equivalent recommended. Introduction to database design concepts. Entering and modifying data, accessing data using visual tools and SQL, building database applications using forms and application development tools. Emphasis on problem-solving techniques. Lecture and laboratory. An eight-week course. Credit not given for both CSCI-A 114 and INFO-I 111.

CSCI-A 201 Introduction to Programming I (4 cr.) CASE N&M Two years of high school mathematics or MATH-M 014 recommended. Fundamental programming constructs, including loops, arrays, classes and files. General problem-solving techniques. Emphasis on modular programming, user-interface design, and developing good programming style. Not intended for computer science majors. Credit not given for both CSCI-A 201 and A 597.

CSCI-A 202 Introduction to Programming II (4 cr.) CASE N&M P: CSCI-A 201 or A 304. Advanced programming techniques: user-defined functions and types, recursion vs iteration, parameter-passing mechanisms; Classic abstract data types and algorithms. Programming style. Object-oriented programming. Web programming. May be counted toward computer science major requirements if completed prior to CSCI-C212. Credit not given for both CSCI-A 202 and A 598.

CSCI-A 216 Digital Multimedia Concepts and Technologies (3 cr.) CSCI-A 110, A 111, or equivalent computing experience recommended. In-depth introduction to the technologies of digital hardware and software relevant to efficient multimedia communication methods. Lectures focus on computational foundations, underlying concepts, and digital methods. Laboratory provides direct experience with concepts presented in lecture, using latest available digital tools to create direct and Web-based multimedia content. Lecture and laboratory.

CSCI-A 290 Tools for Computing (1-4 cr.) Exploration of topics in computing. Common topics include tools for power users. May be repeated for a maximum of 6 credit hours.

CSCI-A 304 Introductory C++ Programming (2 cr.) Programming experience recommended. Topics include aspects of C++ that are not object-oriented, basic data structures, standard libraries, and UNIX tools for project management.

CSCI-A 306 Object-Oriented Programming in C++ (2 cr.) CSCI-A 201, A 304, or C 212 recommended. Topics include objects, classes, encapsulation, inheritance, polymorphism, templates, and exceptions.

CSCI-A 310 Problem Solving Using Data (3 cr.) P: CSCI-C 200 or INFO-I 210 This course introduces algorithms and data structures for solving real world problems using data. Topics include: searching and sorting, basic data structures (heaps, hash tables, binary search and splay trees etc.), concepts of algorithm design (e.g., divide-and-conquer, dynamic programming), graph algorithms and clustering.

CSCI-A 321 Computing Tools for Scientific Research (4 cr.) CASE N&M MATH-M 118 or MATH-M 211 recommended. Introduction to computer-based tools useful for analysis and understanding of scientific data. Basic methods of computation, data processing, and display in systems such as Matlab combined with elementary practical C/C++ programming. Techniques to support customized scientific research tasks, with particular emphasis on biological, neural, and behavioral sciences. Lecture and laboratory.

CSCI-A 338 Network Technologies and Systems Administration (4 cr.) CSCI-A 110, EDUC-W 200, or equivalent computer literacy recommended. Introduction to network principles and current network technology, both hardware and software. Network administration tools and techniques. Laboratory provides practical experience. Credit not given for both A 338 and A 538.

CSCI-A 346 User-Interface Programming (3 cr.) CSCI-A 202, A 306, C 212, or equivalent experience recommended. Learn to prototype and build graphical user interfaces for computer applications. Contemporary software design methodology. Students design and implement prototype interfaces to applications provided by the instructor. Extensive use will be made of both commercial and experimental software tools.

CSCI-A 348 Mastering the World Wide Web (3-4 cr.) Two semesters of programming experience, or equivalent, and some knowledge of operating systems recommended. Project-oriented course leading to ability to maintain a fully functional web site. Topics include internet network protocols and web programming, server administration, protocols, site design, and searching and indexing technologies.

CSCI-B 351 Introduction to Artificial Intelligence (3 cr.) CASE N&M P: CSCI-C 200 or C 211. A survey of techniques for machine intelligence and their relation to human intelligence. Topics include modeling techniques, neural networks, problem-solving methods, heuristics, search, logic, knowledge representation, machine learning, and production systems. Credit not given for both CSCI-B 351 and COGS-Q 351.

CSCI-B 355 Autonomous Robotics (3 cr.) Two semesters of computer programming recommended. Introduction to the design, construction, and control of autonomous mobile robots. This course covers basic mechanics, electronics and programming for robotics, as well as the applications of robots in cognitive science. Credit not given for both CSCI-B 355 and COGS-Q 360.

CSCI-B 363 Bioinformatics Algorithms (4 cr.) One programming class or equivalent programming experience in C/C++, Java or Python recommended. The course will introduce algorithms for addressing real-world biological questions. For each topic, we will start with an important biological question and gradually present algorithms to answer this question. The course will also discuss the strategies to formulate an appropriate computation problem from a biological question to motivate algorithmic thinking.

CSCI-B 365 Introduction to Data Analysis and Mining (3 cr.) Basic programming skills (CSCI-C 200, C-211 or INFO-I 210) recommended. The course objective is to study computational aspects of discovering patterns and relationships in large data. This course is designed to introduce fundamental concepts of data mining and provide hands-on experience in data collection, preprocessing, analysis, clustering and prediction.

CSCI-B 392 Competitive Programming (3 cr.) P: CSCI-C 343. This course focuses on training students to prepare for programming contests (such as the ACM International Collegiate Programming Contest). The students will learn to design time and space efficient algorithms to solve challenging contest problems, and produce bug-free code under the pressure of time in contest. May be repeated for a maximum of 6 credit hours.

CSCI-B 401 Fundamentals of Computing Theory (3 cr.) CASE N&M P: CSCI-C 212 and C 241. Fundamentals of formal language theory, computation models and computability, the limits of computability and feasibility, and program verification.

CSCI-B 403 Introduction to Algorithm Design and Analysis (3 cr.) CASE N&M P: CSCI-C 241, (A 310 or C 343) and MATH-M 212. Algorithm design methodology. General methods for analysis of algorithms. Analysis of the performance of specific algorithms, such as those for searching and sorting. Credit not given for both CSCI-B 403 and B 503.

CSCI-B 430 Security for Networked Systems (3 cr.) P: CSCI-C 231 or INFO-I 231. This course is an extensive survey of network security. The course materials cover threats to information confidentiality, integrity, and availability in different internet layers, and defense mechanisms that control these threats. The course also provides a necessary foundation on network security, such as cryptographic, primitives/protocols, authentication, authorization and access control technologies; and hands-on experiences through programming assignments and course projects. Credit given for only one of CSCI-B 430, INFO-I 430, or I 520.

CSCI-B 433 Systems & Protocol Security & Information Assurance (3 cr.) P: CSCI-C 291 and (CSCI-C 231 or INFO-I 231). This class covers the fundamentals of computer security by looking at how things can go wrong, and how people can abuse the system. This is a matter of creative cheating; to find loopholes and exploit them. After students learn how to attack the system, it is possible to propose ways to make the system secure. Students will gain a basic overview of existing security problems and be exposed to methods that can be used to secure against such problems. The course should be taken by any one designing, selecting, or using applications in which security or privacy plays a role. Credit given for only one of CSCI-B 433, INFO-I 433, or I 533.

CSCI-B 441 Digital Design (4 cr.) CASE N&M P: CSCI-C 335. Organization and logic design of digital systems. Course presents a structured design philosophy, emphasizing hardwired and micro-programmed control. Boolean algebra, hardware building blocks, circuit synthesis, micro-programming. In the laboratory, students build, study, and debug a working minicomputer from elementary hardware components. Lecture and laboratory. Credit not given for both CSCI-B 441 and B 541.

CSCI-B 443 Introduction to Computer Architecture (3 cr.) CASE N&M P: CSCI-C 335 and C 343. Principles of processors, control units, and storage systems. Registers, buses, micro-programming, virtual storage. Relationship between computer architecture and system software. Credit only given for one of CSCI-B 443, CSCI-B 543, or ENGR-E 312

CSCI-B 453 Game Development (3 cr.) P: CSCI-C 292 and CSCI-C 343. By taking this course, students gain high competence developing games using current game engines (e.g., Unity), and have exposure to advanced topics including shader creation, SpatialOS, procedural content generation, and/or creating dynamic UIs or AIs for games.

CSCI-B 455 Principles of Machine Learning (3 cr.) P: MATH-M 211 and (CSCI-C 200 or C 211). In this course, we explore (machine learning) algorithms that

can learn from and make predictions on data. This course introduces the statistical, mathematical, and computational foundations of these frameworks, with a strong focus on understanding the mathematical derivations for the algorithms and simultaneously implementing the algorithms.

CSCI-B 456 Image Processing (3 cr.) P: CSCI-C 212 and MATH-M 212. The course emphasizes the general principle of image processing which includes data structures, algorithms, and analysis and modeling techniques used in modern imaging systems, digital image processing, and low-level computer vision. Topics include image sources, computer representation of images and formats, operations on images, and image analysis.

CSCI-B 457 Introduction to Computer Vision (3 cr.) P: CSCI-A 310 or B 351 or C 343. In this course, the students will learn fundamental computer vision algorithms as well as basic machine learning frameworks necessary for automated understanding of images and videos. Topics will include object recognition from images, activity/event recognition from videos, scene segmentation and clustering, motion and tracking, deep learning for images and videos.

CSCI-B 461 Database Concepts (3 cr.) CASE N&M P: CSCI-C 241 and (A 310 or C 343). Introduction to database concepts and systems. Topics include database models and systems: hierarchical, network, relational, and object-oriented; database design principles; structures for efficient data access; query languages and processing; database applications development; views; security; concurrency; recovery. Students participate in a project to design, implement, and query a database, using a standard database system. Credit not given for both CSCI-B 461 and B 561.

CSCI-B 481 Interactive Graphics (4 cr.) CASE N&M P: CSCI-C 343 and MATH-M 301 or M 303. Computer graphics techniques. Introduction to graphics hardware and software. Two-dimensional graphics methods, transformations, and interactive methods. Three-dimensional graphics, transformations, viewing geometry, object modeling, and interactive manipulation methods. Basic lighting and shading. Video and animation methods. Credit not given for both CSCI-B 481 and B 581.

CSCI-B 490 Seminar in Computer Science (1-4 cr.) Special topics in computer science. May be repeated for a maximum of 8 credit hours.

CSCI-C 102 Great Ideas in Computing (3 cr.) Survey of great ideas in computing and the role of computing in the modern world. Explores how people use computing tools to realize their ideas. Emphasis on the impact of modern technology and the use of hardware and software to create solutions to everyday problems. Lecture and laboratory.

CSCI-C 200 Introduction to Computers and Programming (4 cr.) High school precalculus math recommended. This course is an introduction, broadly, to algorithmic thinking and, specifically, to programming. It teaches the basics of programming using real world applications in natural, physical and social sciences. Students will develop ability to program by identifying problems in real world and then creating a program that solves the problem. Credit given for only one of CSCI-C 200, C 211, H 200, H 211, A 581, or A 591.

CSCI-H 200 Introduction to Computers and Programming, Honors (4 cr.) Honors version of CSCI-C 200. This course is an introduction, broadly, to algorithmic thinking and, specifically, to programming. It teaches the basics of programming using real world applications in natural, physical and social sciences. Students will develop ability to program by identifying problems in real world and then creating a program that solves the problem. Credit given for only one of CSCI-C 200, C 211, H 200, H 211, A 581, or A 591.

CSCI-C 211 Introduction to Computer Science (4 cr.) CASE N&M High school precalculus math recommended. A first course in computer science for those intending to take advanced computer science courses. Introduction to programming and to algorithm design and analysis. Using the Scheme programming language, the course covers several programming paradigms. Lecture and laboratory. Credit given for only one of CSCI- C 211, H 211 or S 211

CSCI-H 211 Introduction to Computer Science, Honors (4 cr.) CASE N&M High school precalculus math recommended. Honors version of CSCI-C 211. A first course in computer science for those intending to take advanced computer science courses. Introduction to programming and to algorithm design and analysis. Using the Scheme programming language, the course covers several programming paradigms. Lecture and laboratory. Credit given for only one of CSCI-C 200, C 211, H 200, H 211, A 581, or A 591.

CSCI-C 212 Introduction to Software Systems (4 cr.) CASE N&M P: CSCI-C 200 or C 211. Design of computer software systems and introduction to programming in the environment of a contemporary operating system. Topics include a modern object-oriented programming language; building and maintaining large projects; and understanding the operating system interface. Lecture and laboratory. Credit given for only one of CSCI-C 212, H 212, or A 592

CSCI-H 212 Introduction to Software Systems, Honors (4 cr.) CASE N&M P: CSCI-C 200 or C 211. Honors version of CSCI-C 212. Design of computer software systems and introduction to programming in the environment of a contemporary operating system. Topics include a modern object-oriented programming language; building and maintaining large projects; and understanding the operating system interface. Lecture and laboratory. Credit given for only one of CSCI-C 212, H 212, or A 592

CSCI-C 231 Introduction to Mathematics of Cybersecurity (3 cr.) The goal of this course is for students to be introduced to the basic mathematical tools used in modern cybersecurity. The course covers introductory mathematical material from a number of disparate fields including probability theory, analysis of algorithms, complexity theory, number theory, and group theory. Credit not given for both CSCI-C 231 and INFO-I 231.

CSCI-C 241 Discrete Structures for Computer Science (3 cr.) CASE N&M P: CSCI-C 200 or C 211. MATH-M 211 recommended. Induction and recursive programs, running time, asymptotic notations, combinatorics and discrete probability, trees and lists, the relational data model, graph

algorithms, propositional and predicate logic. Credit not given for both CSCI-C 241 and H 241.

CSCI-H 241 Discrete Structures for Computer Science, Honors (3 cr.) CASE N&M. P: CSCI-C 200 or C 211. MATH-M 211 recommended. Honors version of CSCI-C 241. Induction and recursive programs, running time, asymptotic notations, combinatorics and discrete probability, trees and lists, the relational data model, graph algorithms, propositional and predicate logic. Credit not given for both CSCI-H 241 and C 241.

CSCI-C 290 Topics in Computer Science (1-3 cr.) Exploration of topics in computing. Common topics include tools for power users. May be repeated for a maximum of 6 credit hours.

CSCI-C 291 System Programming with C and Unix (3 cr.) P: CSCI-A 201 or C 200 or C 211 or INFO-I 211. This course provides an introduction to programming in a Unix (Linux) environment using the C language. The key ideas to be discussed are: the Unix shell, file system and basic shell commands; the emacs text editor; and the C programming language. Credit given for only one of ENGR-E 111, ENGR-H 111, or CSCI-C 291

CSCI-C 292 Introduction to Game Programming (3 cr.) P: CSCI-C 212. This course explores the world of game development with a focus on programming for games. It provides an introduction to game programming using a state-of-the-art language (e.g., C#) in a game engine (e.g., Unity).

CSCI-C 295 Leadership and Learning (1-2 cr.) P: CSCI-A 201 or C 200 or C 211 or INFO-I 210. Students in this course learn and practice how to teach fundamental Computer Science concepts and skills, and investigate strategies to increase K-12 students' interest in CS with different race, gender, age, socioeconomic status, and academic background. Furthermore, this course trains undergraduate instructors in the department to better perform their duties.

CSCI-C 311 Programming Languages (4 cr.) CASE N&M P: CSCI-C 212 and C 241. Systematic approach to programming languages. Relationships among languages, properties and features of languages, and the computer environment necessary to use languages. Lecture and laboratory. Credit given for only one of CSCI-C 311, H 311, A 596 or B 521.

CSCI-H 311 Programming Languages, Honors (4 cr.) CASE N&M P: CSCI-C 212 and C 241. Honors version of CSCI-C 311. Systematic approach to programming languages. Relationships among languages, properties and features of languages, and the computer environment necessary to use languages. Lecture and laboratory. Credit given for only one of CSCI-H 311, C 311, A 596 or B 521.

CSCI-C 322 Object-Oriented Software Methods (4 cr.) P: CSCI-C 212. Design and implementation of complex software systems and applications exploiting the object-oriented paradigm. Selection and effective utilization of object-oriented libraries and interfaces.

CSCI-C 323 Mobile App Development (3 cr.) P: CSCI-C 212. This course focuses on development of mobile applications for modern platforms and introduces common tools and languages used. The course will emphasize the app development cycle: application design, development, testing, publishing and distribution; development tools and emulators/simulators; user interface layout; using sensors including touch, geo-location and orientation; and data management.

CSCI-C 335 Computer Structures (4 cr.) CASE N&M P: CSCI-C 212, C 241 and C 291. Structure and internal operation of computers. The architecture and assembly language programming of a specific computer are stressed, in addition to general principles of hardware organization and low-level software systems. Lecture and laboratory. Credit given for only one of CSCI-C 335, CSCI-H 335 or ENGR-E 201

CSCI-H 335 Computer Structures, Honors (4 cr.) CASE N&M P: CSCI-C 212, C 241 and C 291. Honors version of CSCI-C 335. Structure and internal operation of computers. The architecture and assembly language programming of a specific computer are stressed, in addition to general principles of hardware organization and low-level software systems. Lecture and laboratory. Credit given for only one of CSCI-H 335, CSCI-C 335, or ENGR-E 201

CSCI-C 343 Data Structures (4 cr.) CASE N&M P: CSCI-C 212 and C 241. Systematic study of data structures encountered in computing problems, structure and use of storage media, methods of representing structured data, and techniques for operating on data structures. Lecture and laboratory. Credit not given for both CSCI-C 343 and H 343.

CSCI-H 343 Data Structures, Honors (4 cr.) CASE N&M P: CSCI-C 212 and C 241. Honors version of CSCI-C 343. Systematic study of data structures encountered in computing problems, structure and use of storage media, methods of representing structured data, and techniques for operating on data structures. Lecture and laboratory. Credit not given for both CSCI-H 343 and C 343.

CSCI-C 460 Senior Project I (3 cr.) P: Department approval. Students work on projects in supervised teams, from planning and design to implementation, testing and releasing of a final product. Teamwork, communication, and organizational skills are emphasized in a real-world-style environment.

CSCI-C 470 Senior Project II (3 cr.) P: Department approval. Students work on projects in supervised teams, from planning and design to implementation, testing and releasing of a final product. Teamwork, communication, and organizational skills are emphasized in a real-world-style environment.

CSCI-H 498 Undergraduate Honors Seminar (1-3 cr.) Junior or senior major in computer science or informatics with a GPA of at least 3.3, or permission of instructor. A survey of faculty research in computer-related fields with different professors discussing their research each week. May be repeated for a maximum of 6 credit hours.

CSCI-P 415 Introduction to Verification (3 cr.) CASE N&M P: CSCI-C 311. Tools and techniques for rigorous reasoning about software and digital hardware. Safety, reliability, security, and other design-critical applications. Decision algorithms. Projects involving the use of automated reasoning, such as model checkers, theorem

provers, and program transformation. Credit not given for both CSCI-P 415 and P 515.

CSCI-P 423 Compilers (4 cr.) CASE N&M P: CSCI-C 311. Compiler design and construction, including lexical analysis, parsing, code generation, and optimization. Extensive laboratory exercises. Credit given for only one of CSCI-P 423, P 523, ENGR-E 313, or E 513.

CSCI-P 424 Advanced Functional Programming (3 cr.) P: CSCI-C 311. This course teaches advanced techniques for functional programming, which can be used to make programs easier to read and compose. These techiniques include equational reasoning, types, monads, and code generation. Some of them are useful even when using a "non-functional" language. Some of them are drawn from cutting-edge research.

CSCI-P 434 Distributed Systems (4 cr.) P: CSCI-A 310 or C 343. Principles of distributed systems including sytem design, distributed algorithms, consistency and concurrency, and reliability and availability. The role of these foundational issues in distributed file systems, distributed computing, and data-driven systems. Credit given for only one of CSCI-P 434, B 534, ENGR-E 410, or E 510.

CSCI-P 436 Introduction to Operating Systems (4 cr.) CASE N&M P: CSCI-C 335 and C 343. Organization and construction of computer systems that manage computational resources. Topics include specification and implementation of concurrency, process scheduling, storage anagement, device handlers, mechanisms for event coordination. Lecture and laboratory. Credit given for only one of CSCI-P 436, P 536, ENGR-E 319, or E 519.

CSCI-P 438 Introduction to Computer Networks (4 cr.) P: CSCI-C 335. Foundations of computer networks. Networking hardware technology such as Ethernet, ATM, wireless. Networking protocols (TCP/IP), routing, error correcting. Network services such as DNS, Web servers, virtual private networks (VPN), open SSL. Credit given for only one of CSCI-P 438, P 538, ENGR-E 318, or E 518.

CSCI-P 442 Digital Systems (4 cr.) CASE N&M Elements of computer architecture construction of hardware systems, emphasizing a combination of components to form systems, and applications of general principles of computing to digital implementation. Lecture and laboratory. Credit only given for one of CSCI-P 442, CSCI-P 542, ENGR-E 314, or ENGR-E 514

CSCI-P 462 Database Application Design and Implementation (3 cr.) P: CSCI-B 461. This course deals with practical issues in the design and implementation of database application systems. Topics include database modeling design, query languages, communication with data, transaction management, concurrency control techniques, security, database design procedures, and some advanced database applications, such as data warehousing, data mining, semi-structured data and semantic web.

CSCI-P 465 Software Engineering for Information Systems I (3 cr.) CASE N&M P: CSCI-A 310 or C 343. Analysis design, and implementation of information systems. Project specification. Data modeling. Software design methodologies. Software quality assurance. Supervised team development of a real system for a real client. Credit not given for both CSCI-P 465 and P 565.

CSCI-P 466 Software Engineering for Information Systems II (3 cr.) CASE N&M P: CSCI-B 461 and C 343. Analysis design, and implementation of information systems. Project specification. Data modeling. Software design methodologies. Software quality assurance. Supervised team development of a real system for a real client. Credit not given for both CSCI-P 466 and P 566.

CSCI-Y 390 Undergraduate Independent Study (1-3 cr.) Department approval. Independent research based on existing literature or original work. A report, in the style of a departmental technical report, is required. May be repeated for a maximum of 6 credit hours of any combination of CSCI-Y 390, Y 391, Y 399 and Y 499.

CSCI-Y 391 Undergraduate Independent System Development (1-3 cr.) Department approval. The student designs, programs, verifies, and documents a project assignment. Prior to enrolling, the student must arrange for an instructor to supervise the course activity. May be repeated for a maximum of 6 credit hours of any combination of CSCI-Y 390, Y 391, Y 399 and Y 499.

CSCI-Y 395 Career Development for CSCI Majors (1 cr.) Develop skills and knowledge that enable you to successfully pursue your career search, both at the time of graduation and later as you progress through your career. The course covers techniques and strategies which make your job search more efficient and effective. Offered as an eight week course. Credit given for only one of CSCI-Y 395, ENGR-Y 395, or INFO-Y 395.

CSCI-Y 399 Project in Professional Practice (3 cr.) Department approval. The student designs, programs, verifies, and documents a project assignment selected in consultation with an employer and the department. May be repeated for a maximum of 6 credit hours of any combination of CSCI-Y 390, Y 391, Y 399 and Y 499.

CSCI-Y 499 Honors Research (1-12 cr.) Approval of departmental honors committee. May be repeated for a maximum of 6 credit hours of any combination of CSCI-Y 390, Y 391, Y 399 and Y 499.

CSCI-B 405 Applied Algorithms (3 cr.) P: Prerequisite: CSCI-C 343 or CSCI-H 343 (Data Structures). The course will introduce basic concepts and techniques for algorithmic design and analysis. The course will emphasize key mathematical ideas in efficient algorithms. The course will develop algorithmic thinking critical for formulating computational problems for real-world applications. Prior programming experience in C/C++, Java or Python is expected.

CSCI-B 405 Applied Algorithms (3 cr.) P: CSCI-C 343 or CSCI-H 343 (Data Structure) The course will introduce basic concepts and techniques for algorithmic design and analysis. The course will emphasize key mathematical ideas in efficient algorithms. The course will develop algorithmic thinking critical for formulating computational problems for real-world applications. Prior programming experience in C/C++, Java or Pythom is expected.

Engineering

ENGR-E 101 Innovation and Design (3 cr.) Innovation and Design provides an introduction to Intelligent Systems

Engineering. Students learn about engineering and the focus areas through interactive lectures and hands-on activity quests. Students present each quest with a new media to practice presenting data. Students will learn about professional development and start a digital portfolio.

ENGR-E 110 Engineering Computing Architectures (3 cr.) This course introduces the architecture of computing systems from logic gates through arithmetic logic units, central processing unit, and memory. It proceeds through the integration into a simple, but complete computing device including the necessary software elements.

ENGR-E 111 Software Systems Engineering (4 cr.) This course covers core aspects of the practice of software engineering, from basic programming concepts to design to development, debugging and maintenance. This course will cover software design, considering abstraction, modularity and encapsulation. It will cover requirements and process management, testing and maintenance, common software structures and software development tools. Credit given for only one of ENGR-E 111, ENGR-H 111, or CSCI-C 291

ENGR-H 111 Software Systems Engineering - Honors (4 cr.) This course covers core aspects of the practice of software engineering, from basic programming concepts to design to development, debugging and maintenance. This course will cover software design, considering abstraction, modularity and encapsulation. It will cover requirements and process management, testing and maintenance, common software structures and software development tools. Credit given for only one of ENGR-E 111, ENGR-H 111, or CSCI-C 291.

ENGR-E 201 Computer Systems Engineering (3 cr.) P: ENGR-E 111. This course covers modern computing devices, the computing ecosysytem and introductory material in systems programming, computer architecture, operating systems and computer networks. Coursework includes fundamental concepts at the basis of modern computing systems, covering costs in time, space and energy. The curriculum includes basic operational concepts in programming, computer architecture and networking. Credit given for only one of ENGR-E 201 and CSCI-C 335.

ENGR-E 202 Engineering Sustainable Products (3 cr.) P: ENGR-E 101. The course provides and introduction to prototyping, from an engineering and business approach.
Students will learn a systematic design process that supports the successful engineering of a product, with consideration for manufacturability and sustainability.
Students will engineer a prototype system, such as a power generator, biomedical device, or environmental sensor.

ENGR-E 210 Engineering Cyber-Physical Systems (3 cr.) P: ENGR-E 201 or CSCI-C 335. This course provides an introduction to core topics in cyber-physical systems. These topics include embedded systems, issues of real-time processing, and sensor mechanisms and control algorithms. Students will study applications of these elements in the Internet of Things and Robotics.

ENGR-E 221 Intelligent Systems I (3 cr.) P: One of the following: ENGR-E 111, CSCI-C 200, C 212, C 291 or INFO-I 210. This course introduces important concepts about intelligent systems. It provides a basis in mathematical tools and algorithms used in AI and machine learning. It introduces optimization techniques used in Intelligent Systems II. It will describe many current examples and how they are implemented in cloud systems. The course is based on Python for data analytics.

ENGR-E 222 Intelligent Systems II (3 cr.) In this course students will be familiarized with different specific applications and implementations of intelligent systems and their use in desktop and cloud solutions.

ENGR-E 225 Introduction to Circuits (3 cr.) P: ENGR-E 101, MATH-M 212, and PHYS-P 222. This course is an introduction to circuits and linear analysis. Topics include voltage and current sources, Kirchoff's laws, Ohm's law, Nodal and Mesh analysis, Thevenin and Norton equivalent circuits, operational amplifiers, inductors and capacitors, frequency analysis of 1st order and 2nd order systems, simple filter designs, and power dissipation calculations.

ENGR-E 250 Systems, Signals, and Control (3 cr.) P: ENGR-E 225 and MATH-M 343. Many engineering systems are based on signal processing and this course covers fundamental concepts in signals, systems, and control theory. Basic topics are covered, including continuous and discrete time signals and systems, filtering and sampling, Fourier transforms and its variants, and basic feedback systems.

ENGR-E 299 Engineering Professionalization & Ethics (1 cr.) This course introduces topics in engineering related to professionalism and ethics designed to develop ethical reasoning skills, increase ethical awareness and professionalism, and to analyze ethical dilemmas, specific to engineering. Students will learn ethical principles that can be applied in research, design and development. An eight-week course.

ENGR-E 304 Introduction to Bioengineering (3 cr.) The course introduces the fields of bioengineering and biomedical engineering. Topics include biofabrication, biomanufacturing, bioinstrumentation, drug discovery and delivery, cellular and molecular bioengineering, with a focus on design of different types of instruments and sensors. How to merge the disciplines of engineering and biology for biomedical applications will be discussed. Credit not given for both ENGR-E 304 and E 504.

ENGR-E 311 Circuits and Digital Systems (3 cr.) P: ENGR-E 110 and PHYS-P 222. This course will cover elements of circuits, such as the operation of basic circuit elements, fundamental circuit laws, and analytic techniques in both the time domain and the frequency domain. It will also cover the transistor-level design of circuits in the context of modern integrated-circuit technology.

ENGR-E 312 Modern Computer Architecture (3 cr.) P: CSCI-C 335 or ENGR-E 201. Must be joint-listed with CSCI-B 443. This course introduces the basic hardware structure of a modern programmable computer, including the basic laws underlying performance evaluation. Students will learn about processor control and data paths and how machine instructions execute simultaneously through pipelining and superscalar and multicore

execution, as well as about memory and caching. Credit not given for both ENGR-E 312 and CSCI-B 443.

ENGR-E 313 Engineering Compilers (3 cr.) P: ENGR-E 201. Must be joint-listed with CSCI-P 423. This course covers the engineering of a compiler, from scanning to parsing, semantic analysis and transformations to code generation and optimization. The emphasis of this course is on the hands-on implementations of various components using industry-standard tools. Credit given for only one of ENGR-E 313, E 513, CSCI-P 423, or P 523.

ENGR-E 314 Embedded Systems (3 cr.) P: ENGR-E 201. This course covers Embedded and Real-Time Systems designed for real-time multiprocessing and distributed processing. It discusses theoretical and practical concepts in real-time systems emphasizing both hard and soft real-time distributed multi-processing. Several operating systems (e.g. Xinu, Linux, VxWorks), computer architectures and process scheduling methods will be used to illustrate concepts. Credit not given for both ENGR-E 314 and E 514.

ENGR-E 315 Digital Design with FPGAs (3 cr.) P: ENGR-E 210. This course introduces digital design techniques using field programmable gate arrays (FPGAs). It discusses FPGA architecture, digital design flow using FPGAs, and other technologies associated with field programmable gate arrays. The course study will involve extensive lab projects to give students hands-on experience on designing digital systems on FPGA platforms.

ENGR-E 317 High Performance Computing (3 cr.) P: One of the following: ENGR-E 111, CSCI-C 200, C 212, or C 291. Familiarity with Linux/Unix command-line utilities.Students will learn the development, operation, and application of high performance computing systems prepared to address future challenges demanding capability and expertise in HPC. The course is interdisciplinary combining critical elements from hardware technology and architecture, system software and tools, and programming models and application algorithms with the cross-cutting theme of performance management and measurement. Credit not given for both ENGR-E 317 and E 517.

ENGR-E 318 Engineering Networks (3 cr.) P: ENGR-E 201. Must be joint-listed with CSCI-P 438. This course will cover the engineering of computer networks, considering the architecture and protocols. This course focuses on hands-on implementation and network systems construction. Credit given for only one of ENGR-E 318, E 518, CSCI-P 438, or P 538.

ENGR-E 319 Engineering Operating Systems (3 cr.) P: ENGR-E 201. Must be joint-listed with CSCI-P 436. The objective of this class is to learn the fundamentals of computer operating systems. This class approaches the practice of engineering an operating system in a hands-on fashion, allowing students to understand core concepts along with implementation realities. Credit given for only one of ENGR-E 319, E 519, CSCI-P 436, or P 536.

ENGR-E 321 Advanced Cyber-Physical Systems (3 cr.) P: ENGR-E 210. This course is the entry point into the cyber-physical systems specialization. It provides in-depth coverage of core topics in cyber-physical systems. It will treat issues of data analysis and reactive actuation, as well as power management and mobility. The course will explore formal models for designing and predicting system behavior.

ENGR-E 327 Automated Fabrication Machines (3 cr.) P: ENGR-E 210. This course will engage students in understanding fabrication machines as cyber-physical systems using computer numeric control (CNC), and in understanding how they work by designing, constructing, and programming such devices. This course will provide hands-on experience developing and using 2D and 3D graphics primitives and implementing devices that provide them.

ENGR-E 332 Introduction to Modeling and Simulation (3 cr.) P: (MATH-M 311 or MATH-M 343 or MATH-S 343) and (PHYS-P 222 or PHYS-H 222) This course introduces computational modeling and simulation used for solving problems in many engineering fields. Basics of deterministic and stochastic simulation methods are covered. Optimization techniques, use of high-performance computing, and engineering applications of simulations are discussed.

ENGR-E 340 Introduction to Computational Bioengineering (3 cr.) P: MATH-M 212 and BIOL-L 112. MATH-M 343 recommended. This course introduces key computational modeling techniques for bioengineering, with a focus on cell population kinetics, cell signaling, receptor trafficking, pharmacokinetics/pharmacodynamics, and compartmental and systems physiology methods. Concepts in control theory and optimization will also be applied to steer the modeled biological systems towards design objectives. Credit not given for both ENGR-E 340 and E 542.

ENGR-E 345 Wearable Sensors (3 cr.) The purpose of this course is to give you hands-on experience with wearable sensors and a foundation to understand their design and operation. The course will also serve as a partial survey of sensor designs in human physiological and behavioral monitoring. Credit not given for both ENGR-E 345 and E 545.

ENGR-E 390 Undergraduate Independent Study (1-3 cr.) Department approval. Independent research based on existing literature or original work. A report, in the syle of a departmental technical report, is required. May be repeated for a maximum of 6 credit hours.

ENGR-E 399 Topics in Intelligent Systems Engineering (1-3 cr.) Must be a student in the ISE undergraduate program or instructor's permission. Variable topic. Emphasis is on new developments and research in Intelligent Systems Engineering. May be repeated up to four times with different topics for a maximum of 12 hours.

ENGR-E 410 Engineering Distributed Systems (3 cr.) P: ENGR-E 318 or E 319 or CSCI-P 436 or P 438. Must be joint-listed with CSCI-P 434. Distributed systems are collections of independent elements that appear to users as a single system. This course considers fundamental principles in distributed system construction and explores the history of such systems from distributed operating systems to modern middleware and services. Examples and exercises from current distributed systems. Credit given for only one of ENGR-E 410, E 510, CSCI-P 434, or B 534.

ENGR-E 416 Engineering Cloud Computing (3 cr.) P: ENGR-E 319 or CSCI-P 436. The course covers basic concepts on programming models and tools of cloud computing to support data intensive science applications. Students will get to know the latest research topics of cloud platforms, parallel algorithms, storage and high level language for proficiency with a complex ecosystem of tools that span many disciplines. Credit not given for both ENGR-E 416 and E 516.

ENGR-E 434 Big Data Applications (3 cr.) P: One of the following: ENGR-E 111, CSCI-C 200, or INFO-I 211. This is an overview course of Big Data Applications covering a broad range of problems and solutions. It covers cloud computing technologies and includes a project. Algorithms are introduced and illustrated. Credit given for only one of ENGR-E 434, E 534, INFO-I 423, or I 523.

ENGR-E 435 Image Processing (3 cr.) Experience with signal processing or machine learning; Linear algebra and Calculus II recommended. The input or output of many engineering tools are images. Therefore, engineers need to know how to process them. Image processing will teach students how to design and implement their own algorithms for automatically detecting, classifying, and analyzing objects in images.

ENGR-E 438 Reverse Engineering Embedded Systems (3 cr.) This course provides an introduction to embedded systems reverse engineering. Focus is on the process of reverse engineering using tools and techniques relevant to embedded systems. The course will explore embedded systems architectures, from those based on 8-bit microcontrollers to those based on microprocessors running embedded multitasking operating systems. Credit not given for both ENGR-E 438 and E 538.

ENGR-E 440 Computational Methods for 3-D Biomaterials (3 cr.) P: MATH-M 343 and PHYS-P 221. ENGR-E 340 recommended. This computational engineering course teaches key biophysics and numerical concepts needed to simulate 3-D biological tissues, including finite element methods, conservation laws, biotransport, fluid mechanics, and tissue mechanics. The entire course will combine lectures with hands-on lab projects to simulate 3-D biological materials, and prepare students for computational tissue engineering. Credit not given for both ENGR-E 440 and E 540.

ENGR-E 441 Simulating Cancer as an Intelligent System (3 cr.) P: MATH-M 212 and one of the following: ENGR-E 111, CSCI-C 200, C 212, or C 291. This course explores cancer as an adaptive intelligent system, where renegade cells break the rules, reuse the body's natural processes to re-engineer their environments and evade treatments. We will use computational models to explore this system and the potential for future clinicians to plan treatments with data-driven models. Credit not given for both ENGR-E 441 and E 541.

ENGR-E 443 Computational Modeling Methods for Virtual Tissues (3 cr.) Mechanism-based modeling of biological phenomena (virtual-tissues), a growing field, which addresses problems outside the reach of data-based methods. This project-based course includes modeling the biology of cell behaviors and interactions, formulation of meaningful quantitative models and translation into executable simulations, and will use Python scripting in the CC3D modeling environment. Credit not given for both ENGR-E 443 and E 543.

ENGR-E 448 Computational Multicellular Systems Biology (3 cr.) P: CSCI-A 304 or A 306 or A 321 or ENGR-E 111. This course covers agent-based modeling and multiscale simulation of multicellular biological systems. After introducing background biology, students explore examples in cancer, tissue engineering, bacterial consortia, and infectious diseases including SARS-Co-V-2 (COVID-19). Students showcase their final projects as interactive, cloud-hosted models. We also demonstrate using HPC and AI for large-scale studies. Credit not given for both ENGR-E 448 and E 548.

ENGR-E 451 Simulating Nanoscale Systems (3 cr.) Familiarity with a programming language recommended. Students will learn how to model and simulate material behavior at the nanoscale. Analysis and control of shape, assembly, and flow behavior in soft nanomaterials will be discussed. Applications to engineering problems at the nanoscale will be emphasized. Optimization methods, nonequilibrium systems, and parallel computing will be covered. Credit not given for both ENGR-E 451 and E 551.

ENGR-E 464 Functional Neuroimaging (3 cr.) Functional neuroimaging tools present researchers with an extraordinary opportunity to examine the neurobiological correlates of behavior, expanding research to areas like development, aging and neurological diseases. This course will discuss the physical principles, instrumentation and data analysis methods of the main neuroimaging techniques such as fMRI, NIRS, EEG/MEG, among others. Credit not given for both ENGR-E 464 and E 564.

ENGR-E 470 Advanced Bioengineering (3 cr.) P: BIOT-T 310 or ENGR-E 304. The course introduces tissue engineering and regenerative medicine, neuro-engineering, synthetic biology and computational synthetic biology. Each topic contains a discussion on how to alter and use biological systems for bioengineering applications. Credit not given for both ENGR-E 470 and E 570.

ENGR-E 471 Microfluidic Devices and Systems (3 cr.) P: ENGR-E 101 or E 250. This course gives a fundamental introduction to the science and technology of miniaturization and its applications in creating microfluidic and nanofluidic devices. It discusses methods, tools and measuring devices to design and create micro-/nano-systems, and biomedical applications of these devices and systems such as pressure sensors, mixing devices. Credit not given for both ENGR-E 471 and E 571.

ENGR-E 472 Biomedical Devices and Sensors (3 cr.) P: ENGR-E 101 or E 250. This course covers nano/micro design and fabrication, actuators, sensors, microfluidics, implanted devices, lab-on-a-chip devices, drug delivery systems, detection and measurement systems, and their biomedical applications relevant for clinical medicine, food safety, environmental health, and homeland security. The discussions and projects are designed to address practical problems with engineering solutions. Credit not given for both ENGR-E 472 and E 572.

ENGR-E 483 Information Visualization (3 cr.) This course provides students with a working knowledge on how to visualize abstract information and hands-on

experience in the application of this knowledge to specific domains, different tasks, and diverse, possibly non-technical users. Credit not given for both ENGR-E 483 and E 583.

ENGR-E 484 Scientific Visualization (3 cr.) This course teaches basic principles of human cognition and perception; techniques and algorithms for designing and critiquing scientific visualizations in different domains (neuro, nano, bio-medicine, IoT, smart cities); hands-on experience using modern tools for designing scientific visualizations that provide novel and/or actionable insights; 3D printing and augmented reality deployment; teamwork/project management expertise. Credit not given for both ENGR-E 484 and E 584.

ENGR-E 490 Engineering Capstone Design I (3 cr.) Junior or senior standing. Engineering Capstone Design I is one of two capstone requirements for all Intelligent Systems Engineering students. Students will design engineering projects based on their areas of concentration, which will be supported by dedicated faculty members. Students may choose to conduct advanced research, develop prototypes, design new products or redesign existing products.

ENGR-E 491 Engineering Capstone Design II (3 cr.) Junior or senior standing. Engineering Capstone Design II is the second of two capstone requirements for all Intelligent Systems Engineering students. Students will design engineering projects based on their areas of concentration, which will be supported by dedicated faculty members. Students may choose to conduct advanced research, develop prototypes, design new products or redesign existing products.

ENGR-Y 395 Career Development For ISE Majors (1 cr.) P: Must be Intelligent Systems Engineering BS student. Develop skills and knowledge that enable you to successfully pursue your career search, both at the time of graduation and later as you progress through your career. The course covers techniques and strategies which make your job search more efficient and effective. Offered as an eight week course. Credit given for only one of ENGR-Y 395, CSCI-Y 395, or INFO-Y 395.

Informatics

INFO-I 101 Introduction to Informatics (4 cr.) Problem solving with information technology; introductions to information representation, relational databases, system design, propositional logic, cutting-edge technologies: CPU, operation systems, networks; laboratory emphasizing information technology including Web page design, word processing, databases, using tools available on campus. Credit not given for both INFO-I 101 and H 101.

INFO-H 101 Introduction to Informatics, Honors (4 cr.) Honors version of
INFO-I 101. Problem solving with information technology; introductions to information representation, relational databases, system design, propositional logic, cutting-edge technologies: CPU, operation systems, networks; laboratory emphasizing information technology including Web page design, word processing, databases, using tools available on campus. Credit not given for both INFO-H 101 and I 101.

INFO-I 110 Basic Tools of Informatics I—Programming Concepts (1.5 cr.) CSCI-A 110, A 111, or equivalent computing experience recommended. Introduction to programming for users of computer systems. Emphasis on problem-solving techniques. An eight-week lecture and laboratory course. Cross-listed with CSCI-A 112. Credit not given for both INFO-I 110 and CSCI-A 112.

INFO-I 111 Basic Tools of Informatics II—Introduction to Databases (1.5 cr.) CSCI-A 110, A 111, or equivalent computing experience recommended. Introduction to database design concepts. Entering and modifying data, accessing data using visual tools and SQL, and building database applications using forms and application development tools. Emphasis on problem-solving techniques. An eight-week lecture and laboratory course. Credit not given for both INFO-I 111 and CSCI-A 114.

INFO-I 123 Data Fluency (3 cr.) Data is big. Data is everywhere. How can we possibly be expected to keep up in a world full of data, much of which is data about ourselves? This class provides fundmental skills for the 21st century: understanding data, extracting knowledge from data, generating predictions from data and presenting data.

INFO-I 130 Introduction to Cybersecurity (1 cr.) P: INFO-I 101. This course introduces students to cybersecurity. The course will primarily focus on introduction to three core areas (technical aspects of security, organizational aspects of security, and legal aspects of security). Through examples of security problems in real life, this course will illuminate fundamental ideas and concepts of information security. An eight-week course.

INFO-I 200 Explorations in Informatics (1-3 cr.) Variable topic. Exploration of topics in informatics. The course may cover topics from all areas of informatics. May be repeated with different topics for a maximum of 6 credit hours.

INFO-I 201 Mathematical Foundations of Informatics (4 cr.) P: INFO-I 101 and the completion of the Mathematical Modeling requirement. An introduction to methods of analytical, abstract, and critical thinking; deductive reasoning; and logical and mathematical tools used in information sciences. Topics include propositional and predicate logic, natural deduction proof system, sets, functions and relations, proof methods in mathematics, mathematical induction, and graph theory. Credit not given for both INFO-I 201 and H 201.

INFO-H 201 Mathematical Foundations of Informatics, Honors (4 cr.) P: INFO-I 101 and (MATH-M 118 or A 118 or S 118 or V 118 or (MATH-D 116 and D 117)). Honors version of INFO-I 201. An introduction to methods of analytical, abstract, and critical thinking; deductive reasoning; and logical and mathematical tools used in information sciences. Topics include propositional and predicate logic, natural deduction proof system, sets, functions and relations, proof methods in mathematics, mathematical induction, and graph theory. Credit not given for both INFO-H 201 and I 201.

INFO-I 202 Social Informatics (3 cr.) P: INFO-I 101. Introduction to key social research perspectives and literatures on the use of information and communication technologies. Discusses current topics such as information ethics, relevant legal frameworks, popular

and controversial uses of technology (e.g., peer-to-peer file sharing), digital divides, etc. Outlines research methodologies for social informatics. Credit not given for both INFO-I 202 and H 202.

INFO-H 202 Social Informatics, Honors (3 cr.) P: INFO-I 101. Honors version of INFO-I 202. Introduction to key social research perspectives and literatures on the use of information and communication technologies. Discusses current topics such as information ethics, relevant legal frameworks, popular and controversial uses of technology (e.g., peer-to-peer file sharing), digital divides, etc. Outlines research methodologies for social informatics. Credit not given for both INFO-H 202 and I 202.

INFO-I 210 Information Infrastructure I (4 cr.) P: INFO-I 201 or CSCI-C 241. This course introduces software architectures of information systems and basic concepts and procedures of system and application development. Course topics include PHP programming syntax; procedural programming fundamentals; principles of developing dynamic, database-driven applications for the World Wide Web; relational database concepts; and basic MySQL statements. Credit not given for both INFO-I 210 and H 210.

INFO-H 210 Information Infrastructure I, Honors (4 cr.) P: INFO-I 201 or CSCI-C 241. Honors version of INFO-I 210. This course introduces software architectures of information systems and basic concepts and procedures of system and application development. Course topics include PHP programming syntax; procedural programming fundamentals; principles of developing dynamic, database-driven applications for the World Wide Web; relational database concepts; and basic MySQL statements. Credit not given for both INFO-H 210 and I 210.

INFO-I 211 Information Infrastructure II (4 cr.) P: INFO-I 210 or CSCI-C 200 or C 211. The systems architecture of distributed applications. Advanced programming, including an introduction to the programming of graphical systems. Credit not given for both INFO-I 211 and H 211.

INFO-H 211 Information Infrastructure II, Honors (4 cr.) P: INFO-I 210 or CSCI-C 200 or C 211. Honors version of INFO-I 211. The systems architecture of distributed applications. Advanced programming, including an introduction to the programming of graphical systems. Credit not given for both INFO-H 211 and I 211.

INFO-I 216 Humans, Animals, and Artificial Intelligence (3 cr.) What are the origins and computational foundations of intelligence? How close are we to building machines that think like humans and animals? We will explore how cognitive abilities are distributed across the animal kingdom, investigate which abilities are uniquely human, and discuss progress building artificial intelligence that mimics biological intelligence.

INFO-I 222 The Information Society (3 cr.) In this course, students will learn to think critically about what it means to live in an "Information Society." From printing press to telephone to computer to the Internet, they will explore the history and social implications of the various information revolutions that shaped contemporary commercial, scientific, organizational, political life.

INFO-I 230 Analytical Foundations of Security (3 cr.) P: INFO-I 101. This course will enable students to re-evaluate and conceptualize material learned in discrete courses to consider the topics from their perspective of security. For example, computer system basics such as hardware (CPUs, memory, ...) and software are reconsidered from the perspective of how their interactions create vulnerabilities. Vulnerabilities that combine standard hardware and software configurations will be examined as these illuminate both security and computer networks. Operating systems and file systems are examined from the perspective of access control, permissions, and availability of system services, etc.

INFO-I 231 Introduction to the Mathematics of Cybersecurity (3 cr.) INFO-I 101 and I 201 recommended. Introduces the basic mathematical tools used in modern cybersecurity. Covers mathematical material from a number of disparate fields, including probability theory, analysis of algorithms, complexity theory, number theory, and group theory. Credit not given for both INFO-I 231 and CSCI-C 231.

INFO-I 245 Interaction Design Thinking (3 cr.) This hands-on, project driven course offers a creative approach to the process of designing interactive systems. Activities include researching user behaviors, preferences, and needs and then producing sketches, models, and prototypes to explore possible solutions. Resulting designs are desirable to users, technically feasible, and economically viable.

INFO-I 246 Use and Usability (3 cr.) Students will learn the foundations of user experience (UX). These include basics of human psychology and storytelling as well as paradigms of human-computer interaction (e.g., desktop, mobile, voice). Students will practice translating user and system research into actionable design insights to envision and test diverse design solutions.

INFO-I 300 HCI/Interaction Design (3 cr.) P: INFO-I 202 or I 222. An intermediate course that teaches students how to assess the usability of software through quantitative and qualitative methods, including conducting task analysis, usability studies, heuristic inspections, interviews, surveys, and focus groups. The course also introduces students to the tools and techniques for designing and testing user interfaces based on a human-centered methodology. Credit not given for both INFO-I 300 and H 300.

INFO-H 300 HCI/Interaction Design, Honors (3 cr.) P: INFO- I 202 or I 222. Honors version of INFO-I 300. An intermediate course that teaches students how to assess the usability of software through quantitative and qualitative methods, including conducting task analysis, usability studies, heuristic inspections, interviews, surveys, and focus groups. The course also introduces students to the tools and techniques for designing and testing user interfaces based on a human-centered methodology. Credit not given for both INFO-H 300 and I 300.

INFO-I 301 Presentations for IT Professionals (3 cr.) Must be a LUDDY major. Students present several different types of presentations and engage in developing these "21st Century skills" for their future. The course utilizes an open studio format that allows students to

explore public speaking to better prepare for future educational and professional presentations.

INFO-I 303 Organizational Informatics (3 cr.) P: INFO-I 101. Examines the various needs, uses, and consequences of information in organizational contexts. Topics include organizational types and characteristics, functional areas and business processes, information-based products and services, the use of and redefining the role of information technology, the changing character of work life and organizational practices, sociotechnical structures, and the rise and transformation of information-based industries.

INFO-I 304 Introduction to Virtual Reality (3 cr.) Virtual Reality has applications in fields as diverse as medicine, education, military training, trauma recovery, and artificial intelligence. In this course, students will learn the foundational skills needed to build virtual reality applications. We will focus on software programs for building virtual assets and realistic virtual environments.

INFO-I 308 Information Representation (3 cr.) P: (INFO-I 201 or CSCI-C 241) and (INFO-I 210 or CSCI-C 200 or C 211). The basic structure of information representation in digital information systems. Begins with low-level computer representations such as common character and numeric encodings. Introduces formal design and query languages through Entity Relationship Modeling, the Relational Model, XML, and XHTML. Laboratory topics include SQL and XPath querying. Credit not given for both INFO-I 308 and H 308.

INFO-H 308 Information Representation, Honors (3 cr.) P: (INFO-I 201 or CSCI-C 241) and (INFO-I 210 or CSCI-C 200 or C 211). Honors version of INFO-I 308. The basic structure of information representation in digital information systems. Begins with low-level computer representations such as common character and numeric encodings. Introduces formal design and query languages through Entity Relationship Modeling, the Relational Model, XML, and XHTML. Laboratory topics include SQL and XPath querying. Credit not given for both INFO-H 308 and I 308.

INFO-I 310 Multimedia Arts and Technology (3 cr.) P: INFO-I 300. The study of the evolution of media arts and underlying principles of communication. Application development paradigms in current practice.

INFO-I 311 Application Development (3 cr.) P: INFO-I 210 or CSCI-C 200 or C 211. This undergraduate course uses a professional development environment to teach advanced programming skills using an object oriented programming language. Topics include primitive data types, mathematical functions, string manipulation, arrays, logical statements, loops, methods, classes, inheritance, debugging, exception handling, graphical user interfaces (GUIs), and version control software.

INFO-I 320 Distributed Systems and Collaborative Computing (3 cr.) INFO-I 211 recommended. An introductory treatment of distributed systems and programming. Topics range from the distributed and object models of computation to advanced concepts such as remote method invocations, object brokers, object services, open systems, and future trends for distributed information systems.

INFO-I 330 Legal and Social Informatics of Security (3 cr.) P: (INFO-I 211 or INFO-H 211 or CSCI-C 212 or CSCI-H 212) and INFO-I 230 This course will examine that set of ethical and legal problems most tightly bound to the issues of information control. The interaction and technology changes, but the core issues have remained: privacy, intellectual property, Internet law, concepts of jurisdiction, speech anonymity versus accountability, and ethical decision making in the network environment.

INFO-I 341 Prototyping with Arduino Tools (3 cr.) The course covers material culture and literature of the hobby and professional electronics design communities with the goal of creating a physical prototype that communicates the students' creative and social vision. These student prototypes are model systems that embody the computational and organizational thinking of working effectively within engineering firms.

INFO-I 342 Mobile Programming I (3 cr.) This undergraduate course uses a professional development environment to teach skills to program applications for mobile devices. Topics include graphical user interfaces (GUIs), data management, recording and playing back audio and video, location, maps, and using text messaging within an application.

INFO-I 345 Interaction Design Research (3 cr.) P: INFO-I 245 and I 246. Students will learn the basics of user experience (UX), including theories of experience, UX data collection, and data analysis methods. It also covers fundamental research topics, including research ethics, sampling, and documentation. Students will translate research results into design: experience journey maps, personas, scenarios, and design concepts.

INFO-I 346 Prototyping and Evaluation (3 cr.) P: INFO-I 245 and I 246. This course emphasizes the iterative development of interaction design problems and possible solutions. It incorporates visual thinking, including sketching, storyboarding, map-making, and wireframing; and also paper, visual behavioral, minimum viable prototyping; and evaluation, including usability testing.

INFO-I 356 Globalization, Where We Fit In (3 cr.) Globalization, increasingly enabled by information technology, changes how we work, what we buy, and who we know. New digital technology touches people working eighty-hour weeks in China and others receiving free state-of-the-art drugs in Africa. Learn about the past, present and future of globalization from an information technology perspective, and what it means for you, your career, and your community.

INFO-I 360 Web Design (3 cr.) P: INFO-I 101. Hands-on introduction to the core standards required for professional front-end web design and development (HTML/CSS/Bootstrap). You will create websites, plus learn how web content and style work together, how to make professional choices about web graphics and layout, and how to analyze and critique a website's design and structure.

INFO-I 363 Visual Design for the Web (3 cr.) P: INFO-I 101. Active learning-based introduction to visual and graphic design. We will first learn how to evaluate design, take better photographs, select appropriate content, and edit and manipulate images. Then we will apply and

practice with these concepts to sketch, draw and illustrate digital design compositions and interfaces.

INFO-I 365 JavaScript (3 cr.) P: INFO-I 201 or CSCI-C 200 or CSCI-C 211 or CSCI-A 201 or COGS-Q 260 and INFO-I 360. Hands-on, project-based JavaScript programming course with a focus on creating interactive web interfaces. Goal is to integrate JavaScript with HTML, CSS and responsive web design techniques inorder to capture and respond, both visually and programmatically, to a variety of user interactions and data inputs, including APIs.

INFO-I 368 Introduction to Network Science (3 cr.) P: COGS-Q 260 or CSCI-A 201 or CSCI-C 200 or CSCI-C 211 or INFO-I 210. Friends, computers, the Web, and our brain are examples of networks that pervade our lives. Network science helps us understand complex patterns of connection, interaction, and relationships in many complex systems. Students learn essential concepts and core ideas of network literacy, and basic tools to handle social and information networks.

INFO-I 369 Performance Analytics (3 cr.) P: COGS-Q 260 or CSCI-A 201 or CSCI-C 200 or CSCI-C 211 or INFO-I 210. INFO-I 368 recommended. This course will review quantitative studies aimed at measuring, predicting and understanding performance in social competitive arenas, ranging from social media to financial markets, from professional sports to scientific and technological innovation.

INFO-I 370 Methods for HCC (3 cr.) At least junior standing or permission of instructor. UX/UI Design uses a variety of approaches for obtaining human-centered information and requirements for the design and development of systems and applications. The course surveys key methods, current and emergent, in the field of Human Computer Interaction and Interaction Design to prepare students for a career in IT.

INFO-I 371 Chemical Informatics I (1 cr.) Basic concepts of information representation, storage, and retrieval as they pertain to chemistry. An overview of the techniques that make modern chemical informatics systems work, including the coding techniques that form the basis for chemical information retrieval by structures, nomenclature, and molecular formulas, various methods of coding for visualization of chemical structures and chemical data, and algorithms and techniques used in the modern pharmaceutical industry to enhance reseach efforts.

INFO-I 372 Molecular Modeling (1 cr.) CHEM-C 341 recommended. Molecular modeling and computational chemistry; application of quantum mechanics and molecular mechanics to drive structural and energetic information about molecules; conformational analysis; quantitative structure activity relationships (QSAR) and related methods for drug design.

INFO-I 389 Serve IT Internship in Informatics (1-3 cr.) P: Department Approval. The Serve IT Internship offers students civic and professional working experience in an industry setting using skills acquired in informatics coursework to meet needs in the community through a service-learning experience. May be repeated for a maximum of 3 credit hours.

INFO-I 390 Undergraduate Independent Study (1-3 cr.) Department approval. Independent research based on existing literature or original work. A report, in the style of a departmental technical report, is required. May be repeated for a maximum of 6 credit hours.

INFO-I 391 Internship in Informatics Professional Practice (1-3 cr.) Department approval. Students gain professional work experience in an industry or research organization setting, using skills and knowledge acquired in informatics course work. May be repeated for a maximum of 3 credit hours.

INFO-I 399 Current Topics in Informatics (1-3 cr.) Variable topic course. Emphasis is on new developments and research in informatics. May be repeated once with a different topic.

INFO-I 400 Topics in Informatics (1-3 cr.) Variable topic. Emphasis is on new developments and research in informatics. May be repeated two times with different topics.

INFO-H 400 Topics in Informatics, Honors (1-3 cr.) Honors version of INFO-I 400. Variable topic. Emphasis is on development and research in informatics. May be repeated two times with different topics.

INFO-I 403 Mobile Human Computer Interaction and Design (3 cr.) This course takes a human-centered design approach to engage students in creating cutting edge mobile and wearable systems. Through a semester long project, students identify challenges/barriers/obstacles encountered by individuals and/or groups in their everyday lives and then design, prototype, and evaluate solutions to those challenges.

INFO-I 407 Introduction to Health Informatics (3 cr.) P: INFO-I 300. This is a combined advanced undergraduate and graduate course that provides an introduction to health informatics. By the end of the course, students will be able to describe and apply informatics methods that improve health and well being. Credit not given for both INFO-I 407 and H 407.

INFO-H 407 Introduction to Health Informatics, Honors (3 cr.) P: INFO-I 300. Honors version of INFO-I 407. This is a combined advanced undergraduate and graduate course that provides an introduction to health informatics. By the end of the course, student will be able to describe and apply informatics methods that improve health and well being. Credit not given for both INFO-H 407 and I 407.

INFO-I 411 Animal-Computer Interaction Methods (3 cr.) This courses introduces cutting-edge Animal-Computer Interaction methods with a focus on how they are used to enhance animal welfare, enrichment, husbandry, and cognitive research opportunities. It will also take a critical approach and consider key challenges relating to access, ethics, implementation, scale, and evaluation of ACI methods.

INFO-I 412 Direct Observation and Design (3 cr.) Research methods course focused on the skills of direct observation: the collection, analysis, and representation of observation-based data and it uses in user-centered design. Students carpool for classes held weekly at Indy

Zoo, observing orangutans. Credit not given for both INFO-I 412 and I 512.

INFO-I 413 Usable Artificial Intelligence (3 cr.) Proficiency in basic programming (Python, C, C++, Java, or equivalent) recommended. Building foundational skills in machine learning, natural language processing, and artificial intelligence for data collection, data analysis, data visualization, and decision-making.

INFO-I 414 Seminar on Tech for Animals (3 cr.) This exploratory seminar is an introduction to ACI. We will draw on faculty and student selected readings, multimedia materials, and guest lectures from current ACI practitioners to see what we think about the ethics, history, state-of-the art, and possible futures for this broad field of practice.

INFO-I 421 Applications of Data Mining (3 cr.) INFO-I 308 recommended. The course explores the use of data mining techniques in different settings, including business and scientific domains. The emphasis will be on using techniques instead of developing new techniques or algorithms. Students will select, prepare, visualize, analyze, and present data that leads to the discovery of novel and actionable information.

INFO-I 422 Data Visualization (3 cr.) From dashboards in a car to cutting-edge scientific papers, we extensively use visual representation of data. As our world becomes increasingly connected and digitized and as more decisions are being driven by data, data visualization is becoming a critical skill for every knowledge worker. In this course we will learn fundamentals of data visualization and create visualizations that can provide insights into complex datasets.

INFO-I 423 Big Data Applications and Analytics (3 cr.) The Big Data Applications & Analytics course is an overview course in Data Science and covers the applications and technologies (data analytics and clouds) needed to process the application data. It is organized around rallying cry: Use Clouds running Data Analytics Collaboratively processing Big Data to solve problems in X-Informatics. Credit given for only one of INFO-I 423, I 523, or ENGR-E 534.

INFO-I 424 Big Data Software and Projects (3 cr.) This course studies software HPC-ABDS used in either High Performance Computing or the open source commercial Big Data cloud computing. The student builds analysis systems using this software on clouds and then to use it on a project either chosen by student or selected from list given by instructor. Credit not given for both INFO-I 424 and I 524.

INFO-I 426 Informatics in Disasters and Emergency Response (3 cr.) This course teaches students the skills needed to design and deploy informatics technologies in emergency response and disaster situations, including practical applications. Specific areas include technology design, situational awareness, threat modeling, and data science. Credit not given for both INFO-I 426 and I 516.

INFO-I 427 Search Informatics (3 cr.) P: INFO-I 211. Techniques and tools to automatically crawl, parse, index, store, and search web information, organizing knowledge that can help meet the needs of organizations, communities and individual users. Social and business impact of search engine technology. As a project, students will build a real search engine and compare it with Google.

INFO-I 430 Security for Networked Systems (3 cr.) P: INFO-I 231 or CSCI-C 231. An extensive survey of network security. Covers threats to information confidentiality, integrity, and availability in different internet layers, and defense mechanisms that control these threats. Also provides a necessary foundation on network security, such as cryptographic, primitives/ protocols, authentication, authorization and access control technologies. Hands-on experiences through programming assignments and course projects. Credit given for only one of INFO-I 430, I 520, or CSCI-B 430.

INFO-I 433 Systems & Protocol Security & Information Assurance (3 cr.) P: CSCI-C 291 and (INFO-I 231 or CSCI-C 231). Covers the fundamentals of computer security by looking at how things can go wrong, how people can abuse the system, and ways to make the system secure. Students will gain a basic overview of existing security problems, and be introduced to methods for addressing such problems. Should be taken by anyone designing, selecting, or using applications in which security or privacy plays a role. Credit given for only one of INFO-I 433, I 533, or CSCI-B 433.

INFO-I 435 Management, Access, and Use of Big and Complex Data (3 cr.) Innovation today is emerging from a preponderance of data from sensors, social media, and the Internet. This course covers knowledge representation, data process, and data management for big and complex data. Specific topics include data integration, semantics, and provenance; workflows and pipelines; and distributed noSQL stores. Credit not given for both INFO-I 435 and I 535.

INFO-I 436 Technology Innovation (3 cr.) This course teaches students the process of innovation, specifically in respect to technological innovation. Students are required to ideate technological concepts given a set of constraints and an opportunity space. The focus of the course is on students inventing and implementing without considering the commercial potential of their innovations. Credit not given for both INFO-I 436 and I 566.

INFO-I 437 Design Strategy (3 cr.) Permission of instructor. The course requires students to apply "the" design process to better understand the factors affecting the success or failure of a design beyond the target audience and problem space in order to iterate on the design to propose solutions to avoid its failure, a process known as strategic design.

INFO-I 438 Technology Entrepreneurship (3 cr.) This course will teach students the importance of systems and design thinking as they relate to building and managing a startup holistically. Students will be required to take a business concept from inception to implementation, at least to the degree required to have a minimum viable product (MVP). Credit not given for both INFO-I 438 and I 568.

INFO-I 440 Human Robot Interaction (3 cr.) This course surveys the field of human-robot interaction (HRI), which involves understanding how people perceive and respond to robots and creating robots that interact naturally with people. We will discuss the design, evaluation and societal significance of interactive robots from a human-centered

perspective through readings, discussion and developing HRI prototypes. Credit given for only one of INFO-I 440, H 440 or I 540.

INFO-H 440 Human Robot Interaction, Honors (3 cr.) This course surveys the field of human-robot interaction (HRI), which involves understanding how people perceive and respond to robots and creating robots that interact naturally with people. We will discuss the design, evaluation and societal significance of interactive robots from a human-centered perspective through readings, discussion and developing HRI prototypes. Credit given for only one of INFO-I 440, H 440 or I 540.

INFO-I 441 Interaction Design Practice (3 cr.) INFO-I 300 recommended. Human-computer interaction design (HCID) describes the way a person or group accomplishes tasks with a computer—what the individual or group does and how the computer responds; what the computer does and how the individual or group responds. This course is organized around a collection of readings and three design projects applying human-computer interaction principles to the design, selection, and evaluation of interactive systems.

INFO-I 442 Creating Virtual Assets (3 cr.) P: INFO-I 304. This course will explore advanced techniques for creating virtual assets for virtual reality applications. Topics include 3D modeling, animation, motion capture, sound capture and editing, materials, textures, shaders, and scripting. Students will learn how to export assets to virtual reality, augmented reality, video, still images, and 3D printed objects.

INFO-I 443 Building Virtual Worlds (3 cr.) P: INFO-I 304. This course will explore advanced techniques for designing and building virtual reality worlds. Topics include rigged animation, spatial sound, keyframe and procedural animation, interactivity, intelligent cameras, advanced shaders, and particle systems. Students will develop proficiency with a variety of software tools, development methods, and creation techniques.

INFO-I 444 Artificial Life in Virtual Reality (3 cr.) P: INFO-I 304. This course will explore one powerful application of virtual reality: the study of life, evolution, and artificial intelligence. Students will learn the basic building blocks of biological intelligence, how to build virtual worlds for assessing artificial intelligence, and how to populate virtual worlds with intelligent and autonomous artificial agents.

INFO-I 453 Computer and Information Ethics (3 cr.) Ethical and professionalization issues that arise in the context of designing and using networked information technologies and information resources. Examines frameworks for making ethical decisions, emergent technologies and their ethical implications, information/computer professionalism. Topics include privacy, intellectual property, cybercrime, games, social justice, and codes of professional ethics.

INFO-I 468 Network Science Applications (3 cr.) P: COGS-Q 260 or CSCI-A 201 or CSCI-C 200 or CSCI-C 211 or INFO-I 210. Friends, computers, the Web, and our brain are examples of networks that pervade our lives. Network science helps us understand complex patterns of connection, interaction, and relationships in many complex systems. Students strengthen their understanding of essential concepts, learn networks analytic tools, use models and data from social, infrastructure, and information networks.

INFO-I 469 Collective Intelligence (3 cr.) This course examines the phenomenon of Collective Intelligence from a computational perspective, with theory and applications in the biological, cultural, and economic domains. We will, in particular, focus on the role of social media which is enabling collective intelligence applications at previously unimagined scales.

INFO-I 485 Bioinspired Computing (3 cr.) P: INFO-I 211 or CSCI-C 212. Biological organisms cope with the demands of their environments using solutions quite unlike the traditional human-engineered approaches to problem solving. Biological systems tend to be adaptive, reactive, and distributed. Bio-inspired computing is a field devoted to tackling complex problems using computational methods modeled after design principles encountered in nature. Credit not given for both INFO-I 485 and I 585.

INFO-I 486 Artificial Life (3 cr.) Artificial Life is a broad discipline encompassing the origins, modeling, and synthesis of natural and artificial living entities and systems. Artificial Intelligence, as a discipline, tries to model and understand intelligent systems and behavior, typically at the human level. Credit not given for both INFO-I 486 and I 586.

INFO-I 487 Introduction to Virtual Heritage (3 cr.) This course focuses on how digital technology can represent, restore, disseminate, and help with analysis of artifacts such as vases, furniture, sculpture, monuments, and buildings. Other topics covered include the history and methodologies of Virtual Heritage. Each semester a different case study will provide the focus for the course. Credit not given for both INFO-I 487 and I 587.

INFO-I 488 Advanced Topics in Virtual Heritage (3 cr.) This course teaches students how to create simulations of complex cultural heritage environments such as a room and its furnishings, a building, or a settlement. Also covered are the principles of restorations of art, technologies to disseminate 3D models, and the use of simulations as tools of scientific discovery. Credit not given for both INFO-I 488 and I 588.

INFO-I 489 Serve IT Capstone Internship Informatics (3-6 cr.) P: INFO-I 391 or I 389 (3 credits of one or the other). The Serve IT Capstone Internship offers students civic and professional working experience in an industry setting using skills acquired in informatics coursework to meet needs in the community through the development of a substantial project in a service-learning experience. May be repeated for a maximum of 6 credit hours.

INFO-I 490 Professional Practicum/Internship for Undergraduates (0 cr.) Department approval. Provides for participation in professional training and internship experience.

INFO-I 491 Capstone Project Internship (3-6 cr.) P: INFO-I 211 and I 308. Department approval. Students put their informatics education in practice through the development of a substantial project while working in a professional information technology environment. May be repeated for a maximum of 6 credit hours.

INFO-I 492 Senior Thesis (3 cr.) All required core courses must be completed. Department approval. The senior student prepares and presents a thesis: a substantial, typically multichapter paper based on a well-planned research or scholarly project, as determined by the student and a sponsoring faculty member.

INFO-I 493 Senior Thesis (3 cr.) P: INFO-I 492. Department approval. The senior student prepares and presents a thesis: a substantial, typically multichapter paper based on a well-planned research or scholarly project, as determined by the student and a sponsoring faculty member.

INFO-I 494 Design and Development of an Information System (3 cr.) P: P: (INFO-I 210 or INFO-H 210 or CSCI-C 200 or CSCI-H 200 or CSCI-C 211 or CSCI-H 211) and (INFO-I 211 or INFO-H 211 or CSCI-C 212 or CSCI-H 212) and (INFO-I 300 or INFO-H 300) and (INFO-I 308 or INFO-H 308) and INFO-Y 395 Students work on capstone projects in supervised teams. They select an appropriate project (preferably based on cognate) and then learn to develop a plan that leads to success. Teamwork, communication, and organizational skills are emphasized in a real-world-style environment. Credit not given for both INFO-I 494 and H 494.

INFO-H 494 Design and Development of an Information System, Honors (3 cr.) P: All required core courses must be completed. Honors version of INFO-I 494. Students work on capstone projects in supervised teams. They select an appropriate project (preferably based on cognate) and then learn to develop a plan that leads to success. Teamwork, communication, and organizational skills are emphasized in a real-world-style environment. Credit not given for both INFO-H 494 and I 494.

INFO-I 495 Design and Development of an Information System (3 cr.) P: INFO-I 494. Students work on capstone projects in supervised teams. They select an appropriate project (preferably based on cognate) and then learn to develop a plan that leads to success. Teamwork, communication, and organizational skills are emphasized in a real-world-style environment. Credit not given for both INFO-I 495 and H 495.

INFO-H 495 Design and Development of an Information System, Honors (3 cr.) P: INFO-I 494. Honors version of INFO-I 495. Students work on capstone projects in supervised teams. They select an appropriate project (preferably based on cognate) and then learn to develop a plan that leads to success. Teamwork, communication, and organizational skills are emphasized in a real-world-style environment. Credit not given for both INFO-H 495 and I 495.

INFO-H 498 Honors Seminar (1-3 cr.) Junior or senior major in INFO with GPA at least 3.3 or permission of instructor. A survey of faculty research in computer related fields with different professors discussing their research each week. May be repeated for a maximum of 6 credit hours.

INFO-I 499 Readings and Research in Informatics (1-3 cr.) Department approval. Independent readings and research related to a topic of special interest to the student. Written report required. May be repeated for a maximum of 6 credit hours for any combination of INFO-I 499 and H 499.

INFO-H 499 Readings and Research in Informatics, Honors (1-3 cr.) Department approval. Honors version of INFO-I 499. Independent readings and research related to a topic of special interest to the student. Written report required. May be repeated for a maximum of 6 credit hours for any combination of INFO-I 499 and H 499.

INFO-T 100 Topics in Informatics Technology (1-3 cr.) Variable topic. The course serves as an introduction to a specific information technology in a hands-on setting. Emphasis is on problem solving techniques using technology. Credit hours may not be applied toward satisfying major requirements in the School of Informatics, Computing, and Engineering. May be repeated up to three times with different topics for a maximum of 3 credit hours.

INFO-Y 395 Career Development for Informatics Majors (1 cr.) Helps students develop skills and knowledge to successfully pursue a career search, both at the time of graduation and as they progress through their careers. The course covers techniques and strategies to make the job search more efficient and effective. Offered as an eight week course. Credit given for only one of INFO-Y 395, CSCI-Y 395, or ENGR-Y 395.

LLLC-Y 101 Technology Leadership and Innovation I (1.5 cr.) P: Prerequisite: Must be a student in the Luddy School of Informatics, Computing, and Engineering. This course will focus on developing student leaders by providing resources and tools to empower them in setting goals, teamwork, communication, and decision-making skills. Students will have an opportunity to interact and develop relationships with School of Informatics and Computing faculty, staff, alumni, upper class students, and conduct research.

LLLC-Y 102 Technology Leadership and Innovation II (1.5 cr.) P: INFO-Y 101. The focus of this course will be on developing you as a professional and a future leader. Topics addressed will include professional identity development; working in a diverse team; leadership in a global/multinational workforce; the role of social media; and the process and development of professional mentor relationships.

SICE-Y 100 Exploring Tech Pathways (1 cr.) Technology is everywhere, and how it relates to the world today is very important to the future. This interactive course will offer students the opportunity to explore the many academic / career pathways available specifically through Luddy, as well as within the broader technology workforce, with a focus on self-reflection. Offered as an eight week course.

Information and Library Science

ILS-L 150 Information Sources in Telecommunications (1 cr.) Designed specifically for undergraduates who are premajors or majors in telecommunications and who are required to complete a research project or term paper. Training in use of computerized database systems, as well as selection and use of advanced reference sources. Graded on S/F basis.

ILS-L 161 Library Skills and Resources (1 cr.) Techniques and skills for researching term papers, speeches, and other library projects.

ILS-L 416 Individual in the Information Age (3 cr.) Focuses on emerging information and communication technologies, identifying political, social, and economic trends that have major impact on information sources and access. Students are encouraged to explore individual approaches to the information concepts and issues, understood in a social context.

ILS-Z 115 From James Bond To Zombie Apocalypse and NSA Leaks: Evaluating Information And Intelligence (3 cr.) Using the collection, assessment, analysis, and presentation skills of the intelligence community students will explore important, current policy issues including international relations, privacy, cyber security, war, and humanitarian issues. Students will become familiar with all basic intelligence functions such as the different types of INT: human intelligence, signals intelligence, etc. as well as counterintelligence, hacking, and encryption.

ILS-Z 221 Intelligence Analytics (3 cr.) Intelligence analysis takes information from different sources, considers its deficiencies and biases, combines it with historical, political, technical, social, ideological, economic, and religious knowledge, and uses analytic methods to create background and recommendations for decision makers. Analytic techniques involve qualitative methods used in business for project management and problem solving.

ILS-Z 311 Spy Tech for Non-Technical Spies (3 cr.) Information is collected by sensors and analyzed by computers for decision making. Satellites and drones are examples of platforms developed for gathering technical information. This course is designed for non-technical students to explore powerful reconnaissance and surveillance technologies as they are used for spying and for business and government functions.

ILS-Z 321 Introduction to Metadata (3 cr.) This course introduces students to principles underlying the development and implementation of metadata schemes and issues of interoperability, standardization, and evaluation of metadata schemes. The course provides extensive opportunities for hands-on application of metadata principles and practices in the development, implementation and evaluation of metadata records.

ILS-Z 331 Strategic Intelligence (3 cr.) This class introduces concepts and methods of identifying, collecting, analyzing, and presenting strategic intelligence from perspectives including competitive and strategic military intelligence, globalized crime, government policy, and natural disasters. We examine disruption, networks, systems theory, asymmetric warfare, organizational structure, and information warfare that have impacted modern strategy and strategic intelligence.

ILS-Z 341 Information Visualization (3 cr.) The visual representation of information requires a deep understanding of human perceptual and cognitive capabilities, computer graphics, interface and interaction design, and creativity. This course provides an overview of state-of-the-art information visualization. Students learn to produce effective temporal, geospatial, topical and network visualization, empowering them to render data into insights.

ILS-Z 351 Moles, Deception, and Counterintelligence (3 cr.) Counterintelligence involves disrupting adversaries' information flow or disseminating disinformation to make them act contrary to their interests. In this class, students explore concepts and techniques of counterintelligence. Assignments allow students to apply course content to real-world threats with a focus on U.S. perspectives in concise papers designed for busy decision-makers.

ILS-Z 362 Communication in Electronic Environments: Online Trolling (3 cr.) This course examines online trolling exploring why people engage in online deviant behaviors, and how others respond to and manage trolls. Conceptualizations and examples of trolling from scholarly literature, popular media, and online communities are critically examined. Assignments allow students to develop informed understandings about trolling and its social impacts.

ILS-Z 399 Topics in Information and Library Science (1-4 cr.) Study of specific topics in information and library science. May be repeated five times (24 credit hours) when topic varies.

ILS-Z 410 Social and Ethical Impacts of Big Data (3 cr.) This course introduces students to new social and ethical challenges arising from the use of data in a broad sense, and the technical and societal approaches to address such challenges. More specifically, this course provides a survey of the social, political, legal, and organizational issues that surround the creation, dissemination, and use of big data from the perspective of social informatics.

Specializations

Equivalent honors versions of regular courses may substitute for all requirements. Please see specific course descriptions, posted in respective bulletin, for prerequisites and other pertinent information.

Please add or change your specialization through SAMS.

Students must receive a minimum grade of C- in each specialization course.

- Biological and Health Data Science
- Data Science Design
- Data Systems
- Foundational Data Science
- Networks and Applied Data Analytics

Common Ground - General Education Requirements

In summer 2011, Indiana University Bloomington instituted a new campus-wide General Education Program. All IUB undergraduate students who matriculate in or after first summer session 2011 will be required to complete the campus-wide GenEd program prior to graduation. Some courses may overlap and satisfy the Common Ground General Education requirements as well as some additional Luddy General Education requirements needed to complete CSCIBS, DSCIBS, INFOBS, or ISENGRBS majors.

The Common Ground

GenEd requirements, course listings and information can be found in the General Education bulletin.

Basic Degree Requirements

Students must successfully complete a minimum of 120 credit hours (this excludes no credit courses) for the Bachelor of Science degree. Students must complete the specific degree requirements of the Luddy School of Informatics, Computing, and Engineering as follows:

- Students must have a minimum cumulative grade point average of 2.0 (C), excluding no credit courses. Any course taken to satisfy the major requirements must be completed with a minimum grade of C- unless otherwise specified and the grade point average of all courses taken in the major must be at least 2.0. The major requirements for data science include core courses, data science electives, math and science foundations courses and specialization area courses.
- Students must complete a minimum of 30 credit hours in courses at the 300-400 (junior-senior) level.
- Students must complete at least 12 credit hours of course work in the major field of study on the Bloomington campus.
- Students are expected to complete the requirements for their undergraduate degree within eight years of admission to Indiana University. Students are allowed to continue beyond this time period only at the discretion of the Student Services office.
- Courses that fulfill the requirements for a specialization area may also meet the general education distribution requirements.
- Specialization area courses cannot count as data science core courses or data science elective courses.

Luddy Degree and Major Requirements

**** Equivalent honors versions of regular courses may substitute for all requirements. Please see specific course descriptions, posted in respective bulletin, for prerequisites and other pertinent information. ****

The Luddy School of Informatics, Computing, and Engineering student SAMS enables students to check their academic degree information, add/drop minors, add/change specializations/cognates/concentrations and apply to graduate. Students are responsible for these actions.

Luddy Degree Requirements

Diversity in the United States (3 cr.)

This is a General Education shared goal required by all schools. Luddy students must check the listing of courses at CASE requirements for the College of Arts and Sciences. The course must be taken through the Indiana University Bloomington campus or an IU administered or IU co-sponsored Overseas Study program.

Intensive Writing (3 cr.)

One intensive writing course at the 200 level or above after completing the English composition requirement. Intensive writing courses at IUB are defined by the College of Arts and Sciences. Students must check the listings for courses at CASE requirements for the College of Arts and Sciences.

Intensive Writing credit will not be awarded for transfer courses and will not be awarded for written work in courses that are not listed as Intensive Writing unless special arrangements have been completed and approved prior to the relevant deadline. All special arrangements must be approved by the director of undergraduate studies in the respective division. The deadline for submitting a proposal to satisfy Intensive Writing by special arrangement is the end of the 2nd week of classes (for regular semester-length courses) and the end of the first week of classes for a summer session course.

Natural Sciences (10 cr.)

Courses may not double count between this requirement, math and science foundations, major, or specialization.

Course list located in the General Education bulletin OR the CASE requirements for the College of Arts and Sciences.

General Electives

Remaining credit hours may be used to fulfill minors or pursue personal interests. Students may obtain a maximum of three minors. A maximum of 4 combined HPER-E, SPH-I, SPH-O, and SPH-W credit hours and 10 MUS-X credit hours below the 100 level may be used in total hours.

Major Requirements

A major GPA of at least 2.000 for all courses taken in the major is required (all major course attempt grades are included).

A minimum grade of C- or higher is required for a course to fulfill a requirement in the major.

Students must complete the following:

Diversity and Ethics (3 cr.)

- ILS-Z 410 Social and Ethical Impacts of Big Data

Mathematics and Science Foundations (10 cr.)

- MATH-E 201 Linear Algebra for Data Science
- MATH-E 265 Probability for Data Science (new course)
- MATH-M 211 Calculus I

Programming and Discrete Structures (7 cr.)

- CSCI-C 200 Introduction to Computers and Programming or INFO-I 210 Information Infrastructure
- CSCI-C 241 Discrete Structures for Computer Science or INFO-I 201 Mathematical Foundations of Informatics

Core courses:

- CSCI-A 310 Problem Solving Using Data
- DSCI-D 321 Data Representation and Processing
- DSCI-D 351 Big Data Analytics
- INFO-I 123 Data Fluency
- STAT-S 350 Introduction to Statistical Inference

- STAT-S 352 Data Modeling and Inference

Capstone:

- DSCI-D 498 Data Science Capstone I
- DSCI-D 499 Data Science Capstone II

Specialization Area Courses

Students should, in consultation with their academic advisor, choose a specialization area before their junior year. Students must receive a minimum grade of C- in each course. Please consult the specialization section of this bulletin for the list of specialization areas.

Biological and Health Data Science

1. Select four courses from the following:
   - BIOL-L 388 Digital Biology
   - CSCI-B 363 Bioinformatics Algorithms
   - ENGR-E 340 Introduction to Computational Bioengineering
   - INFO-I 407 Introduction to Health Informatics
   - STAT-S 363 Data Analytics for Life Sciences (new course)
2. Select one course from the following:
   - CSCI-B 365 Introduction to Data Analysis and Mining
   - ENGR-E 483 Information Visualization
   - ENGR-E 484 Scientific Visualization
   - INFO-I 422 Data Visualization
   - STAT-S 470 Exploratory Data Analysis

Data Science Design

Select five courses from the following:

- ENGR-E 483 Information Visualization
- ENGR-E 484 Scientific Visualization
- INFO-I 345 Interaction Design Research
- INFO-I 346 Prototyping and Evaluation
- INFO-I 422 Data Visualization
- INFO-I 436 Technology Innovation
- INFO-I 437 Design Strategy
- INFO-I 438 Technology Entrepreneurship
- SOAD-C 381 Topical Issues in Collaborative Design

Data Systems

1. Must complete:
   - CSCI-B 461 Database Concepts
   - CSCI-C 291 SYSTEM PROG WITH C AND UNIX or ENGR-E 111 SOFTWARE SYSTEMS ENGINEERING
   - CSCI-C 335 COMPUTER STRUCTURES or ENGR-E 210 ENGINEERING CYBER-PHYSICAL SYSTEMS
2. Select two courses from the following:
   - CSCI-P 434 Distributed Systems
   - CSCI-P 465 SOFTWARE ENGINEERING FOR INFORMATION SYSTEMS I
   - ENGR-E 314 EMBEDDED SYSTEMS
   - ENGR-E 416 ENGINEERING CLOUD COMPUTING

Foundational Data Science

1. Select two courses from the following:
   - CSCI-B 365 Introduction to Data Analysis and Mining
   - CSCI-B 403 Introduction to Algorithm Design and Analysis
   - CSCI-B 455 Principles of Machine Learning
   - CSCI-B 457 Introduction to Computer Vision
   - CSCI-B 461 Database Concepts
   - CSCI-P 434 Distributed Systems
2. Select two courses from the following:
   - STAT-S 420 Introduction to Statistical Theory
   - STAT-S 425 Nonparametric Theory and Data Analysis
   - STAT-S 426 Bayesian Theory and Data Analysis
   - STAT-S 431 Applied Linear Models I
   - STAT-S 440 Multivariate Data Analysis
   - STAT-S 470 Exploratory Data Analysis
3. Select one additional course from the lists above

Networks and Applied Data Analytics

1. Must complete:
   - INFO-I 368 Introduction to Network Science
   - INFO-I 422 Data Visualization
2. Select one course from the following:
   - INFO-I 400 Topics in Informatics (Topic: Storytelling with Data)
   - INFO-I 421 Application of Data Mining
   - INFO-I 423 Big Data Applications and Analytics
   - INFO-I 427 Search Informatics
   - INFO-I 468 Advanced Network Science
   - STAT-S 470 Exploratory Data Analysis
3. Select one course from the following:
   - BUS-K 353 Business Analytics and Modeling
   - ILS-Z 221 Intelligence Analytics
   - INFO-I 369 Performance Analytics
   - INFO-I 407 Health Informatics
   - INFO-I 469 Collective Intelligence
4. Select one additional course from the lists above

BS in Data Science

- Common Ground - General Education Requirements
- Basic Requirements
- Luddy Degree and Major Requirements
- Specializations

Degree Programs

B.S. in Computer Science

B.S. in Data Science

B.S. in Informatics

B.S. in Intelligent Systems Engineering

B.A. in Computer Science (offered through the College of Arts and Sciences)

B.S. in Cybersecurity and Global Policy (offered through the Hamilton Lugar School of Global and International Studies)

Certificates and Minors

Concurrent/Sequential Baccalaureate Degrees

Game Development Specialization

- Must complete:
  - MSCH-C 210 Introduction to Games
  - MSCH-G 300 Game Production I
  - MSCH-G 310 Game Design I
- Must complete:
  - CSCI-B 453 Game Development
  - CSCI-C 292 Introduction to Game Programming
  - CSCI-C 460 Senior Project 1
  - CSCI-C 470 Senior Project II
- Select one course from the following:
  - CSCI-B 351 Introduction to Artificial Intelligence
  - CSCI-C 290 Topics in Computer Science (topic: Games and Puzzles)
- Select one course from the following:
  - CSCI-B 481 Interactive Graphics
  - CSCI-C 323 Mobile App Development
  - CSCI-P 438 Introduction to Computer Networks
  - CSCI-P 465 Software Engineering for Information Systems I
- Select one course from the following:
  - CSCI-B 401 Fundamentals of Computing Theory
  - CSCI-B 403 Introduction to Algorithm Design and Analysis
  - CSCI-B 461 Database Concepts

Software Engineering

1. CSCI-B 461 Database Concepts

2. CSCI-P 465 Software Engineering for Information Systems

3. Select one course from the following:

- CSCI-C 322 Object-Oriented Software Methods
- CSCI-P 466 Software Engineering for Information Systems II

4. Select one course from the following:

- CSCI-C 323 Mobile App Development
- CSCI-C 335 Computer Structures

5. Select one course from the following:

- CSCI-B 403 Introduction to Algorithm Design and Analysis
- CSCI-P 415 Introduction to Verification
- CSCI-P 423 Compilers
- CSCI-P 436 Introduction to Operating Systems

6. Select one additional P course

Bachelor of Science in Computer Science

- Common Ground - General Education Requirements
- Basic Requirements
- Luddy Degree and Major Requirements
- Specializations

Common Ground– General Education Requirements

In summer 2011, Indiana University Bloomington instituted a new campus-wide General Education Program. All IUB undergraduate students who matriculate in or after first summer session 2011 will be required to complete the campus-wide GenEd program prior to graduation.

Some courses may overlap and satisfy the Common Ground General Education requirements as well as some additional Luddy General Education requirements needed to complete CSCIBS, DSCIBS, INFOBS, or ISENGRBS majors.

The Common Ground

GenEd requirements, course listings and information can be found in the General Education bulletin.

Basic Degree Requirements

Students must successfully complete a minimum of 120 credit hours (this excludes no credit courses) for the Bachelor of Science degree. Students must complete the specific degree requirements of the Luddy School of Informatics, Computing, and Engineering as follows:

- Students must have a minimum cumulative grade point average of 2.0 (C), excluding no credit courses). Any course taken to satisfy the major requirements must be completed with a minimum grade of C- unless otherwise specified and the grade point average of all courses taken in the major must be at least 2.0. The major requirements for computer science include core courses, computer science electives, math courses and specialization area courses.
- Students must complete a minimum of 30 credit hours in courses at the 300-400 (junior-senior) level.
- Students must complete at least 12 credit hours of course work in the major field of study on the Bloomington campus.
- Students are expected to complete the requirements for their undergraduate degree within eight years of admission to Indiana University. Students are allowed to continue beyond this time period only at the discretion of the Student Services office.
- Courses that fulfill the requirements for a specialization area may also meet the general education distribution requirements.
- Specialization area courses cannot count as computer science core courses, required math courses or computer science elective courses.
- If specialization area courses are equivalent to computer science major course requirements, students should substitute an alternate course.

Luddy Degree and Major Requirements

**** Equivalent honors versions of regular courses may substitute for all requirements. Please see specific course descriptions, posted in respective bulletin, for prerequisites and other pertinent information. ****

The Luddy School of Informatics, Computing, and Engineering student database (SAMS) enables students to check their academic degree information, add/drop minors, add/change specializations/ cognates/concentrations and apply to graduate. Students are responsible for these actions.

Luddy Degree Requirements

Diversity in the United States (3 cr.)

This is a General Education shared goal required by each school. Luddy students much check the listings for courses at CASE requirements for the College of Arts and Sciences. The course must be taken through the Indiana University Bloomington campus or an IU administered or IU co-sponsored Overseas Study program.

Intensive Writing (3 cr.)

One intensive writing course at the 200 level or above after completing the English composition requirement. Intensive writing courses at IUB are defined by the College of Arts and Sciences. Students must check the listings for courses at CASE requirements for the College of Arts and Sciences.

Intensive Writing credit will not be awarded for transfer courses and will not be awarded for written work in courses that are not listed as Intensive Writing unless special arrangements have been completed and approved prior to the relevant deadline. All special arrangements must be approved by the director of undergraduate studies in the respective division. The deadline for submitting a proposal to satisfy Intensive Writing by special arrangement is the end of the 2nd week of classes (for regular semester-length courses) and the end of the first week of classes for a summer session course.

Natural Science (12 cr.)

Select twelve credit hours from the following:

- PSY-P 155 Introduction to Psychological and Brain Sciences
- PSY-P 211 Methods of Experimental Psychology
- COGS-Q 370 Experiments and Models in Cognition
- ASTRONOMY (any course)
- BIOLOGY (any course)
- CHEMISTRY (any course)
- EARTH AND ATMOSPHERIC SCIENCES (any course)
- PHYSICS (any course)
- BIOTECHNOLOGY (any course)
- MEDICAL SCIENCES (any course)
- PSY-P 300+ COURSES (such as neuroscience)
- MUS-A 111 Electronics I
- VSCI-V 250 The Miracle of Sight

General Electives

Remaining credit hours may be used to fulfill minors or pursue personal interests. Students may obtain a maximum of three minors. A maximum of 4 combined HPER-E, SPH-I, SPH-O, and SPH-W credit hours and 10 MUS-X credit hours below the 100 level may be used in total hours.

Major Requirements

A major GPA of at least 2.000 for all courses taken in the major is required (all major course attempt grades are included).

A minimum grade of C- or higher is required for a course to fulfill a requirement in the major.

12 hours in the major must be completed on the Bloomington campus.

Students must complete the following:

Core courses:

- CSCI-C 200 Introduction to Computers and Programming or CSCI-C 211 Introduction to Computer Science
- CSCI-C 212 Introduction to Software Systems
- CSCI-C 241 Discrete Structures for Computer Science
- CSCI-C 343 Data Structures
- CSCI-Y 395 Career Development for Computer Science Majors

One approved specialization (see specializations area in bulletin)

45 hours including Core courses and Specialization with the remaining courses drawn from the following list – at least 26 of the 45 hours must be at the 300 level or above.

- CSCI-A 290 Tools for Computing (maximum of 3 total credit hours)
- CSCI-B, C, H, and P courses numbered 200 and above
- CSCI-Y 390* Undergraduate Independent Study
- CSCI-Y 391* Undergraduate Independent System Development
- CSCI-Y 399* Project in Professional Practice
- CSCI-Y 499* Honors Research
- CSCI-H 498 Honors Seminar (at most 1 hour)
- ENGR-E 101 Innovation and Design (if completed before or concurrently with CSCI-C 212)
- ENGR-E 321 Advanced Cyber Physical Systems
- INFO-I 101 Introduction to Informatics (if completed before or concurrently with CSCI-C 212)
- INFO-I 494/INFO-I 495 Design and Development of an Information System - authorization required, please see advisor
- MATH-M 471 Numerical Analysis I
- MATH-M 472 Numerical Analysis II

* Only 6 total hours in these 4 courses

Mathematical Science Requirement:

If used in specialization area (excluding the Security specialization), it may not be used to satisfy this requirement.

- MATH-M 211 Calculus I (or equivalent proficiency)

Select two from the following:

- MATH-M 212 Calculus II
- MATH-M 3XX (all 300 level courses)
- MATH-M 4XX (all 400 level courses)
- MATH-T 336 Topics in Euclidean Geometry

- MATH-T 403 Modern Algebra for Secondary Teachers
- ECON-E 370 Statistical Analysis for Business and Economics
- PHIL-P 251 Intermediate Symbolic Logic
- STAT-S 350 Introduction to Statistical Inference
- STAT-S 352 Data Modeling and Inference

Specialization Area Courses

Students should, in consultation with their academic advisor, choose a specialization area before their junior year. Students must receive a minimum grade of C– in each course. Please consult the specialization section of this bulletin for the list of specialization areas.

Bachelor of Science in Computer Science with Honors

Students must satisfy the requirements for the B.S. in Computer Science degree and the following additional requirements:

- Overall GPA 3.3 or greater
- Computer Science major GPA 3.3 or greater
- Completion of at least 11 hours of CSCI Honors courses (can include CSCI-Y 499).
- At least 29 of the 45 hours required for the major completed at the 300 level or above

Specializations

**** Equivalent honors versions of regular courses may substitute for all requirements. Please see specific course descriptions, posted in respective bulletin, for prerequisites and other pertinent information. ****

Please add or change your specialization through SAMS.

Students must receive a minimum grade of C- in each specialization course.

- Artificial Intelligence
- Data Science
- Foundations
- Game Development
- Programming Languages
- Security
- Software Engineering
- Systems

Artificial Intelligence Specialization

1. Select two courses from the following:
   - CSCI-B 351 Introduction to Artificial Intelligence
   - CSCI-B 365 Introduction to Data Analysis and Mining
   - CSCI-B 455 Principles of Machine Learning
2. Select two courses from the following (if not used above):
   - CSCI-B 351 Introduction to Artificial Intelligence
   - CSCI-B 355 Autonomous Robotics
   - CSCI-B 363 Bioinformatics Algorithms
   - CSCI-B 365 Introduction to Data Analysis and Mining
   - CSCI-B 455 Principles of Machine Learning
   - CSCI-B 456 Image Processing
   - CSCI-B 457 Introduction to Computer Vision
   - STAT-S 350 Introduction to Statistical Inference
3. Select one course from the following:
   - CSCI-B 401 Fundamentals of Computing Theory
   - CSCI-B 403 Introduction to Algorithm Design and Analysis
   - CSCI-P 415 Introduction to Verification

Data Science Specialization

1. Must complete:
   - CSCI-B 403 Introduction to Algorithm Design and Analysis
   - CSCI-B 461 Database Concepts
2. Select one course from the following:
   - CSCI-B 365 Introduction to Data Analysis and Mining
   - CSCI-B 455 Principles of Machine Learning
3. Select one course from the following (if not used above):
   - CSCI-B 351 Introduction to Artificial Intelligence
   - CSCI-B 365 Introduction to Data Analysis and Mining
   - CSCI-B 455 Principles of Machine Learning
   - CSCI-C 311 Programming Languages
   - CSCI-P 434 Distibuted Systems
   - CSCI-P 462 Database Application Design and Implementation
4. Select one course from the following:
   - CSCI-B 401 Fundamentals of Computing Theory
   - CSCI-P 415 Introduction to Verification
   - STAT-S 350 Introduction to Statistical Inference

Foundations Specialization

1. CSCI-B 401 Fundamentals of Computing Theory
2. CSCI-B 403 Introduction to Algorithm Design and Analysis
3. Select one course from the following:
   - CSCI-P 415 Introduction to Verification
   - CSCI-B 461 Database Concepts
4. Select two courses from the following (if used in major math requirement, it may not be used to satisfy this requirement):
   - CSCI-C 311 Programming Languages
   - CSCI-B 455 Principles of Machine Learning
   - CSCI-B 504 Introduction to Cryptography **OR** MATH-M 453 Cryptography
   - MATH-M 301 Linear Algebra and Applications **OR** MATH-M 303 Linear Algebra for Undergraduates
   - MATH-M 365 Introduction to Probability and Statistics
   - MATH-M 471 Numerical Analysis I

Programming Languages Specialization

1. CSCI-C 311 Programming Languages

2. CSCI-P 423 Compilers
3. Select two courses from the following:
    - CSCI-B 441 Digital Design
    - CSCI-B 461 Database Concepts
    - CSCI-B 490 Seminar in Computer Science (approved topic)
    - CSCI-C 335 Computer Structures
    - CSCI-P 424 Advanced Functional Programming
    - CSCI-P 436 Introduction to Operating Systems
4. Select one course from the following:
    - CSCI-B 401 Fundamentals of Computing Theory
    - CSCI-B 403 Introduction to Algorithm Design and Analysis
    - CSCI-P 415 Introduction to Verification

Security Specialization

Math courses will also fulfill the Mathematical Science requirement in the major.

1. MATH-M 211 Calculus I
2. MATH-M 212 Calculus II **OR** MATH-M 213 Accelerated Calculus
3. MATH-M 301 Linear Algebra and Applications
4. MATH-M 365 Introduction to Probability and Statistics

Additional requirements:

1. CSCI-B 430 Security for Networked Systems
2. CSCI-B 433 Systems & Protocol Security & Information Assurance
3. CSCI-C 231 Introduction to Mathematics of Cybersecurity
4. CSCI-C 291 System Programming with C and Unix
5. CSCI-C 335 Computer Structures
6. CSCI-P 436 Introduction to Operating Systems
7. CSCI-P 438 Introduction to Computer Networks

Systems Specialization

1. CSCI-C 291 System Programming with C and Unix
2. CSCI-C 335 Computer Structures
3. Select one project course from the following:
    - CSCI-P 436 Introduction to Operating Systems
    - CSCI-P 438 Introduction to Computer Networks
    - CSCI-P 442 Digital Systems
    - CSCI-P 545 Embedded and Real-Time Systems
4. Select one additional systems course from the following (if not used above):
    - CSCI-P 434 Distributed Systems
    - CSCI-P 436 Introduction to Operating Systems
    - CSCI-P 438 Introduction to Computer Networks
    - CSCI-B 441 Digital Design
    - CSCI-P 442 Digital Systems
    - CSCI-B 443 Introduction to Computer Architecture
    - CSCI-B 490 Seminar in Computer Science (approved topic)
    - CSCI-P 545 Embedded and Real-Time Systems
5. Select one course from the following:
    - CSCI-B 401 Fundamentals of Computing Theory
    - CSCI-B 403 Introduction to Algorithm Design and Analysis
    - CSCI-P 415 Introduction to Verification

Web Design and Development Cognate

Required:

- INFO-I 360 Web Design

Select four courses from the following:

- INFO-I 363 Visual Design for the Web
- INFO-I 365 JavaScript
- INFO-I 389 Serve IT Internship in Informatics (3 total hurs)
- INFO-I 400 Topics in Informatics
    - Topic: Cross-Platform Mobile Programming
    - Topic: Mobile HCI Design

Virtual Reality

Required:

- INFO-I 304 Introduction to Virtual Reality
- INFO-I 442 Creating Virtual Assets
- INFO-I 443 Building Virtual Worlds
- INFO-I 444 Artificial Life in Virtual Reality

Select one course from one of the following skill set groups

Artificial Intelligence

- COGS-Q 320 Computation in the Cognitive and Information Sciences
- CSCI-B 351 Introduction to Artificial Intelligence
- CSCI-B 355 Autonomous Robotics
- INFO-I 216 Humans, Animals, and Artificial Intelligence
- INFO-I 413 Usable Artificial Intelligence
- INFO-I 440 Human Robot Interaction
- INFO-I 469 Collective Intelligence

Data Analytics

- ENGR-E 434 Big Data Applications
- ENGR-E 484 Scientific Visualization
- INFO-I 123 Data Fluency
- INFO-I 368 Introduction to Network Science
- INFO-I 369 Performance Analytics
- INFO-I 421 Applications of Data Mining
- INFO-I 422 Data Visualization
- INFO-I 423 Big Data Applications and Analytics
- INFO-I 424 Big Data Software and Projects
- INFO-I 427 Search Informatics
- INFO-I 435 Management, Access, and Use of Big and Complex Data
- INFO-I 468 Network Science Applications

Game Design

- CSCI-C 292 Introduction to Game Programming

- MSCH-G 310 Game Design I
- MSCH-G 320 Game Art and Sound

Mobile App Development

- CSCI-C 323 Mobile App Development
- INFO-I 342 Mobile Programming
- INFO-I 400 Topics in Informatics (topic: Cross-platform Mobile Programming)

Virtual Reality

- INFO-I 400 Topics in Informatics (topic: Applied Augmented Reality)
- INFO-I 400 Topics in Informatics (topic: Intro to Virtual Reality World Design & Culture)
- INFO-I 400 Topics in Informatcs (topic: VR Animation, Light, and Sound)

Animal-Computer Interaction

Required:

- ABEH-A 101 Introduction to Animal Behavior
- INFO-I 216 Humans, Animals, and Artificial Intelligence
- INFO-I 411 Animal-Computer Interaction Methods
- INFO-I 414 Seminar in Animal-Computer Interaction

Select one course from the following:

Animal Behavior, Cognition, and Conservation Management

- ABEH-A 400 Advanced Workshop in Animal Behavior
- BIOL-L 453 Sensory Ecology
- BIOL-Z 460 Animal Behavior
- COGS-Q 345 Animal Cognition
- GEOG-G 448 Capitalism and Nature
- INFO-I 400 Topics in Informatics
  - Topic: Technological Nature
- INFO-I 412 Direct Observation and Design
- SPEA-E 460 Wildlife Management

Artificial Intelligence and Data Analytics

- COGS-Q 351 Introduction to Artificial Intelligence and Computer Simulation
- CSCI-B 351 Introduction to Artificial Intelligence
- CSCI-B 355 Autonomous Robotics
- ENGR-E 434 Big Data Applications
- ENGR-E 483 Information Visualization
- ENGR-E 484 Scientific Visualization
- INFO-I 368 Introduction to Network Science
- INFO-I 413 Usable Artificial Intelligence
- INFO-I 422 Data Visualization

Augmented and Virtual Reality

- CSCI-B 453 Game Development
- INFO-I 304 Introduction to Virtual Reality
- INFO-I 442 Creating Virtual Assets
- INFO-I 443 Building Virtual Worlds
- INFO-I 444 Artificial Life in Virtual Reality

Geospatial Information System

- GEOG-G 336 Environmental Remote Sensing
- GEOG-G 436 Advanced Remote Sensing: Digital Image Processing
- GEOG-G 438 Advanced Geographic Information Systems
- GEOG-G 439 GIS and Environmental Analysis
- GEOG-G 478 Global Change, Food, and Farming Systems
- GEOG-G 488 Applied Spatial Statistics

IoT Systems and Physical Fabrication

- CSCI-P 442 Digital Systems
- ENGR-E 314 Embedded Systems
- ENGR-E 327 Automated Fabrication Machines
- INFO-I 341 Prototyping with Arduino Tools
- INFO-I 400 Topics in Informatics
  - Topic: Makerspace: Design & Fabrication
- INFO-I 440 Human Robot Interaction

Mobile App Development

- CSCI-C 323 Mobile App Development
- INFO-I 342 Mobile Programming
- INFO-I 400 Topics in Informatics
  - Topic: Cross-Platform Mobile Programming

Qualitative Methods and Design

- INFO-I 370 Methods for HCC
- INFO-I 426 Informatics in Disasters and Emergency Response
- INFO-I 440 Human-Robot Interaction

Technology Entrepreneurship

- INFO-I 436 Technology Innovation
- INFO-I 437 Design Strategy
- INFO-I 438 Technology Entrepreneurship

Web and Database Design

- CSCI-B 461 Database Concepts
- CSCI-P 462 Database Application Design and Implementation
- INFO-I 360 Web Design

Human-Computer Interaction/Design

Required:

- INFO-I 245 Interaction Design Thinking
- INFO-I 246 Use and Usability
- INFO-I 345 Interaction Design Research
- INFO-I 346 Prototyping and Evaluation

Select one course from the following:

- INFO-I 303 Organizational Informatics
- INFO-I 310 Multimedia Arts and Technology
- INFO-I 311 Application Development
- INFO-I 360 Web Design
- INFO-I 399 Current Topics in Informatics (3 hour approved topic)
- INFO-I 400 Topics in Informatics (3 hour approved topic)
- INFO-I 436 Technology Innovation
- INFO-I 437 Design Strategy
- INFO-I 438 Technology Entrepreneurship

- INFO-I 440 Human Robot Interaction
- INFO-I 4XX (HCI/D capstone, new course)

Media Cognate

Required (for all options):

MSCH-C 101 Media

Option 1: Media and Society

- MSCH-C 213 Introduction to Media and Society
  and
- Select three 300/400 level MSCH-F or MSCH-S courses

Option 2: Media Production

- MSCH-C 223 Introduction to Design and Production
- MSCH-C 228 Introduction to Production Techniques and Practices
  and
- Select two 300/400 level MSCH-P courses

Option 3: Game Design and Development

- MSCH-C 210 Introduction to Games
- MSCH-C 220 Game Technology
- MSCH-G 300 Game Production I
- MSCH-G 310 Game Design I
- MSCH-G 320 Game Art and Sound

Select one course from the following:

- MSCH-C 200 The Videogame Industry: Systems and Management
- MSCH-C 215 History of Videogames
- MSCH-G 440 Game Aesthetics

Option 4: Journalism and Digital Storytelling

- MSCH-C 223 Introduction to Design and Production
- MSCH-C 225 Reporting, Writing, and Editing
- MSCH-C 226 Visual Communication
- MSCH-C 228 Introduction to Production Techniques and Practices
  and
- Select one 300/400 level MSCH-J, MSCH-G, or MSCH-P courses

Bachelor of Science in Informatics

- Common Ground - General Education Requirements
- Basic Requirements
- Luddy Degree and Major Requirements
- Cognates

Common Ground - General Education Requirements

In summer 2011, Indiana University Bloomington instituted a new campus-wide General Education Program. All IUB undergraduate students who matriculate in or after first summer session 2011 will be required to complete the campus-wide GenEd program prior to graduation. Some courses may overlap and satisfy the Common Ground General Education requirements as well as some additional Luddy General Education requirements needed to complete CSCIBS, DSCIBS, INFOBS, or ISENGRBS majors.
Please be aware that some courses in the INFOBS major require a higher gpa to fulfill a requirement than the same course in the General Education requirement.

The Common Ground

GenEd requirements, course listings and information can be found in the General Education bulletin.

Basic Requirements

Students must successfully complete a minimum of 120 credit hours (this excludes no credit courses) for the Bachelor of Science degree. Students must complete the specific degree requirements of the Luddy School of Informatics, Computing, and Engineering as follows:

- Students must have a minimum cumulative grade point average of 2.0 (C), excluding no credit courses. Any course taken to satisfy the major requirements must be completed with a minimum grade of C- unless otherwise specified and the grade point average of all courses taken in the major must be at least 2.0. The major requirements for informatics include core courses, informatics electives and cognate area courses.
- Students must complete a minimum of 30 credit hours in courses at the 300-400 (junior-senior) level.
- Students must complete at least 12 credit hours of course work in the major field of study on the Bloomington campus.
- Students are expected to complete the requirements for their undergraduate degree within eight years of admission to Indiana University. Students are allowed to continue beyond this time period only at the discretion of the Student Services office.
- Courses that fulfill the requirements for a cognate area may also meet the general education distribution requirements.
- Cognate area courses cannot count as informatics core courses or informatics advanced/elective courses.

Luddy Degree and Major Requirements

**** Equivalent honors versions of regular courses may substitute for all requirements. Please see specific course descriptions, posted in respective bulletin, for prerequisites and other pertinent information. ****

The Luddy School of Informatics, Computing, and Engineering student SAMS enables students to check their academic degree information, add/drop minors, add/change specializations/cognates/concentrations and apply to graduate. Students are responsible for these actions.

Luddy Degree Requirements

Diversity in the United States (3 cr.)

This is a General Education shared goal required by all schools. Luddy students must check the listings for courses at CASE requirements for the College of Arts and Sciences. The course must be taken through the Indiana University Bloomington campus or an IU administered or IU co-sponsored Overseas Study program.

Intensive Writing (3 cr.)

One intensive writing course at the 200 level or above, with a minimum grade of C, after completing the English composition requirement. Intensive writing courses at IUB are defined by the College of Arts and Sciences. Students must check the listings for courses at CASE requirements for the College of Arts and Sciences.

Intensive Writing credit will not be awarded for transfer courses and will not be awarded for written work in courses that are not listed as Intensive Writing unless special arrangements have been completed and approved prior to the relevant deadline. All special arrangements must be approved by the director of undergraduate studies in the respective division. The deadline for submitting a proposal to satisfy Intensive Writing by special arrangement is the end of the 2nd week of classes (for regular semester-length courses) and the end of the first week of classes for a summer session course.

Statistics (3 cr.)

This course may not double count in the Natural and Mathematical Sciences requirement.

Select one of the following Statistics courses:

- ANTH-A 306 Anthropological Statistics
- CJUS-K 300 Techniques of Data Analysis
- ECON-E 370 Statistical Analysis for Business and Economics
- MATH-M 365 Introduction to Probability and Statistics
- POLS-Y 395 Quantitative Political Analysis
- PSY-K 300 Statistical Techniques
- PSY-K 310 Statistical Techniques
- SOC-S 371 Statistics in Sociology
- SPEA-K 300 Statistical Techniques
- SPH-Q 381 Introduction to Biostatistics
- STAT-K 310 Statistical Techniques
- STAT-S 300 Introduction to Applied Statistical Methods
- STAT-S 301 Applied Statistical Methods for Business
- STAT-S 350 Introduction to Statistical Inference

Ethics (3 cr.)

This course may not double count in the Arts and Humanities requirement.

Select one ethics course from the following.

- INFO-I 453 Computer and Information Ethics
- PHIL-P 141 Introduction to Ethical Theories and Problems
- PHIL-P 242 Applied Ethics
- PHIL-P 340 Classics in Ethics
- PHIL-P 342 Problems of Ethics
- REL-R 170 Religion, Ethics, and Public Life

Arts and Humanities (6 Cr.) Courses may not double count between this requirement, ethics, major, or cognate.

These courses may overlap with the Common Ground A&H. Course lists located at CASE requirements for the College of Arts and Sciences OR in the General Education bulletin.

Natural and Mathematical Sciences (3 cr.)

Courses may not double count between this requirement, math and statistics, major, or cognate.

One 3 hour course plus one 5 hour course OR three 3 hour courses of N&M, excluding INFO-I 101. **These courses may overlap with the Common Ground N&M**. Course lists located at CASE requirements for the College of Arts and Sciences OR in the General Education bulletin.

General Electives

Remaining credit hours may be used to fulfill minors or pursue personal interests. Students may obtain a maximum of three minors. A maximum of 4 combined HPER-E, SPH-I, SPH-O, and SPH-W credit hours and 10 MUS-X credit hours below the 100 level may be used in total hours.

Major Requirements

A major GPA of at least 2.000 for all courses taken in the major is required (all major course attempt grades are included).

A minimum grade of C- or higher (unless otherwise noted) is required for a course to fulfill a requirement in the major.

12 hours in the major must be completed on the Bloomington campus.

Required Informatics Core Courses

- INFO-I 101 Introduction to Informatics (must complete with a minimum grade of C)
- INFO-I 201 Mathematical Foundations of Informatics
- INFO-I 202 Social Informatics OR INFO-I 222 The Information Society
- INFO-I 210 Information Infrastructure I
- INFO-I 211 Information Infrastructure II
- INFO-I 300 Human-Computer Interaction Design and Programming - **Must be completed on the Indiana University Bloomington campus**
- INFO-I 308 Information Representation - **Must be completed on the Indiana University Bloomington campus**
- INFO-Y 395 Career Development for Informatics Majors **- Must be completed on the Indiana University Bloomington campus**

Advanced Informatics Courses

Advanced informatics courses may not double count as elective courses.

Select 6 credit hours from the following:

* If pursuing a Computer Science Cognate, five courses must be completed if substituting CSCI-C 211/C 212 for INFO-I 210/I 211 and CSCI-C 241 for INFO-I 201 in the major (one additional course for each CSCI course used in the major).

- INFO-I 301 Presentations for IT Professionals
- INFO-I 303 Organizational Informatics
- INFO-I 304 Introduction to Virtual Reality
- INFO-I 310 Multimedia Arts and Technology
- INFO-I 311 Application Development

- INFO-I 320 Distributed Systems and Collaborative Computing
- INFO-I 330 Legal and Social Informatics of Security
- INFO-I 341 Prototyping for Arduino Tools
- INFO-I 342 Mobile Programming
- INFO-I 345 Interaction Design Research
- INFO-I 346 Prototyping and Evaluation
- INFO-I 356 Globalization, Where We Fit In
- INFO-I 360 Web Design
- INFO-I 363 Visual Design for the Web
- INFO-I 365 JavaScript
- INFO-I 368 Introduction to Network Science
- INFO-I 369 Performance Analytics
- INFO-I 370 Methods for HCC
- INFO-I 390 Undergraduate Independent Study
- INFO-I 399 Current Topics in Informatics
- INFO-I 400 Topics in Informatics
- INFO-I 403 Mobile Human Computer Interaction and Design
- INFO-I 407 Introduction to Health Informatics
- INFO-I 411 Animal-Computer Interaction Methods
- INFO-I 412 Direct Observation and Design
- INFO-I 413 Usable Artificial Intelligence
- INFO-I 414 Seminar in Animal-Computer Interaction
- INFO-I 421 Applications of Data Mining
- INFO-I 422 Data Visualization
- INFO-I 423 Big Data Applications and Analytics
- INFO-I 424 Big Data Software and Projects
- INFO-I 426 Informatics in Disasters and Emergency Response
- INFO-I 427 Search Informatics
- INFO-I 430 Security for Networked Systems
- INFO-I 433 Systems & Protocol Security & Information Assurance
- INFO-I 435 Management, Access, and Use of Big and Complex Data
- INFO-I 436 Technology Innovation
- INFO-I 437 Design Strategy
- INFO-I 438 Technology Entrepreneurship
- INFO-I 440 Human Robot Interaction
- INFO-I 441 Interaction Design Practice
- INFO-I 442 Creating Virtual Assets
- INFO-I 443 Building Virtual Worlds
- INFO-I 444 Artificial Life in Virtual Reality
- INFO-I 453 Computer and Information Ethics
- INFO-I 468 Advanced Network Science
- INFO-I 469 Collective Intelligence
- INFO-I 485 Bioinspired Computing
- INFO-I 486 Artificial Life
- INFO-I 487 Introduction to Virtual Heritage
- INFO-I 488 Advanced Topics in Virtual Heritage
- INFO-I 499 (3 credit hour course)
- CSCI-B, C or P 300 level course
- CSCI-B, C or P 400 level course

Informatics Electives

Informatics elective courses may not double count as advanced informatics courses.

Courses listed below are subject to the successful completion of prerequisites or approval of the instructor.

Select 6 credit hours from the following:

- INFO-I 301 Presentations for IT Professionals
- INFO-I 303 Organizational Informatics
- INFO-I 304 Introduction to Virtual Reality
- INFO-I 310 Multimedia Arts and Technology
- INFO-I 311 Application Development
- INFO-I 320 Distributed Systems and Collaborative Computing
- INFO-I 330 Legal and Social Informatics of Security
- INFO-I 341 Prototyping for Arduino Tools
- INFO-I 342 Mobile Programming
- INFO-I 345 Interaction Design Research
- INFO-I 346 Prototyping and Evaluation
- INFO-I 356 Globalization, Where We Fit In
- INFO-I 360 Web Design
- INFO-I 363 Visual Design for the Web
- INFO-I 365 JavaScript
- INFO-I 368 Introduction to Network Science
- INFO-I 369 Performance Analytics
- INFO-I 370 Methods for HCC
- INFO-I 390 Undergraduate Independent Study
- INFO-I 399 Current Topics in Informatics
- INFO-I 400 Topics in Informatics
- INFO-I 403 Mobile Human Computer Interaction and Design
- INFO-I 407 Introduction to Health Informatics
- INFO-I 411 Animal-Computer Interaction Methods
- INFO-I 412 Direct Observation and Design
- INFO-I 413 Usable Artificial Intelligence
- INFO-I 414 Seminar in Animal-Computer Interaction
- INFO-I 421 Applications of Data Mining
- INFO-I 422 Data Visualization
- INFO-I 423 Big Data Applications and Analytics
- INFO-I 424 Big Data Software and Projects
- INFO-I 426 Informatics in Disasters and Emergency Response
- INFO-I 427 Search Informatics
- INFO-I 430 Security for Networked Systems
- INFO-I 433 Systems & Protocol Security & Information Assurance
- INFO-I 435 Management, Access, and Use of Big and Complex Data
- INFO-I 436 Technology Innovation
- INFO-I 437 Design Strategy
- INFO-I 438 Technology Entrepreneurship
- INFO-I 440 Human Robot Interaction
- INFO-I 441 Interaction Design Practice
- INFO-I 442 Creating Virtual Assets
- INFO-I 443 Building Virtual Worlds
- INFO-I 444 Artificial Life in Virtual Reality
- INFO-I 453 Computer and Information Ethics
- INFO-I 468 Advanced Network Science
- INFO-I 469 Collective Intelligence
- INFO-I 485 Bioinspired Computing
- INFO-I 486 Artificial Life
- INFO-I 487 Introduction to Virtual Heritage
- INFO-I 488 Advanced Topics in Virtual Heritage
- INFO-I 499 (3 credit hour course)
- BUS-K 303 Technology and Business Analysis
- BUS-S 302 Management Information Systems

- BUS-S 305 Technology Infrastructure
- BUS-S 307 Data Management
- BUS-S 308 Business Application Development
- BUS-S 310 Systems Analysis and Project Management
- BUS-S 433 Information Systems Security
- CJUS-P 300 Topics in Criminal Justice (Topic: Cyber Crime & Digital Evidence)
- COGS-Q 351 Introduction to Artificial Intelligence and Computer Simulation
- CSCI- Any course at the 300 or 400 level (3 credit hour course)
- MSCH-G 300 Game Production I
- MSCH-G 310 Game Design I: Concepts
- MSCH-G 400 Game Production II
- MSCH-G 410 Games Design II: Systems
- MSCH-G 420 Advanced Game Art I
- MSCH-G 430 Game Art II
- MSCH-G 450 Game Workshop I: Prototype
- MSCH-H 300 EPS Communications Law
- MSCH-J 300 Communications Law
- MSCH-J 360 Journalism Specialties (Topic: Esports Journalism)
- MSCH-J 448 Global Journalism: Issues and Research
- MSCH-L 322 Telecommunications Policymaking
- MSCH-L 425 Telecommunications Regulation
- MSCH-M 421 Economics of Communications Industries
- MSCH-P 351 Video Field and Post Production
- MSCH-P 353 Audio Production
- MSCH-P 354 Program Graphics and Animation
- MSCH-P 356 TV Studio Production
- MSCH-P 369 Sound Design
- MSCH-P 433 Video Documentary
- MSCH-P 434 Documentary Production
- MSCH-P 452 Topical Seminar in Design and Production (Topic: Advanced Video Game Design and Production)
- MSCH-P 454 DVD Authoring
- MSCH-T 427 International Telecommunications
- SOAD-S 310 Interactive Media
- SOC-S 339 The Sociology of Media
- SOC-S 377 Digital Society
- SPEA-V 369 Managing Information Technology

Capstone
Select one of the following capstone options for a total of 6 hours:

- INFO-I 494/I 495 Design and Development of an Information System - **Must be completed on the Indiana University Bloomington campus**
- INFO-I 491 Capstone Project Internship - **Must be enrolled through Indiana University Bloomington**
- INFO-I 489 Serve IT Capstone Internship Informatics - **Must be enrolled through Indiana University Bloomington**
- INFO-I 492/I 493 Senior Thesis - **Must be enrolled through Indiana University Bloomington**

Cognate Area Courses

Students should, in consultation with their academic advisor, choose a cognate area before their sophomore year. Students must receive a minimum grade of C- in each course and a cumulative GPA of 2.0 or higher in their cognate area. **Cognate area courses may not double count in any area except the Common Ground General Education requirements .** Please consult the cognate area of this bulletin for the list of cognate areas.

Cognates

**** Equivalent honors versions of regular courses may substitute for all requirements. Please see specific course descriptions, posted in respective bulletin, for prerequisites and other pertinent information. ****

Please add or change your cognate through SAMS.

A cognate GPA of at least 2.000 for all courses taken in the cognate is required (all cognate course attempt grades are included).

A minimum grade of C- or higher is required for a course to fulfill a requirement in the cognate.

Cognate area courses cannot also count as informatics core courses or informatics advanced/elective courses.

Note: Some cognates complete minor requirements. Please consult the bulletin of the minor's school for the specific requirements of the minor. Students are responsible for adding the minor to their degree record through the the Luddy School of Informatics, Computing, and Engineering student database.

- Animal-Computer Interaction
- Art and Design
- Biology
- Business
- Chemistry
- Cognitive Science
- Computer Science
- Economics
- Geography
- Human-Centered Computing
- Human-Computer Interaction/Design
- Linguistics
- Mathematics
- Media
- Medical Sciences
- Music
- Philosophy of Mind and Cognition
- Pre-Health Professions
- Psychology
- Public and Environmental Affairs
- Public Health
- Security
- Virtual Reality
- Web Design and Development

Biology Cognate

Option 1: Foundations

Required:

- BIOL-L 111 Foundations of Biology: Diversity, Evolution, and Ecology

- BIOL-L 112 Foundations of Biology: Biological Mechanisms
- BIOL-L 113 Biology Laboratory
- Select nine additional credit hours from the Biology Advanced Elective list

Option 2: Molecular, Genomics, and Bio-Technology

Required:

- BIOL-L 112 Foundations of Biology: Biological Mechanisms
- BIOL-L 211 Molecular Biology
- CHEM-C 101 Elementary Chemistry and CHEM-C 121 Elementary Chemistry Laboratory OR CHEM-C 103 Introduction to Chemical Principles
- CHEM-C 117 Principles of Chemistry and Biochemistry
- Select two additional courses (minimum 6 credit hours) from the Biology Advanced Elective list OR from the courses below:
    - BIOL-L 311 Genetics
    - BIOL-L 322 Writing Workshop in Biology
    - BIOT-T 322 Biotechnology Writing and Communication

Option 3: Microbiology

Required

- BIOL-L 112 Foundations of Biology: Biological Mechanisms
- BIOL-L 211 Molecular Biology
- BIOL-M 250 Microbiology
- BIOL-M 3/400 level course - 1 additional course
- CHEM-C 101 Elementary Chemistry and CHEM-C 121 Elementary Chemistry Laboratory OR CHEM-C 103 Introduction to Chemical Principles
- CHEM-C 117 Principles of Chemistry and Biochemistry

Business Cognate

Required (for both options):

- BUS-A 200 Foundations of Accounting (***recommended***) **OR** BUS-A 304 Financial Reporting and Analysis **OR** BUS-A 306 Management Accounting and Analysis
- BUS-K 201 The Computer in Business (minimum grade of C required)

Option 1: Business and Society

Select three courses from the following:

- BUS-F 300 Introduction to Financial Management
- BUS-G 300 Introduction to Managerial Economics and Strategy
- BUS-J 306 Strategic Management and Leadership
- BUS-L 201 Legal Environment of Business
    - *If you take BUS-L 20L as an elective, please see your advisor to submit an exception for it to count for this option*
- BUS-L 302 Sustainability Law and Policy
- BUS-M 300 Introduction to Marketing
- BUS-P 300 Introduction to Operations Management
- BUS-W 300 New Venture Management
- BUS-Z 302 Managing and Behavior in Organizations

Option 2: Business, Data, and Technology

Required:

- BUS-K 303 Technology and Business Analysis
- BUS-L 201 Legal Environment of Business

Select two courses from the following:

- BUS-K 315 Business Process Management
- BUS-K 360 VBA and Application Integration
- BUS-S 305 Technology Infrastructure
- BUS-S 307 Data Management

Chemistry Cognate

Required:

- CHEM-C 117 Principles of Chemistry and Biochemistry I
- CHEM-C 341 Organic Chemistry I Lectures
- CHEM-C 342 Organic Chemistry II Lectures

Select 6 credits from the following:

- CHEM-A 314 Biological and Environmental Chemical Analysis OR CHEM-C 318 Spectrochemistry and Separation
- CHEM-C 317 Equilibria and Electrochemistry
- CHEM-C 360 Introductory Physical Chemistry OR CHEM-C 361 Physical Chemistry of Bulk Matter
- CHEM-C 360 Introductory Physical Chemistry OR CHEM-C 362 Physical Chemistry of Molecules
- CHEM-C 430 Inorganic Chemistry
- CHEM-C 443 Organic Spectroscopy
- CHEM-C 460 Nuclear Chemistry
- CHEM-C 481 Physical Biochemistry
- CHEM-C 483 Biological Chemistry OR CHEM-C 484 Biomolecules and Catabolism
- CHEM-C 485 Biosynthesis Pathways and Control of Metabolism
- CHEM-N 331 Intermediate Inorganic Chemistry
- CHEM-N 337 Intermediate Inorganic Chemistry Laboratory

Cognitive Science Cognate

Required:

- COGS-Q 240 Philosophical Foundations of the Cognitive and Information Sciences
- COGS-Q 260 Programming for the Cognitive and Information Sciences
- COGS-Q 320 Computation in the Cognitive and Information Sciences
- COGS-Q 370 Experiments and Models in Cognition

Select one course from the following:

- COGS-Q 301 Brain and Cognition
- COGS-Q 351 Introduction to Artificial Intelligence and Computer Simulation
- COGS-Q 360 Autonomous Robotics

Computer Science Cognate

Four, instead of two, Advanced Informatics courses must be completed if substituting (CSCI-C 200 or C 211)/C 212 for INFO-I 210/I 211 in the major.

Required:

- CSCI-C 200 Introduction to Computers and Programming **OR** CSCI-C 211 Introduction to Computer Science
- CSCI-C 212 Introduction to Software Systems
- CSCI-C 241 Discrete Structures for Computer Science

Select one course from the following:

- CSCI-C 335 Computer Structures
- CSCI-C 343 Data Structures

Advanced Computer Science electives

- At lease five additional CSCI (B, C, P) credit hours at the 300/400 level. CSCI-Y 390 or Y 499 may be completed for a total of 3 credit hours.

Economics Cognate

Required:

- MATH-M 119 Brief Survey of Calculus I **OR** MATH-M 211 Calculus I
- ECON-E 251 Fundamentals of Economics I **OR** ECON-B 251 Fundamentals of Economics for Business I
- ECON-E 252 Fundamentals of Economics II **OR** ECON-B 252 Fundamentals of Economics for Business II
- ECON-E 321 Intermediate Microeconomic Theory

AND

Option 1: Economic and Game Theory

Select two courses from the following:

- ECON-E 327 Game Theory
- ECON-E 390 Undergraduate Seminar in Economics (topic: Networks)
- ECON-E 392 Seminar in Computational Methods and Econometrics (topic: Computational Methods in Macroeconomics)

Option 2: Quantitative

ECON-E 370 is a prerequisite for ECON-E 371 and E 471. Students pursuing this option should take ECON-E 370 as their STATS course requirement.

Select two courses from the following:

- ECON-E 371 Introduction to Applied Econometrics
- ECON-E 392 Seminar in Computational Methods and Econometrics (topic: Big Data)
- ECON-E 471 Econometric Theory and Practice I

Option 3: General

Select two courses from the following:

- 300/400 level ECON courses (excluding ECON-E 370, E 496 and X 373). At least one of these courses must be numbered above ECON-E 321.

Art and Design Cognate

Required (for all options):

- SOAD-A 101 Creative Core: Color **OR** SOAD-A 103 Creative Core: 3D Design
- SOAD-A 102 Creative Core: Drawing

Option 1: Digital Art

Required:

- SOAD-S 210 Digital Art: Survey and Practice

Select one of the following sequences:

- SOAD-S 310 Interactive Multimedia and SOAD-S 410 Advanced Multimedia
  OR
- SOAD-S 311 Video Art and SOAD-S 411 Digital Video
  OR
- SOAD-S 313 3D Computer Graphics and SOAD-S 413 Computer Graphical Environments

Select one of the following courses not used as part of the above sequence:

- SOAD-S 310 Interactive Multimedia
- SOAD-S 311 Video Art
- SOAD-S 313 3D Computer Graphics

Option 2: Graphic Design

Required:

- SOAD-S 250 Graphic Design I
- SOAD-S 351 Typography I
- SOAD-S 352 Production for the Graphic Designer
- SOAD-S 450 Graphic Design Problem Solving

Geography Cognate

Select one course from the following:

- GEOG-G 107 Physical Systems of the Environment
- GEOG-G 109 Weather and Climate
- GEOG-G 110 Human Geography in a Changing World
- GEOG-G 120 Regions of the World

Select four courses from the following:

- GEOG-G 237 Mapping our World: From Mercator to Mashups
- GEOG-G 250 Computing in the Geospatial Sciences
- GEOG-G 336 Environmental Remote Sensing
- GEOG-G 338 Geographic Information Science
- GEOG-G 436 Advanced Remote Sensing: Digital Image Processing
- GEOG-G 438 Advanced Geographic Information Science
- GEOG-G 488 Applied Spatial Statistics

Human-Centered Computing Cognate

Select 5 courses from the following:

- CSCI-A 216 Digital Multimedia Concepts and Technologies

- INFO-I 303 Organizational Informatics
- INFO-I 304 Introduction to Virtual Reality
- INFO-I 310 Multimedia Arts and Technology
- INFO-I 330 Legal and Social Informatics of Security
- INFO-I 341 Prototyping for Arduino Tools
- INFO-I 360 Web Design
- INFO-I 370 Methods for HCC
- INFO-I 399 Current Topics in Informatics (approved topic)
- INFO-I 400 Topics in Informatics (approved topic)
- INFO-I 407 Introduction to Health Informatics
- INFO-I 426 Informatics in Disasters and Emergency Response
- INFO-I 436 Technology Innovation
- INFO-I 437 Design Strategy
- INFO-I 438 Technology Entrepreneurship
- INFO-I 440 Human Robot Interaction
- INFO-I 441 Interaction Design Practice
- INFO-I 453 Computer and Information Ethics
- INFO-I 469 Collective Intelligence
- INFO-I 487 Introduction to Virtual Heritage
- INFO-I 488 Advanced Topics in Virtual Heritage

Linguistics Cognate

Required:

- LING-L 203 Introduction to Linguistic Analysis
- LING-L 306 Phonetics

Select two courses from the following:

- LING-L 307 Phonology
- LING-L 308 Morphology
- LING-L 310 Syntax
- LING-L 325 Semantics
- LING-L 431 Field Methods

Select one course from the following:

- LING-L 445 The Computer and Natural Language
- LING-L 485 Topics in Linguistics
- MATH-M 385 Mathematics from Language
- Any course from outside the Department of Linguistics with sufficient computational content, subject to approval by the Linguistics Undergraduate Advisor.

Mathematics Cognate

Required:

- MATH-M 211 Calculus I
- MATH-M 212 Calculus II

Select one course from the following:

- MATH-M 301 Linear Algebra and Applications
- MATH-M 303 Linear Algebra for Undergraduates

Select two courses from the following:

- MATH-M 343 Introduction to Differential Equations with Applications I
- MATH-M 344 Introduction to Differential Equations with Applications II
- MATH-M 353 Discrete Mathematics
- MATH-M 365 Introduction to Probability and Statistics
- MATH-M 371 Elementary Computational Methods
- MATH-M 447 Mathematical Models and Applications I
- MATH-M 453 Cryptography

Medical Sciences Cognate

Required:

- ANAT-A 215 Basic Human Anatomy
- PHSL-P 215 Basic Human Physiology

Select six credit hours from the following:

- ANAT-A 464 Human Tissue Biology
- ANAT-A 480 Human Anatomy for Medical Imaging Evaluation
- MSCI-M 131 Disease and the Human Body **OR** MSCI-M 216 Medical Science of Psychoactive Drugs
- MSCI-M 300 Topics in Medical Sciences
- MSCI-M 360 Introduction to Pathophysiology
- MSCI-M 450 Undergraduate Research in Biomedical Sciences
- MSCI-M 470 Mechanisms of Human Disease
- MSCI-M 480 Molecular Biology of Cancer: Cell Signaling and Fate
- MSCI-M 485 Physiology of Human Disease
- MSCI-M 490 Special Topics in Biomedical Sciences
- PHSL-P 416 Comparative Animal Physiology
- PHYS-P 314 Introduction to Medical Physics

Music Cognate

Select two courses from the following:

- MUS-A 100 Foundations of Audio Technology
- MUS-A 330 Modern Recording Studion Techniques
- MUS-T 109 Rudiments of Music I
- MUS-Z 120 Music in Multimedia
- MUS-Z course at 300/400 level

Select one of the following sequences:

- MUS-Z 111 Introduction to Music Theory and MUS-Z 211 Music Theory II
  OR
- MUS-T 151 Music Theory and Literature I and MUS-T 152 Music Theory and Literature II

Required:

- MUS-Z 361 Introduction to MIDI and Computer Music

Philosophy of Mind and Cognition Cognate

Required:

- PHIL-P 360 Introduction to Philosophy of Mind
- COGS-Q 240 Philosophical Foundations of the Cognitive and Information Sciences

Select one course from the following:

- PHIL-P 250 Introductory Symbolic Logic
- PHIL-P 251 Intermediate Symbolic Logic
- PHIL-P 352 Logic and Philosophy

Select two courses from the following:

- PHIL-P 211 Early Modern Philosophy
- PHIL-P 310 Topics in Metaphysics
- PHIL-P 312 Topics in the Theory of Knowledge
- PHIL-P 320 Philosophy of Language
- PHIL-P 366 Philosophy of Action

Pre-Health Professions Cognate

Required:

- BIOL-L 112 Foundations of Biology: Biological Mechanisms
- CHEM-C 117 Principles of Chemistry and Biochemistry I
- CHEM-C 127 Principles of Chemistry and Biochemistry I Lab

Select seven or more credit hours from the following:

- ANAT-A 215 Basic Human Anatomy
- BIOL-L 113 Biology Laboratory
- BIOL-L 211 Molecular Biology
- CHEM-C 341 Organic Chemistry I Lectures
- CHEM-C 342 Organic Chemistry II Lectures
- CHEM-C 343 Organic Chemistry I Laboratory
- CHEM-N 331 Intermediate Inorganic Chemistry
- CHEM-N 337 Intermediate Inorganic Chemistry Laboratory
- PHSL-P 215 Basic Human Physiology
- PHYS-P 201 General Physics I **OR** PHYS-P 221 Physics I

Psychology Cognate

Required:

Select one course (or sequence) from the following:

- PSY-P 101 Introductory Psychology I and PSY-P 102 Introductory Psychology II
- PSY-P 155 Introduction to Psychological and Brain Sciences

Select four courses from the following:

- PSY-P 325 Psychology of Learning
- PSY-P 329 Sensation and Perception
- PSY-P 330 Perception/Action
- PSY-P 335 Cognitive Psychology
- PSY-P 346 Neuroscience
- PSY-P 349 Cognitive Neuroscience
- PSY-P 350 Human Factors/Ergonomics
- PSY-P 404 Computer and Statistical Models in Psychology
- PSY-P 411 Neural Bases of Learning and Memory
- PSY-P 453 Decision-making and the Brain
- PSY-P 457 Topics in Psychology
  - Topic: Implementing Computer Controlled Behavioral Exp in Psychological Science
  - Topic: Network Science in Cognitive and Psychological Science
  - Topic: Neural Language of Music Perception
  - Topic: Speech Perception and Spoken Word Recognition
  - Topic: The Connected Brain
- PSY-P 461 Human Memory

Public and Environmental Affairs Cognates

Option 1: Environmental Management Cognate

Required:

- SPEA-E 183 Environment and People
- SPEA-E 272 Introduction to Environmental Sciences
- SPEA-E 363 Environmental Management

Select one course from the following:

- INFO-I 400 Topics in Informatics (Topic: Environmental Pol Health Design)
- SPEA-E 340 Environmental Economics and Finance
- SPEA-E 476 Environmental Law and Regulation
- SPEA-V 424 Environmental Law, Justice and Politics

Select two courses from the following:

- INFO-I 400 Topics in Informatics (Topic: Environmental Pol Health Design) if not used above
- SPEA-E 355 Introduction to Limnology
- SPEA-E 410 Introduction to Environmental Toxicology
- SPEA-E 412 Risk Communication
- SPEA-E 422 Urban Forest Management
- SPEA-E 431 Water Supply and Wastewater Treatment
- SPEA-E 440 Wetlands Ecology and Management
- SPEA-E 451 Air Pollution and Control
- SPEA-E 452 Solid and Hazardous Waste Management
- SPEA-E 456 Lake and Watershed Management
- SPEA-E 457 Introduction to Conservation Biology
- SPEA-E 460 Fisheries and Wildlife Management
- SPEA-E 461 Fisheries and Wildlife Management Laboratory

Option 2: Healthcare Management and Policy Cognate

Required:

- SPEA-H 124 Overview of the U.S. Healthcare System
- SPEA-V 373 Human Resource Management in the Public Sector

Select three courses from the following:

- SPEA-E 324 Controversies in Environmental Health
- SPEA-H 350 Fundamentals of Healthcare Financial Management
- SPEA-H 401 Strategic Planning in Health Organizations
- SPEA-H 402 Hospital Administration
- SPEA-H 403 Pharmaceutical Industry and Public Policy
- SPEA-H 411 Chronic and Long-Term Care Administration
- SPEA-H 432 Health Care Marketing
- SPEA-H 455 Topics in Public Health

Option 3: Policy Analysis Cognate

Required:

- SPEA-V 181 US Policy and Administration

- SPEA-V 182 Policy-making Around the World: Comparative and International Approaches

Select three courses from the following:

- SPEA-V 348 Management Science
- SPEA-V 370 Research Methods and Statistical Modeling
- SPEA-V 379 Performance Measurement and Program Evaluation
- SPEA-V 386 Case Studies for Policy Analysis
- SPEA-V 401 Financial and Cost-Benefit Analysis
- SPEA-V 449 Senior Policy Seminar

Option 4: Public Financial Management Cognate

Required:

- SPEA-V 186 Introduction to Public Budgeting and Finance
- SPEA-V 246 Elements of Governmental and Nonprofit Financial Accounting Cycle
- SPEA-V 346 Introduction to Government Accounting and Financial Reporting
- SPEA-V 361 Financial Management

Select one course from the following:

- SPEA-V 371 Financing Public Affairs
- SPEA-V 374 Intermediate Public Budgeting and Finance for Public Affairs
- SPEA-V 401 Financial and Cost-Benefit Analysis
- SPEA-V 439 Debates in Public Finance

Option 5: Urban Planning and Community Development Cognate

Required:

- SPEA-V 161 Urban Problems and Solutions
- SPEA-V 365 Urban Development and Planning
- SPEA-V 462 Community Development

Select two courses from the following:

- SPEA-A 241 Community Engagement in the Arts
- SPEA-V 236 Managing and Leading Organizations
- SPEA-V 340 Urban Government Administration
- SPEA-V 412 Leadership and Ethics
- SPEA-V 421 Metropolitan Development

Public Health Cognate

Option 1: Public Health

Required:

- SPH-B 150 Introduction to Public Health
- SPH-B 366 Community Health
- SPH-B 403 Public Health Program Planning
- SPH-E 311 Human Disease and Epidemiology

Select one course from the following:

- INFO-I 400 Topics in Informatics (Topic: Environmental Pol Health Design)
- SPH-B 310 Health Care in Diverse Communities
- SPH-B 354 Multidisciplinary Perspectives on Gerontology
- SPH-F 150 Introduction to Life Span Human Development
- SPH-F 255 Human Sexuality
- SPH-F 258 Marriage and Family Interaction
- SPH-H 172 International Health and Social Issues
- SPH-H 174 Prevention of Violence in American Society
- SPH-H 180 Stress Prevention and Management
- SPH-H 220 Death and Dying
- SPH-H 263 Personal Health
- SPH-H 305 Women's Health
- SPH-H 306 Men's Health
- SPH-H 315 Consumer Health
- SPH-H 318 Drug Use in American Society
- SPH-H 320 The Nature of Cancer
- SPH-H 326 AIDS and Other Sexually Transmitted Diseases
- SPH-H 334 Heart Health and Diabetes
- SPH-H 351 Complementary and Alternative Approaches to Health
- SPH-H 381 Introduction to Health Information and Statistics
- SPH-H 418 The Nature of Addiction
- SPH-H 464 Coordinated School Health Programs
- SPH-N 220 Nutrition for Health
- SPH-N 231 Human Nutrition
- SPH-N 331 Life Cycle Nutrition
- SPH-N 336 Community Nutrition
- SPH-V 241 Foundations of Environmental Health

Option 2: Epidemiology

Required:

- SPH-E 311 Introduction to Epidemiology
- SPH-Q 381 Introduction to Biostatistics

Select three courses from the following:

- SPH-E 250 Public Health Surveillance and Monitoring
- SPH-E 350 Infectious Diseases: Outbreaks and Field Investigations
- SPH-E 353 Distribution and Determinants of Chronic Diseases
- SPH-E 358 Epidemiologic Methods: Concepts
- SPH-E 359 Epidemiologic Methods: Applications
- SPH-Q 400 Introduction to Biostatistical Computing

Option 3: Sport Marketing and Management

Required:

- SPH-M 211 Introduction to Sport Management
- SPH-M 318 Managing the Sport Enterprise
- SPH-M 418 Sport Marketing

Select two courses from the following:

- SPH-C 213 Introduction to Sport Communication
- SPH-C 329 Issues in Sport Communication
- SPH-M 304 Sport Industry Studies
- SPH-M 328 Issues in Intercollegiate Athletics
- SPH-M 333 Sport in America: Historical Perspectives
- SPH-M 382 Sport in American Society
- SPH-M 404 Colloquium in Sport Management
- SPH-M 411 Legal Issues in Sport Settings
- SPH-M 415 Sport Promotions and Public Relations
- SPH-M 423 Financial Principles in Sport
- SPH-M 426 Sales Management in Sport

- SPH-M 428 Strategic Management in the Sport Industry

Security Cognate

Required:

- CSCI-C 291 System Programming with C and Unix
- INFO-I 130 Introduction to Cybersecurity
- INFO-I 230 Analytical Foundations of Security
- INFO-I 231/CSCI-C 231 Introduction to the Mathematics of Cybersecurity
- INFO-I 430/CSCI-B 430 Security for Networked Systems
- INFO-I 433/CSCI-B 433 Systems & Protocol Security & Information Assurance

Select one course from the following:

- BUS-S 433 Information Systems Security
- INFO-I 330 Legal and Social Informatics of Security
- INFO-I 399 Current Topics in Informatics (approved topic)
- INFO-I 400 Topics in Informatics (approved topic)
- INFO-I 453 Computer and Information Ethics

Computer Engineering/Cyber-Physical Systems Concentration

Required:

- ENGR-E 210 Engineering Cyber-Physical Systems
- ENGR-E 222 Intelligent Systems I
- ENGR-E 312 Modern Computer Architecture **OR** ENGR-E 321 Advanced Cyber-Physical Systems
- ENGR-E 315 Digital Design with FPGAs
- MATH-M 301 Linear Algebra and Applications **OR** MATH-M 303 Linear Algebra for Undergraduates
  - **OR** any math or science course by approval
- MATH-M 343 Introduction to Differential Equations with Applications I

Select five courses from the following:

- ENGR-E 311 Circuits and Digital Systems
- ENGR-E 312 Modern Computer Architecture **OR** ENGR-E 321 Advanced Cyber-Physical Systems (if not used in above requirement)
- ENGR-E 313 Engineering Compilers
- ENGR-E 314 Embedded Systems
- ENGR-E 317 High Performance Computing
- ENGR-E 318 Engineering Networks
- ENGR-E 319 Engineering Operating Systems
- ENGR-E 327 Automated Fabrication Machines
- ENGR-E 399 Topics in Intelligent Systems Engineering (approved topic)
- ENGR-E 345 Wearable Sensors
- ENGR-E 416 Engineering Cloud Computing
- ENGR-E 434 Big Data Applications
- ENGR-E 435 Image Processing

Select two additional courses from the following:

- Any ISE course not already used in major or concentration
- Any math or science course by approval

Bachelor of Science in Intelligent Systems Engineering

- Common Ground - General Education Requirements
- Basic Requirements
- Luddy Degree and Major Requirements
- Concentrations

Common Ground - General Education Requirements

In summer 2011, Indiana University Bloomington instituted a new campus-wide General Education Program. All IUB undergraduate students who matriculate in or after first summer session 2011 will be required to complete the campus-wide GenEd program prior to graduation. Some courses may overlap and satisfy the Common Ground General Education requirements as well as some additional Luddy General Education requirements needed to complete CSCIBS, DSCIBS, INFOBS, or ISENGRBS majors.

The Common Ground

GenEd requirements, course listings and information can be found in the General Education bulletin.

Basic Degree Requirements

Please see criteria for applying for the ISE major in the Admissions area of this bulletin.

Students must successfully complete a minimum of 120 credit hours (this excludes no credit courses) for the Bachelor of Science degree. Students must complete the specific degree requirements of the Luddy School of Informatics, Computing, and Engineering as follows:

- Students must have a minimum cumulative grade point average of 2.0 (C), excluding no credit courses. Any course taken to satisfy the major requirements must be completed with a minimum grade of C- unless otherwise specified and the grade point average of all courses taken in the major must be at least 2.0. The major requirements for intelligent systems engineering include math and science foundation courses, engineering core courses, engineering electives, and concentration courses.
- Students must complete a minimum of 30 credit hours in courses at the 300-400 (junior-senior) level.
- Students must complete at least 12 credit hours of course work in the major field of study on the Bloomington campus.
- Students are expected to complete the requirements for their undergraduate degree within eight years of admission to Indiana University. Students are allowed to continue beyond this time period only at the discretion of the Student Services office.
- Courses that fulfill the requirements for a concentration area may also meet the general education distribution requirements.
- Concentration area courses cannot count as engineering core courses, required math courses, or engineering elective courses.
- If concentration area courses are equivalent to intelligent systems major course requirements, student should substitute an alternate course.

Luddy Degree and Major Requirements

**** Equivalent honors versions of regular courses may substitute for all requirements. Please see specific course descriptions, posted in respective bulletin, for prerequisites and other pertinent information. ****

The Luddy School of Informatics, Computing, and Engineering student SAMS enables students to check their academic degree information, add/drop minors, add/change specializations/cognates/concentrations and apply to graduate. Students are responsible for these actions.

Luddy Degree Requirements

Diversity in the United States (3 cr.)

This is a General Education shared goal required by all schools. Luddy students must check the listings for courses at CASE requirements for the College of Arts and Sciences. The course must be taken through the Indiana University Bloomington campus or an IU administered or IU co-sponsored Overseas Study program.

Major Requirements

A major GPA of at least 2.000 for all courses taken in the major is required (all major course attempt grades are included).

A minimum grade of C- or higher is required for a course to fulfill a requirement in the major.

12 hours in the major must be completed on the Bloomington campus.

Students must complete the following:

Natural and Mathematical Sciences

Must complete:

- MATH-M 211 Calculus I
- MATH-M 212 Calculus II
- PHYS-P 221 Physics I
- PHYS-P 222 Physics II

Select 1 course from the following:

- MATH-M 365 Introduction to Probability and Statistics
- STAT-S 350 Introduction to Statistical Inference
- 300 level statistics equivalent with approval of DUGS

Core courses

Must complete:

- ENGR-E 101 Innovation and Design
- ENGR-E 110 Engineering Computing Architectures
- ENGR-E 111 Software Systems Engineering
- ENGR-E 201 Computer Systems Engineering
- ENGR-E 221 Intelligent Systems I
- ENGR-E 225 Introduction to Circuits
- ENGR-E 250 Systems, Signals, and Control
- ENGR-E 299 Engineering Professionalization and Ethics
- ENGR-E 332 Introduction to Modeling and Simulation
- ENGR-Y 395 Career Development for ISE Majors
- MATH-E 449 Advanced Undergraduate Engineering Mathematical Methods

Each semester Undergraduate Research or Internship will be available.

Capstone

Must complete:

- ENGR-E 490 Engineering Capstone Design I
- ENGR-E 491 Engineering Capstone Design II

Concentration Area Courses

Students should, in consultation with their academic advisor, choose a concentration area. Students must receive a minimum grade of C– in each course. Please consult the concentration area section of this bulletin for the list of concentration areas.

Students may use up to 12 hours of graduate level coursework to count towards their undergraduate degree.

Concentrations

Please add or change your concentration through SAMS.

Students must receive a minimum grade of C– in each concentration area course.

- Bioengineering
- Computer Engineering/Cyber-Physical Systems
- Nanoscale Systems Engineering

Bioengineering Concentration

Required:

- BIOL-L 112 Foundations of Biology: Biological Mechanisms
- BIOL-L 211 Molecular Biology **OR** other approved science course with approval of DUGS
- BIOL-L 312 Cell Biology **OR** other approved science course with approval of DUGS
- CHEM-C 117 Principles of Chemistry and Biochemistry I
- ENGR-E 210 Engineering Cyber-Physical Systems **OR** ENGR-E 222 Intelligent Systems
- MATH-M 343 Introduction to Differential Equations with Applications I

Select 6 courses from the following:

- BIOT-T 310 Biotechnology Lecture
- BIOT-T 315 Biotechnology Laboratory
- CHEM-C 341 Organic Chemistry I Lectures
- ENGR-E 304 Introduction to Bioengineering
- ENGR-E 399 Topics in Intelligent Systems Engineering (approved topic)
- ENGR-E 340 Introduction to Computational Bioengineering
- ENGR-E 345 Wearable Sensors
- ENGR-E 435 Image Processing
- ENGR-E 441 Simulating Cancer as an Intelligent System
- ENGR-E 443 Computation Modeling Methods for Virtual Tissues
- ENGR-E 448 Computational Multicellular Systems Biology
- ENGR-E 470 Advanced Bioengineering
- ENGR-E 471 Microfluidic Devices and Systems

- ENGR-E 472 Biomedical Devices and Sensors

Select 2 courses from the following:

- Any ISE course not already used in major or concentration
- Any science or math course with approval of DUGS

Nanoscale Systems Engineering Concentration

Required:

- CHEM-C 117 Principles of Chemistry and Biochemistry I
- CHEM-C 361 Physical Chemistry of Bulk Matter
- ENGR-E 210 Engineering Cyber-Physical Systems **OR** ENGR-E 222 Intelligent Systems
- MATH-M 311 Calculus III
- MATH-M 312 Calculus IV **OR** MATH-M 301 Linear Algebra and Applications **OR** MATH-M 303 Linear Algebra for Undergraduates
- PHYS-P 301 Physics III
- PHYS-P 331 Theory of Electricity and Magnetism I

Select 5 courses from the following:

- CHEM-C 321 Advanced and Nanoscale Materials
- CHEM-C 416 Surface Analysis and Surface Chemistry
- ENGR-E 311 Circuits and Digital Systems
- ENGR-E 321 Advanced Cyber-Physical Systems (if not used below)
- ENGR-E 340 Introduction to Computational Bioengineering
- ENGR-E 399 Topics in Intelligent Systems Engineering (approved topic)
- ENGR-E 443 Computational Modeling Methods for Virtual Tissues
- ENGR-E 451 Simulating Nanoscale Systems
- ENGR-E 472 Biomedical Devices and Sensors

Select 2 courses from the following (totaling at least 5 hours):

- Any ISE course not already used in major or concentration by approval
- Any math or science course by approval

Certificates & Minors

The undergraduate minors or certificate allows a student majoring in another school to get appropriate training in informatics and obtain certification as someone who knows how to apply informatics tools to that subject area. Students may obtain a maximum of three minors.

**** Equivalent honors versions of regular courses may substitute throughout the certificate or minor. ****

Certificate in Informatics

Students must be an IU admitted degree-seeking student and certificate will be awarded concurrently or after an IU degree.

Students may obtain an area certificate in Informatics by successfully completing 8 courses.

A certificate GPA of at least 2.000 for all courses taken in the certificate is required (all certificate course attempt grades are included).

A minimum grade of C- (unless otherwise noted) is required for a course to fulfill a requirement in the certificate.

Required Courses:

** If pursuing a Computer Science degree, you will need to take an additional informatic elective course for each course you substitute between the Computer Science major and the Informatics certificate. (CSCI--C 211/212 for INFO-I 210/211 and CSCI-C 241 for INFO-I 201, etc.)

- INFO-I 101 Introduction to Informatics (minimum grade of C required in this course)
- INFO-I 201 Mathematical Foundations of Informatics
- INFO-I 202 Social Informatics OR INFO-I 222 The Information Society
- INFO-I 210 Information Infrastructure I
- INFO-I 211 Information Infrastructure II
- INFO-I 300 Human-Computer Interaction Design and Programming - **Must be completed on the Indiana University Bloomington campus**
- INFO-I 308 Information Representation - **Must be completed on the Indiana University Bloomington campus**

In addition, students must take one three hour course from the list of informatics electives (list can be found under the BS Informatics area, Luddy Degree and Major Requirements). CSCI majors may not count advanced level CSCI courses in this certificate if used in major requirements.

Minor in Animal-Computer Interaction

Students may obtain a minor in Animal-Computer Interaction by successfully completing five courses totaling a minimum of 15 credit hours, nine of which are at the 300/400 level.

A minor GPA of at least 2.000 for all courses taken in the minor is required (all minor course attempt grades included).

A minimum grade of C- is required for a course to fulfill a requirement in the minor.

Required Courses:

- ABEH-A 101 Introduction to Animal Behavior
- INFO-I 216 Human, Animals, and Artificial Intelligence
- INFO-I 411 Animal-Computer Interaction Methods
- INFO-I 414 Seminar in Animal-Computer Interaction

Select one course from the following:

Animal Behavior, Cognition, and Conservation Management

- ABEH-A 400 Advanced Workshop in Animal Behavior
- BIOL-L 453 Sensory Ecology
- BIOL-Z 460 Animal Behavior
- COGS-Q 345 Animal Cognition
- GEOG-G 448 Capitalism and Nature
- INFO-I 400 Topics in Informatics
  - Topic: Technological Nature
- INFO-I 412 Direct Observation and Design

- SPEA-E 460 Wildlife Management

Artificial Intelligence and Data Analytics

- COGS-Q 351 Introduction to Artificial Intelligence and Computer Simulation
- CSCI-B 351 Introduction to Artificial Intelligence
- CSCI-B 355 Autonomous Robotics
- ENGR-E 434 Big Data Applications
- ENGR-E 483 Information Visualization
- ENGR-E 484 Scientific Visualization
- INFO-I 368 Introduction to Network Science
- INFO-I 413 Usable Artificial Intelligence
- INFO-I 422 Data Visualization

Augmented and Virtual Reality

- CSCI-B 453 Game Development
- INFO-I 304 Introduction to Virtual Reality
- INFO-I 442 Creating Virtual Assets
- INFO-I 443 Building Virtual Worlds
- INFO-I 444 Artificial Life in Virtual Reality

Geospatial Information System

- GEOG-G 336 Environmental Remote Sensing
- GEOG-G 436 Advanced Remote Sensing: Digital Image Processing
- GEOG-G 438 Advanced Geographic Information Systems
- GEOG-G 439 GIS and Environmental Analysis
- GEOG-G 478 Global Change, Food and Farming Systems
- GEOG-G 488 Applied Spatial Statistics

IoT Systems and Physical Fabrication

- CSCI-P 442 Digital Systems
- ENGR-E 314 Embedded Systems
- ENGR-E 327 Automated Fabrication Machines
- INFO-I 341 Prototyping with Arduino Tools
- INFO-I 400 Topics in Informatics
  - Topic: Makerspace: Design & Fabrication
- INFO-I 440 Human Robot Interaction

Mobile App Development

- CSCI-C 323 Mobile App Development
- INFO-I 342 Mobile Programming
- INFO-I 400 Topics in Informatics
  - Topic: Cross-Platofrm Mobile Programming

Qualitative Methods and Design

- INFO-I 370 Methods for HCC
- INFO-I 426 Informatics in Disasters and Emergency Response
- INFO-I 440 Human-Robot Interaction

Technology Entrepreneurship

- INFO-I 436 Technology Innovation
- INFO-I 437 Design Strategy
- INFO-I 438 Technology Entrepreneurship

Web and Database Design

- CSCI-B 461 Database Concepts
- CSCI-P 462 Database Application Design and Implementation
- INFO-I 360 Web Design

Minor in Computer Science

Students may obtain a minor in Computer Science by successfully completing six courses totaling a minimum of 20 credit hours, at least nine hours must be at the 300/400 level.

A minor GPA of at least 2.000 for all courses taken in the minor is required (all minor course attempt grades included).

A minimum grade of C- is required for a course to fulfill a requirement in the minor.

Required Courses:

- CSCI-C 200 Introduction to Computers and Programming **OR** CSCI-C 211 Introduction to Computer Science
- CSCI-C 212 Introduction to Software Systems
- CSCI-C 241 Discrete Structures for Computer Science

Select one course from the following:

- CSCI-C 335 Computer Structures
- CSCI-C 343 Data Structures

Advanced Computer Science electives:

- At least five additional CSCI (B, C, P) credit hours at the 300/400 level. CSCI-Y 390 or Y 499 may be completed for a total of 3 credit hours.

Minor in Data Science

Students may obtain a minor in Data Science by successfully completing five courses totaling a minimum of 16 credit hours, nine of which are at the 300/400 level.

A minor GPA of at least 2.000 for all courses taken in the minor is required (all minor course attempt grades included).

A minimum grade of C- is required for a course to fulfill a requirement in the minor.

Required Courses:

- CSCI-C 200 Introduction to Computers and Programming OR CSCI-C 211 Introduction to Computer Science
  - If completing with CSCI-C 211, knowledge of Python is expected
- CSCI-C 241 Discrete Structures for Computer Science OR INFO-I 201 Mathematical Foundations of Informatics
- CSCI-A 310 Problem Solving Using Data OR CSCI-C 343 Data Structures
- DSCI-D 321 Data Representation
- DSCI-D 351 Big Data Analytics OR Approved 3/400 level course approved by DSCI department including:
  - CSCI-B 351 Introduction to Artificial Intelligence
  - CSCI-B 365 Introduction to Data Analysis and Mining

- CSCI-B 403 Introduction to Algorithm Design and Analysis
- CSCI-B 455 Principles of Machine Learning
- CSCI-B 457 Introduction to Computer Vision
- CSCI-B 461 Database Concepts
- CSCI-P 434 Distributed Systems
- STAT-S 350 Introduction to Statistical Inference

Minor in Human-Centered Computing

Students may obtain a minor in Human-Centered Computing by successfully completing a minimum of 15 credit hours.

A minor GPA of at least 2.000 for all courses taken in the minor is required (all minor course attempt grades included).

A minimum grade of C- (unless otherwise noted) is required for a course to fulfill a requirement in the minor.

The minor introduces students with little or no background in computing to the social, cultural, ethical and organizational dimensions of computing and information technology, as well as the role of design in the creation of new technology.

For Informatics Majors:
Select five courses from the following:

- CSCI-A 216 Digital Multimedia Concepts and Technologies
- INFO-I 303 Organizational Informatics
- INFO-I 304 Introduction to Virtual Reality
- INFO-I 310 Multimedia Arts and Technology
- INFO-I 330 Legal and Social Informatics of Security
- INFO-I 341 Prototyping for Arduino Tools
- INFO-I 360 Web Design
- INFO-I 370 Methods of HCC
- INFO-I 399 Current Topics in Informatics (3 credit hour approved topic)
- INFO-I 400 Topics in Informatics (3 credit hour approved topic)
- INFO-I 407 Introduction to Health Informatics
- INFO-I 426 Informatics in Disasters and Emergency Response
- INFO-I 436 Technology Innovation
- INFO-I 437 Design Strategy
- INFO-I 438 Technology Entrepreneurship
- INFO-I 440 Human Robot Interaction
- INFO-I 441 Interaction Design Practice
- INFO-I 453 Computer and Information Ethics
- INFO-I 469 Collective Intelligence
- INFO-I 487 Introduction to Virtual Heritage
- INFO-I 488 Advanced Topics in Virtual Heritage

For non-Informatics Majors:

Required Courses:

- INFO-I 101 Introduction to Informatics (minimum grade of C required in this course) **OR** CSCI-A 110 Introduction to Computers and Computing
- INFO-I 202 Social Informatics OR INFO-I 222 The Information Society
- INFO-I 300 Human-Computer Interaction Design and Programming

Select two courses from the following:

- INFO-I 303 Organizational Informatics
- INFO-I 304 Introduction to Virtual Reality
- INFO-I 310 Multimedia Arts and Technology
- INFO-I 330 Legal and Social Informatics of Security
- INFO-I 341 Prototyping for Arduino Tools
- INFO-I 360 Web Design
- INFO-I 370 Methods of HCC
- INFO-I 399 Current Topics in Informatics (3 credit hour approved topic)
- INFO-I 400 Topics in Informatics (3 credit hour approved topic)
- INFO-I 407 Introduction to Health Informatics
- INFO-I 426 Informatics in Disasters and Emergency Response
- INFO-I 436 Technology Innovation
- INFO-I 437 Design Strategy
- INFO-I 438 Technology Entrepreneurship
- INFO-I 440 Human Robot Interaction
- INFO-I 441 Interaction Design Practice
- INFO-I 453 Computer and Information Ethics
- INFO-I 469 Collective Intelligence
- INFO-I 487 Introduction to Virtual Heritage
- INFO-I 488 Advanced Topics in Virtual Heritage

Minor in Human-Computer Interaction/Design

Student may obtain a minor in Human-Computer Interaction/Design by successfully completing five courses totaling a minimum of 15 credit hours, nine of which are at the 300/400 level.

A minor GPA of at least 2.000 for all courses taken in the minor is required (all minor course attempt grades included).

A minimum grade of C- is required for a course to fulfill a requirement in the minor.

Required courses:

- INFO-I 245 Interaction Design Thinking
- INFO-I 246 Use and Usability
- INFO-I 345 Interaction Design Research
- INFO-I 346 Prototyping and Evaluation

Select one course from the following:

- INFO-I 303 Organizational Informatics
- INFO-I 310 Multimedia Arts and Technology
- INFO-I 311 Application Development
- INFO-I 360 Web Design
- INFO-I 399 Current Topics in Informatics (3 hour approved topic)
- INFO-I 400 Topics in Informatics (3 hour approved topic)
- INFO-I 436 Technology Innovation
- INFO-I 437 Design Strategy
- INFO-I 438 Technology Entrepreneurship
- INFO-I 440 Human Robot Interaction
- INFO-I 4** HCI/D capstone (new course)

Minor in Informatics

Students may obtain a minor in Informatics by successfully completing five courses totaling a minimum of 17 credit hours. At least three of the five courses (9 hours) must be at the 300/400 level.

A minor GPA of at least 2.000 for all courses taken in the minor is required (all minor course attempt grades included).

A minimum grade of C- (unless otherwise noted) is required for a course to fulfill a requirement in the minor.

Required Course:

- INFO-I 101 Introduction to Informatics (minimum grade of C required in this course)

A programming course selected from the following:

- INFO-I 210 Information Infrastructure I
- CSCI-A 201 Introduction to Programming I
- CSCI-C 200 Introduction to Computers and Programming or CSCI-C 211 Introduction to Computer Science

Select 9 credit hours of INFO courses at the 3/400 level

These can include by approval:

- INFO-I 389 Serve IT Internship in Informatics (no more than 3 credit hours)
- INFO-I 390 Undergraduate Independent Study (no more than 3 credit hours)
- INFO-I 391 Internship in Informatics Professional Practice (no more than 3 credit hours)

Minor in Information Technology

Computer Science majors may not claim this minor.

Students may obtain a minor in Information Technology by successfully completing a minimum of 15 credit hours.

A minor GPA of at least 2.000 for all courses taken in the minor is required (all minor course attempt grades included).

A minimum grade of C- is required for a course to fulfill a requirement in the minor.

Choose one introductory programming path (one or two courses) from the following:

- CSCI-C 200 Introduction to Computers and Programming **OR** CSCI-C 211 Introduction to Computer Science
  OR
- CSCI-A 201 Introduction to Programming I and CSCI-A 202 Introduction to Programming II
  OR
- INFO-I 210 Information Infrastructure I and INFO-I 211 Information Infrastructure II

Required Course:

- CSCI-A 338 Network Technologies and Administration

Select one course from the following:

- CSCI-A 321 Computing Tools for Scientific Research
- CSCI-A 348 Mastering the World Wide Web

Select at least 3 additional CSCI credit hours at the 3/400 level

Minor in Intelligence Studies

Students may obtain a minor in Intelligence Studies by successfully completing a minimum of 15 credit hours.
Students in the Academic Group CO (COLL1, COLS1, COSP1, MSCH1, SGIS1, and SOAD1) must have 9 credit hours in 300/400 level courses.

A minor GPA of at least 2.300 for all courses taken in the minor is required (all minor course attempt grades included).

A minimum grade of C+ is required for a course to fulfill a requirement in the minor.

Intelligence Studies works with information that may not be authoritative or reliable, that may actually be deceptive, and lacks context for purposes of national security or competitive intelligence.

Required Courses:

- ILS-Z 115 Evaluating Intelligence and Information
- ILS-Z 221 Intelligence Analytics

Select one course from the following:

- CJUS-P 407 Terrorism
- ENGR-E 483 Information Visualization
- GEOG-G 237 Mapping our World
- INTL-I 210 Diplomacy, Security, Governance
- INTL-L 250 Introduction to International Law and Legal Institutions
- MSCH-C 206 Media Reporting in a Global World
- POLS-Y 311 Democracy and National Security
- SPEA-J 202 Criminal Justice Data, Methods, and Resources

*GEOG-G 237 and INTL-I 210 cannot be used by students in the COLL.

Select two courses from the following:

- ILS-Z 311 Spy Tech for Non-Technical Spies
- ILS-Z 331 Strategic Intelligence
- ILS-Z 351 Moles, Deception, and Counterintelligence
- ILS-Z 399 Topics in Information and Library Science (Topic: Dark Arts: Corporate Espionage)
- GEOG-G 336 Environmental Remote Sensing
- INFO-I 427 Search Informatics
- INFO-I 453 Computer and Information Ethics
- INTL-I 422 Contested Territories/Conflicted Identities
- POLS-Y 360 United States Foreign Policy
- POLS-Y 368 Russian and Soviet Foreign Policy
- POLS-Y 209 Protests in a Global World
- POLS-Y 239 US Foreign Policy and the Muslim World
- SPEA-J 324 Technology, Crime, and Public Safety
- SPEA-V 272 Terrorism and Public Policy

Minor in Intelligent Systems Engineering

Students may obtain a minor in Intelligent Systems Engineering by successfully completing a minimum of 18 credit hours. Students in the Academic Group CO (COLL1, COLS1, COSP1, MSCH1, SGIS1, and SOAD1) must have 9 credit hours in 300/400 level courses.

A minor GPA of at least 2.000 for all courses taken in the minor is required (all minor course attempt grades included).

A minimum grade of C- is required for a course to fulfill a requirement in the minor.

Intelligent Systems Engineering brings together core intelligent systems engineering practices with an opportunity to explore their application in various disciplines. Students gain skills not found in their major that are reinforced and complemented by the ISE minor.

Required Course:

- ENGR-E 101 Innovation and Design

Select two courses from the following:

- ENGR-E110 Engineering Computer Architectures
- ENGR-E111 Software Systems Engineering
- ENGR-E201 Computer Systems Engineering
- ENGR-E210 Engineering Cyber-Physical Systems
- ENGR-E221 Intelligent Systems I
- ENGR-E222 Intelligent Systems II
- ENGR-E225 Introduction to Circuits
- ENGR-E250 Systems, Signals, and Control

Select three additional courses from the following:

- Any 300-level Intelligent Systems Engineering course
- Any 400-level Intelligent Systems Engineering course

Minor in Security Informatics

Students may obtain a minor in Security Informatics by successfully completing a minimum of 16 credit hours.

A minor GPA of at least 2.000 for all courses taken in the minor is required (all minor course attempt grades included).

A minimum grade of C- is required for a course to fulfill a requirement in the minor.

The minor is an appropriate addition for students interested in gaining significant exposure to issues, challenges and techniques relevant to computer based security.

Required Courses:

- CSCI-C 291 System Programming with C and Unix
- INFO-I 130 Introduction to Cybersecurity
- INFO-I 230 Analytical Foundations of Security
- INFO-I 231/CSCI-C 231 Introduction to the Mathematics of Cybersecurity
- INFO-I 430/CSCI-B 430 Security for Networked Systems
- INFO-I 433/CSCI-B 433 Systems & Protocol Security & Information Assurance

Select one course from the following:

- BUS-S 433 Information Systems Security
- CSCI-B 490 Seminar in Computer Science
  - Topic: Active Cyber Defense
- INFO-I 330 Legal and Social Informatics of Security
- INFO-I 399 Current Topics in Informatics (3 credit hour approved topic)
- INFO-I 400 Topics in Informatics (3 credit hour approved topic)
- INFO-I 453 Computer and Information Ethics

Minor in Virtual Reality

Students may obtain an minor in Virtual Reality by successfully completing five courses totaling a minimum of 15 credit hours, nine of which are at the 300/400 level.

A minor GPA of at least 2.000 for all courses taken in the minor is required (all minor course attempt grades included).

A minimum of C- is required for a course to fulfill a requirement in the minor.

Required:

- INFO-I 304 Introduction to Virtual Reality
- INFO-I 442 Creating Virtual Assets
- INFO-I 443 Building Virtual Worlds
- INFO-I 444 Artificial Life in Virtual Reality

Select one course from one of the following skills set groups

Artificial Intelligence

- COGS-Q 320 Computation in the Cognitive and Information Sciences
- CSCI-B 351 Introduction to Artificial Intelligence
- CSCI-B 355 Autonomous Robotics
- INFO-I 216 Humans, Animals, and Artificial Intelligence
- INFO-I 413 Usable Artificial Intelligence
- INFO-I 440 Human Robot Interaction
- INFO-I 469 Collective Intelligence

Data Analytics

- ENGR-E 434 Big Data Applications
- ENGR-E 484 Scientific Visualization
- INFO-I 123 Data Fluency
- INFO-I 368 Performance Analytics
- INFO-I 421 Applications of Data Mining
- INFO-I 422 Data Visualization
- INFO-I 423 Big Data Applications and Analytics
- INFO-I 424 Big Data Software and Projects
- INFO-I 427 Search Informatics
- INFO-I 435 Management, Access, and Use of Big and Complex Data
- INFO-I 468 Network Science Applications

Game Design

- CSCI-C 292 Introduction to Game Programming
- MSCH-G 310 Game Design I
- MSCH-G 320 Game Art and Sound

Mobile App Development

- CSCI-C 323 Mobile App Development
- INFO-I 342 Mobile Programming
- INFO-I 400 Topics in Informatics (topic: Cross-platform Mobile Programming)

Virtual Reality

- INFO-I 400 Topics in Informatics (topic: Applied Augmented Reality)
- INFO-I 400 Topics in Informatics (topic: Intro to Virtual Reality World Design & Culture)
- INFO-I 400 Topics in Informatics (topic: VR Animation, Light, and Sound)

Minor in Web Design and Development

Required:

- INFO-I 360 Web Design

Select one course from the following:

- CSCI-A 201 Introduction to Programming I
- CSCI-C 200 Introduction to Computers and Programming
- CSCI-C 211 Introduction to Computer Science
- COGS-Q 260 Programming for the Cognitive and Information Sciences
- INFO-I 210 Information Infrastructure I

Select three courses from the following:

- INFO-I 308 Information Representation
- INFO-I 363 Visual Design for the Web
- INFO-I 365 JavaScript
- INFO-I 389 Serve IT Internship in Informatics (3 total hours)
- INFO-I 400
  - Topic: Cross-Platform Mobile Programming
  - Topic: Mobile HCI Design

Bachelor of Science in Music - Outside Field

CSCI

An outside field GPA of at least 2.000 for all courses taken is required (all course attempt grades included).

A minimum of 27 CSCI hours with a minimum grade of C- is required for a course to fulfill a requirement in the outside field.

- CSCI-C 200 Introduction to Computers and Programming or CSCI-C 211 Introduction to Computer Science
- CSCI-C 212 Introduction to Software Systems
- CSCI-C 241 Discrete Structures for Computer Science
- CSCI-C 343 Data Structures
- Specialization of choice

DSCI

An outside field GPA of at least 2.000 for all courses taken is required (all course attempt grades included).

A minimum of 28 CSCI/DSCI hours with a minimum grade of C- is required for a course to fulfill a requirement in the outside field.

- CSCI-A 310 Problem Solving Using Data
- CSCI-C 200 Introduction to Computers and Programming or CSCI-C 211 Introduction to Computer Science
- CSCI-C 241 Discrete Structures for Computer Science
- DSCI-D 321 Data Representation
- DSCI-D 351 Big Data Analytics
- MATH-E 265 Introduction to Probability and Statistics for Data Science
- STAT-S 350 Introduction to Statistical Inference
- STAT-S 352 Data Modeling and Inference
- Specialization Course

INFO

An outside field GPA of at least 2.000 for all courses taken is required (all course attempt grades included).

A minimum of 27 INFO hours with a minimum grade of C- is required for a course to fulfill a requirement in the outside field.

- INFO-I 101 Introduction to Informatics (minimum grade of C required in this course)
- INFO-I 201 Mathematical Foundations of Informatics
- INFO-I 202 Social Informatics OR INFO-I 222 The Information Society
- INFO-I 210 Information Infrastructure I
- INFO-I 211 Information Infrastructure II
- INFO-I 300 Human-Computer Interaction Design and Programming
- INFO-I 308 Information Representation
- INFO elective (see list under INFO major)

ISE

An outside field GPA of at least 2.000 for all courses taken is required (all course attempt grades included).

A minimum of 28 ISE hours with a minimum grade of C- is required for a course to fulfill a requirement in the outside field.

- ENGR-E 101 Innovation and Design
- ENGR-E 110 Engineering Computing Architectures
- ENGR-E 111 Software Systems Engineering
- ENGR-E 201 Computer Systems Engineering
- ENGR-E 221 Intelligent Systems I
- ENGR-E 225 Introduction to Circuits
- Choose 3 Engineering electives (ENGR-E 210, E 250 or any 300/400 level ENGR course)

Outside Minors and Certificates

Students may pursue minors and certificates in other schools. Up to three minors may appear on the student's Indiana University transcript. Some cognates complete minor requirements. Please consult the bulletin of the minor's school for the specific requirements of the minor. The department offering the minor defines the requirements for the minor. Students are required to follow the department's rules regarding grades, prerequisites and course requirements. Students are responsible for adding the minor to their degree record through SAMS (Luddy School of Informatics, Computing, and Engineering student database).

**** An exception to the above, if different from the school offering the minor:**

A minor GPA of at least 2.000 for all courses taken in the minor is required (all minor course attempt grades included).

A minimum grade of C- is required for a course to fulfill a requirement in the minor.

Certificate in Entrepreneurship

This cross campus certificate consists of fifteen credit hours. Only students outside of the Kelley School of Business will be admitted into the Certificate in Entrepreneurship program. New requirements can be found on the Kelley website.

To be considered for the certificate, students must apply online: Certificate Application

A minimum grade of C in all courses with an overall certificate GPA of 2.5 is required.

Kelley School of Business:

Required Courses:

- BUS-W 212 Exploring Entrepreneurship
- BUS-W 300 Small Business Management
- BUS-Z 302 Managing and Behavior in Organizations

School of Informatics, Computing, and Engineering Courses

Select two courses from the following:

- INFO-I 436 Technology Innovation
- INFO-I 437 Design Strategy
- INFO-I 438 Technology Entrepreneurship

Concurrent/Sequential Baccalaureate Degrees

Students pursuing two undergraduate degrees in the Luddy School of Informatics, Computing, and Engineering may double count up to two courses (any level) towards the major requirements for both degrees.

Concurrent Degree

Students may be permitted to pursue a Luddy School of Informatics, Computing, and Engineering degree concurrently with another degree-granting IU-Bloomington school. Students should have completed the 200 level core courses of the 2nd degree, or at least enrolled in the last core course(s). When students have completed these core courses, with a cumulative gpa of 2.0, they must see a Luddy School of Informatics, Computing, and Engineering advisor to submit the 2nd degree.

Sequential Baccalaureate Degree

Students may be permitted to pursue a Luddy School of Informatics, Computing, and Engineering degree after completion of a first degree from Indiana University or another university. Students from another university must first be admitted to Indiana University as a degree seeking student. Please see http://www.indiana.edu/~iuadmit/ for admission information.

Students seeking second degree candidacy should review the guidelines available from the Luddy School of Informatics, Computing, and Engineering office. After admission to Indiana University, please email siceugrd@indiana.edu for registration approval.

Students with a bachelor's degree who wish to further their education should also consider becoming qualified for admission to a graduate program.

Graduate Programs

Thirty (30) credit hours are required for the M.S. (some majors require more than 30), all of which may be taken in a single department; at least 20 of these credit hours must be earned in the major field. A minimum of 9 credit hours of course work or at least three courses in the major field (excluding thesis) must be numbered 500 or above.

BSMS Accelerated Programs and 4+1 Programs

To apply to a BS MS Accelerated program, you must be a current undergraduate student at Luddy's School of Informatics, Computing, and Engineering. To apply for a 4+1 program, you must be a current undergraduate student at Indiana University.

You must first talk with your undergraduate advisor who will review your academic record to ensure that you meet the admission requirements. To apply for a 4+1 program, you must first talk with the advisor of the 4+1 program. If the advisor determines that you have met the admission requirements, they will provide you with an invitation code which will give you access to the application. They will also proved you with an application fee waiver code.

To apply to any of the Luddy graduate programs, students must submit the following:

APPLICATION

- Online Graduate and Professional Admissions Application

STATEMENT OF PURPOSE (also called Personal Statement) Upload in the Program Materials section

The admissions committee requires all applicants to submit a personal statement. Be sure to put your name on your personal statement. Statements can be submitted only once. Your statement should be sincere, direct, and most of all, written by you. Be sure to follow the instructions provided in the online application as to what you should include in your personal statement as each program may have different requirements. You may also use your statement to explain any anomalies in your academic record. Personal statements have no word limit. Statements are typically 1-3 pages long and often include an explanation of:

- Why our program is the right fit for your academic/ career goals
- Why you want to be part of the program
- A description of your academic goals and your abilities
- A discussion of your plans after completion of the degree
- Information on the area of research you would like to pursue, if applicable

RESUME/CV Upload in the Program Materials section

Resumes/CVs can be submitted only once with your online application as we do not accept updated versions later.

TRANSCRIPTS, MARK SHEETS AND DEGREE CERTIFICATIONS Upload in the Program Materials section

You must scan and upload copies of your transcript(s), mark sheets(s) and degree certifications(s) in the Program Materials section of the IU Graduate CAS application. Scanned copies are marked as unofficial.

LETTERS OF RECOMMENDATION Upload in the Program Materials section

One (1) letter of recommendation is required. The recommendation should should be from academic and/or professional references who can attest to your abilities, accomplishments, strengths, knowledge, and experience.

If you have questions about your application, email goluddy@iu.edu.

Intelligent Systems Engineering

HOW TO APPLY

We require that you submit your application online. For up-to-date information and expectations, please visit our "How to Apply" page. There is a checklist to guide you through the application, and you should pay particular attention to the instructions regarding transcripts. We are unable to review incomplete applications.

WHAT WE ARE LOOKING FOR

We want to know if your interests and abilities match the program you are applying for and if you seem likely to benefit from an education in the department. If you think it is helpful, you can supplement the required application materials with other information that sheds light on your capabilities. A resume or curriculum vitae is ideal for including citations or links to any published work, hardware artifacts, or software artifacts you have produced.

EDUCATIONAL BACKGROUND

We do not require a bachelor's degree in computer science, informatics, or a related field, but we are looking for a background in key areas. For example, for computer science degrees, you should have had courses in data structures, machine organization and assembly language, and discrete structures.

LETTERS OF REFERENCE

Except in special cases, references should be from academic faculty, including at least some in informatics and computing. We ask for three letters, but you may submit more. If you have experience as a teaching assistant, a letter from your teaching supervisor attesting to your teaching abilities could help your application for aid.

GRE SCORES

The Graduate Record Examination (GRE) General Test is optional. GRE scores are good for five (5) years from the date you took the exam. We do not have cut-offs for GRE scores, preferring instead to use the full information available in your application to evaluate. Submit scores to institution code 1324 and department code 0402. If your name on the test report differs from the name on the online application, please list the test score name in the comment section of the application.

TOEFL SCORES

Prospective students must demonstrate a level of English proficiency adequate for graduate study. We require all students who are non-native English speakers to submit the Test of English as a Foreign Language (TOEFL) scores. TOEFL scores are good for two (2) years from the date you took the exam. We expect a minimum score of 100 or higher on the Internet-based test (iBT), 250 on the computer-based test or 600 or higher on the paper-based test. Submit TOEFL scores to institution code 1324 and department code 78.

STATEMENT OF PURPOSE

The most important information to include in your statement of purpose concerns your academic goals. Tell us which Indiana University faculty you are interested in, as well as your research areas of interest. You may also use your statement of purpose to explain any anomalies in your record. The length should be approximately 500 words.

TRANSCRIPTS

Submit transcripts via the online application from each previous undergraduate or graduate institution other than Indiana University that you have attended.

RESUME

A skills-based resume helps to identify your most relevant areas of achievement and knowledge. Listing programming languages is helpful as is including any awards or publications.

INTERNATIONAL APPLICANTS

If you are not a citizen or permanent resident of the United States, you will receive an email from the Office of International Services (OIS), requesting you to submit financial documentation. Financial documentation must demonstrate that you have resources available to support your first year of study in the United States. OIS will issue immigration documents once they receive requested documentation. Visit their website for in-depth information at ois.iu.edu. Direct any questions regarding the student visa process to newtoiu@iu.edu, rather than the department.

APPLICATION DEADLINES

Deadlines for application submission for each program are published on our "How to Apply" page.

ADMISSION STATUS AND NOTIFICATION

We will let you know as soon as we have reached a decision.

Occasionally, denied applicants contact us for an explanation. Unfortunately, we receive several hundred applications per year, and we do not have the staff to explain admission decisions on a case-by-case basis.

DUAL MASTER'S PROGRAM

Under a provision that allows credit earned to satisfy the major requirements of one program to count as elective credit in a second program, students enrolled in dual programs may qualify for two master's degrees. The graduate advisor will negotiate any area of substantial overlap in the two courses of study. A student must be formally admitted to both programs. It is required to meet

program requirements for both degrees and complete all coursework within six years.

CONTACT INFORMATION AND RESOURCES

- Any admissions questions not covered in our "How to Apply" content?
  - Email goluddy@iu.edu
- Any international-student questions?
  - Email newtoiu@indiana.edu rather than the department
- The "How to Apply" page contains the most up-to-date and comprehensive information regarding each step of the admissions process. Read in its entirety and use the included Application Checklist when completing your application.
- Luddy Homepage - information on all programs, faculty, research, and happenings at the Luddy School of Informatics, Computing, and Engineering.

Data Science Online

How to Apply

We require that you submit your application online. For up-to-date information and expectations, please visit our "How to Apply" page. There are specific instructions to guide you through the application, and you should pay attention to the transcript section. Please be advised incomplete applications are not reviewed for admission consideration.

What We Are Looking For

We want to know if your interests and abilities match the program you are applying for and if you seem likely to benefit from an education in the school. If you think it is helpful, you can supplement the required application materials with other information that sheds light on your capabilities. A resume or curriculum vitae is ideal for including citations or links to any published work, conference presentations, or other items you have produced.

Items that are important in the evaluation process include:

EDUCATIONAL BACKGROUND

We require all applicants to hold a four (4) year US Bachelor's degree or equivalent. Your degree does not need to be in the fields of computer science, or other science discipline; however, these key areas are important. You should have some experience or working knowledge of programming languages such as Python and R, as well as an understanding of mathematical principles (linear algebra, calculus, probability, statistics, or discrete math) before joining the program; experience with data structures and algorithms is helpful, but not required.

LETTER OF REFERENCE

You will be required to provide contact information for one academic or professional who can attest to your abilities, accomplishments, strengths, and unique experiences. Additional references may be provided to further support your application.

STATEMENT OF PURPOSE

The most important information to include in your statement of purpose concerns your academic goals. Tell us your academic background as it relates to the field of data science, career goals, and overall aspiration for applying to this specific program. You may also use your statement of purpose to explain any anomalies in your record. The length should be approximately 750 words (1-1.5 pages).

TRANSCRIPTS

Submit scanned copies of your academic records directly to the Luddy Office of Online Education with your graduate application. For further details regarding your academic records, please refer to our application instructions on the "How to Apply" page.

RESUME

A skills-based resume helps to identify your most relevant areas of achievement and knowledge. Listing programming languages is helpful, as is including any awards or publications

APPLICATION DEADLINES

Deadlines for application submission for each program are published on our "How to Apply" page.
Please note our online programs operate on an admission deadline system. This means the date on which your application becomes complete - not when it is submitted - determines whether you have successfully met the deadline for admissions consideration.

ADMISSION STATUS AND NOTIFICATION

We evaluate applications after the established deadlines. We will let you know as soon as we have reached a decision, generally four (4) to five (5) weeks from the application deadline.

Occasionally, denied applicants contact us for an explanation. Unfortunately, we receive hundreds of applications per year, so information about our decision may be limited.

CONTACT INFORMATION AND RESOURCES

- Any admission questions not covered in our "How to Apply" content?
  - Email luddyonl@indiana.edu

Data Science - Residential

How to Apply

We require that you submit your application online. For up-to-date information and expectations, please visit our "How to Apply" page. There are specific application instructions to guide you through the application, and you should pay particular attention to the instructions regarding transcripts. We are unable to review incomplete applications.

What We Are Looking For

We want to know if your interests and abilities match the program you are applying for and if you seem likely to benefit from an education in the school. If you think it is helpful, you can supplement the required application materials with other information that sheds light on your capabilities. A resume or curriculum vitae

is ideal for including citations or links to any published work, hardware artifacts, or software artifacts you have produced.

Items that are important in the evaluation process include:

EDUCATIONAL BACKGROUND

We do not require a bachelor's degree in computer science, informatics, or a related field, but we are looking for background in key areas. You should have some experience or knowledge of programming languages such as Python and R, as well as an understanding of mathematical principles (ie: linear algebra, calculus, probability, statistics, or discrete math) before joining the program; experience with data structures and algorithms is helpful, but not required.

LETTERS OF REFERENCE

Except in special cases, references should be from academic faculty, including at least some in informatics and computing. We ask for three letters but you may submit more.

GRE SCORES

The Graduate Record Examination (GRE) General Test is optional. We do not have cut-offs for GRE scores, preferring instead to use the full information available in your application to evaluate. Submit scores to institution code **1324** and department code **0403**. If your name on the test report differs from the name on the online application, please list the test score name in the comment section of the application.

TOEFL SCORES

Prospective students must demonstrate a level of English proficiency adequate for graduate study. We require all students who are non-native English speakers to submit the Test of English as a Foreign Language (TOEFL) scores. TOEFL scores are good for two (2) years from the date you took the exam. We expect a minimum score of 100 on the Internet-based test (iBT), 250 on the computer-based test or 600 or higher on the paper-based test. Submit TOEFL scores to institution **1324** and department code **99**.

STATEMENT OF PURPOSE

The most important information to include in your statement of purpose concerns your academic goals. Tell us which research areas you are interested in and which Indiana University faculty you would like to work with. You may also use your statement of purpose to explain any anomalies in your record. The length should be approximately 750 words.

TRANSCRIPTS

Submit transcripts via the online application from each previous undergraduate or graduate institution other than Indiana University that you have attended. You can upload transcripts under the "Department Information" tab, "additional upload" section. Combine all pages from one or more transcripts into a single .pdf document. We are most interested in the grades you received in courses that are relevant to our graduate programs.

RESUME

A skills-based resume helps to identify your most relevant areas of achievement and knowledge. Listing programming languages is helpful as is including any awards or publications.

INTERNATIONAL APPLICANTS

If you are not a citizen or permanent resident of the United States, you will receive an email from the Office of International Services (OIS), requesting you to submit financial documentation. Financial documentation must demonstrate that you have resources available to support your first year of study in the United States. OIS will issue immigration documents once they receive requested documentation. Visit their website for in-depth information at ois.iu.edu. Direct any questions regarding the student visa process to newtoiu@iu.edu rather than the department.

APPLICATION DEADLINES

Deadlines for application submission for each program are published on our "How to Apply" page.

ADMISSION STATUS AND NOTIFICATION

We will let you know as soon as we have reached a decision.

Occasionally, denied applicants contact us for an explanation. Unfortunately, we receive several hundred applications per year, and we do not have the staff to explain admission decisions on a case-by-case basis.

CONTACT INFORMATION AND RESOURCES

- Any admissions questions not covered in our "How to Apply" content?
  - Email goluddy@iu.edu
- Any international-student questions?
  - Email newtoiu@iu.edu rather than the department
- The "How to Apply" page contains the most up-to-date and comprehensive information regarding each step of the admissions process. Read it in its entirety and use the included Application Instructions when completing your application.
- Luddy Homepage - information on all programs, faculty, research, and happenings at the Luddy School of Informatics, Computing, and Engineering.

Admissions

- Admitted Students
- Financial Aid & Scholarships
- B.S.M.S. Accelerated Programs and 4+1 Programs
- Computer Science
- Data Science - Residential
- Data Science - Online
- Informatics
- Information and Library Science
- Intelligent Systems Engineering

Admitted Students

Congratulations on your admittance to the Luddy School of Informatics, Computing, and Engineering. We're eager for you to join our close-knit community.

We have an orientation for new graduate students each fall, when we'll tell you what you need to know to start off on the right foot.

International students will also attend international orientation, which covers a wide range of topics about studying and living in the United States. IU's Office of International Services can answer any questions you have about visas and other paperwork. This office will be a resource for you throughout your IU career, helping you adjust to U.S. culture, meet your academic goals, complete required paperwork, make good financial choices, and more.

Financial Aid & Scholarships

Tuition & Fees

Indiana University is committed to keeping its degrees affordable for in-state and out-of-state students, both through low costs and generous financial aid.

The Office of Student Financial Assistance has information about current costs of attendance for full-time, domestic graduate students. Costs for international students are slightly different and include mandatory health insurance.

Master's and doctoral students have access to a wide range of financial aid and scholarships from the school, Indiana University, and outside sources such as the federal government.

We offer a variety of assistantships to our Ph.D. students, as well as a limited number of fellowships. In addition, IU offers a number of diversity-building fellowships.

You can learn more about financial aid opportunities from Student Central and the University Graduate School Funding and Fees pages.

International Students

The Office of International Services has information about financial aid and employment for international students. See the information about financial aid for prospective graduate students, employment for F-1 students and J-1 students, and other money matters.

Computer Science

HOW TO APPLY

We require that you submit your application online. For up-to-date information and expectations, please visit our "How to Apply" page. There is a checklist to guide you through the application, and you should pay particular attention to the instructions regarding transcripts. We are unable to review incomplete applications.

WHAT WE ARE LOOKING FOR

We want to know if your interests and abilities match the program you are applying for and if you seem likely to benefit from an education in the school. If you think it is helpful, you can supplement the required application materials with other information that sheds light on your capabilities. A resume or curriculum vitae is ideal for including citations or links to any published work, hardware artifacts, or software artifacts you have produced.

Items that are important in the evaluation process include:

EDUCATIONAL BACKGROUND

We do not require a bachelor's degree in computer science, informatics, or a related field, but we are looking for a background in key areas. For example, for computer science degrees, you should have had courses in data structures, machine organization and assembly language, and discrete structures.

LETTERS OF REFERENCE

Except in special cases, references should be from academic faculty, including at least some in informatics and computing. We ask for three letters, but you may submit more. If you have experience as a teaching assistant, a letter from your teaching supervisor attesting to your teaching abilities could help your application for aid.

GRE SCORES

The Graduate Record Examination (GRE) General Test is optional. GRE scores are good for five (5) years from the date you took the exam. We do not have cut-offs for GRE scores, preferring instead to use the full information available in your application to evaluate. Submit scores to institution code 1324 and department code 0402. If your name on the test report differs from the name on the online application, please list the test score name in the comment section of the application.

TOEFL SCORES

Prospective students must demonstrate a level of English proficiency adequate for graduate study. We require all students who are non-native English speakers to submit the Test of English as a Foreign Language (TOEFL) scores. TOEFL scores are good for two (2) years from the date you took the exam. We expect a minimum score of 100 or higher on the Internet-based test (iBT), 250 on the computer-based test or 600 or higher on the paper-based test. Submit TOEFL scores to institution code 1324 and department code 78.

STATEMENT OF PURPOSE

The most important information to include in your statement of purpose concerns your academic goals. Tell us which Indiana University faculty you are interested in, as well as your research areas of interest. You may also use your statement of purpose to explain any anomalies in your record. The length should be approximately 500 words.

TRANSCRIPTS

Submit transcripts via the online application from each previous undergraduate or graduate institution other than Indiana University that you have attended.

RESUME

A skills-based resume helps to identify your most relevant areas of achievement and knowledge. Listing programming languages is helpful as is including any awards or publications.

INTERNATIONAL APPLICANTS

If you are not a citizen or permanent resident of the United States, you will receive an email from the Office of International Services (OIS), requesting you to submit

financial documentation. Financial documentation must demonstrate that you have resources available to support your first year of study in the United States. OIS will issue immigration documents once they receive requested documentation. Visit their website for in-depth information at ois.iu.edu. Direct any questions regarding the student visa process to newtoiu@iu.edu, rather than the department.

APPLICATION DEADLINES

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ADMISSION STATUS AND NOTIFICATION

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DUAL MASTER'S PROGRAM

Under a provision that allows credit earned to satisfy the major requirements of one program to count as elective credit in a second program, students enrolled in dual programs may qualify for two master's degrees. The graduate advisor will negotiate any area of substantial overlap in the two courses of study. A student must be formally admitted to both programs. It is required to meet program requirements for both degrees and complete all coursework within six years.

CONTACT INFORMATION AND RESOURCES

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  - Email goluddy@iu.edu
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  - Email newtoiu@indiana.edu rather than the department
- The "How to Apply" page contains the most up-to-date and comprehensive information regarding each step of the admissions process. Read in its entirety and use the included Application Checklist when completing your application.
- Luddy Homepage - information on all programs, faculty, research, and happenings at the Luddy School of Informatics, Computing, and Engineering.

Information and Library Science

Application Procedures

HOW TO APPLY

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WHAT WE ARE LOOKING FOR

We want to know if your interests and abilities match the program you are apply for and if you seem likely to benefit from an education in the school. If you think it is helpful, you can supplement the required application materials with other information that sheds light on your capabilities. A resume or curriculum vitae is ideal for including citations or links to any published work, hardware artifacts, or software artifacts you have produced.

Items that are important in the evaluation process include:

EDUCATIONAL BACKGROUND

We admit students with a wide variety of academic backgrounds. To apply to ILS, you must have the equivalent of a four-year U.S. bachelor's degree from an accredited college or university. If you're an international student, learn more about equivalent degrees at the IU Office of International Services.

LETTERS OF REFERENCE

Letters of reference need to be from professors or employers who are familiar with your abilities and can estimate how well you would do in a rigorous graduate program in this field.

GRE SCORES

The Graduate Record Examination (GRE) General Test is optional. GRE scores are good for five (5) years from the date you took the exam. We do not have cut-offs for GRE scores, preferring instead to use the full information available to evaluate. Submit scores to institution code 1324 and department code 0402. If your name on the test report differs from the name on the online application, please list the test score name in the comment section of the application.

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STATEMENT OF PURPOSE

The most important information to include in your statement of purpose concerns your academic goals. Tell us which Indiana University faculty you are interested in, as well as your research areas of interest. You may also use your statement of purpose to explain any anomalies in your record. The length should be approximately 500 words.

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4+1 Masters Programs

Current IU students applying to the accelerated masters program will need to provide the following documents:

1. Online Application
2. Resume/CV
3. Cover Letter
4. One Letter of Reference
5. GRE if current IU GPA is below 3.2

Informatics

Innovation permeates the Luddy School of Informatics, Computing, and Engineering. Our rare combination of interdisciplinary programs - including informatics, computer science, data science, library science, information science, and intelligent systems engineering - makes our school one of the largest, broadest, and most accomplished of its kind. Informatics is among the STEM programs in the areas of science, technology, engineering, and math.

The Luddy School of Informatics, Computing, and Engineering offers MS degrees in animal informatics, bioinformatics, computer science, data science, human computer interaction, informatics, intelligent systems engineering, library science, and secure computing, as well as doctoral degrees in computer science, informatics, information science, and intelligent systems engineering.

WHAT WE ARE LOOKING FOR

We are looking for intelligent, collaborative, and hard-working students! Indiana University's Luddy School of Informatics, Computing, and Engineering is a diverse community and students have extraordinary opportunities such as internships, research, cultural programs, and global connections. Employers from a variety of industries hire our graduates as well as provide internships for our students. With a graduate degree from Indiana University's Luddy School of Informatics, Computing, and Engineering coupled with a student's undergraduate degree, they will have a first-rate education that will give them an extra edge in the job market.

EDUCATIONAL BACKGROUND

Our students come from a variety of educational backgrounds - from technology to the sciences and liberal arts. Some of our students have earned a bachelor's degree while others have earned both a bachelor's and a master's degree. Likewise, some of our students enter the program with no work experience while other students have numerous years of work experience.

APPLICATION DEADLINES

Deadlines for application submission for each program are published on our "How to Apply" page.

APPLICATION REQUIREMENTS

Email goluddy@iu.edu with questions.

The IU Graduate CAS application has four sections (Personal Information, Academic History, Supporting Information, and Program Materials). The Personal Information, Academic History, and Supporting Information sections are part of the "common application". The Program Materials section is specific to the program you have selected If you apply to another program at Indiana University, you will only need to update the Program Materials section, you may want to review the "How to Apply" page on the website.

All completed applications reviewed by the admissions review committee are considered for financial awards which the Luddy School may be offering. If you are admitted, the admit letter will detail the financial award, if any. Every year we have limited funds to distribute. The majority of our master's students receive no funding. Some students find part-time employment to help offset the cost of their education, to gain experience in their field of study, or simply to earn some money.

To apply to any of the Luddy graduate programs, students must submit the following:

APPLICATION

Online Graduate and Professional Admissions Application.

STATEMENT OF PURPOSE (also called Personal Statement) Upload in the Program Materials section

The admissions committee requires all applicants to submit a personal statement. Be sure to put your name on your personal statement. Statements can be submitted only once. Your statement should be sincere, direct, and most of all, written by you. Be sure to follow the instructions provided in the online application as to what you should include in your personal statement as each program may have different requirements. You may also use your statement to explain any anomalies in your academic record. Personal statements have no word limit. Statements are typically 1-3 pages long and often include an explanation of:

- Why our program is the right fit for your academic/ career goals
- Why you want to be part of the program

- A description of your academic goals and your abilities
- A discussion of your plans after completion of the degree
- Information on the area of research you would like to pursue, if applicable

RESUME/CV Upload in the Program Materials section

Resumes/CVs can be submitted only once with your online application as we do not accept updated versions later.

TRANSCRIPTS, MARK SHEETS AND DEGREE CERTIFICATIONS Upload in the Program Materials section

You must scan and upload copies of your transcript(s), mark sheets(s) and degree certifications(s) in the Program Materials section of the IU Graduate CAS application. Scanned copies are marked as unofficial.

LETTER OR RECOMMENDATIONS (Program Materials section)

We require three (3) letters of recommendation. You may enter a maximum of 5 recommenders. Recommendations should be from academic and/or professional references who can attest to your abilities, accomplishments, strengths, knowledge, and experience. If you have experience as a teaching assistant, consider asking your teaching supervisor to write a recommendation. Once you have saved recommendation information, an email request will be sent automatically to the recommender on your behalf. Please advise your recommender to look for this email in their inbox, as well as their spam or junk-mail folder.

TOEFL, TOEFL AT HOME EDITION, IELTS, OR DUOLINGO (for international students) Upload scanned copies of score sheet in Academic History Section

All non-native English speakers must be proficient in English. Many of our students score 100 or above for TOEFL; 7.0 or above for IELTS; and 120 or above for Duolingo.

You must submit your official test scores by the application deadline. It can take a few weeks for your scores to be sent and processed, so please plan accordingly. On your application, you must enter current TOEFL or IELTS scores in the Academic History section of your application.

- Note about Duolingo scores: You cannot enter your scores in the Academic History section of the application. You can upload scanned copies copies of your scores and we will use these as official scores until the official scores arrive. These scanned copies should be uploaded in the Program Materials section of your application.

For TOEFL, our school code is 1324. For the department codes go to this link. If the program is not listed, use the department code of 60. For IELTS, you will send scores to "Indiana University, Bloomington - Office of International Admissions". For Duolingo, you will send your scores to "Indiana University - Undergraduate/Graduate".

If you are applying to an M.S. program, you are required to submit English proficiency test scores. However, if you have earned a degree from a U.S. university, the English proficiency requirement will be waived for M.S. applicants.

If you are applying to a Ph.D. program, you are required to submit English proficiency scores regardless of any previous university location.

PROGRAM SPECIFIC QUESTIONS/DOCUMENTS (Program Materials section)

The Program Materials section of the IU Graduate CAS application system is specific to the program to which you are applying. You will need to complete the Program Materials section for each program you apply to at the Luddy School.

PORTFOLIO, required for all HCI applicantsupload in Program Materials section

Applying to the Human Computer Interaction MS and the Informatics Ph.D. Human Computer Interaction Design programs requires the submission of a portfolio. Your portfolio should show you best work. You do not need to sow design work, if that is not your best work. An applicant with a software engineering background might submit a system; one with a literature background might submit a critical essay; one with a business background might submit a business plant. Focus on quality, rather than quantity. Portfolios can be submitted only once. No revisions or updates will be allowed.

GRE OFFICIAL TEST SCORES, optional (Academic History Section)

The submission of GRE scores is optional. If you wish to submit test scores, please use 1324 for the institution code and 0000 for the department code. GRE scores must have been earned within the past five years.

APPLICATION REVIEW and NOTIFICATION

The admissions committee will review only completed applications. The review process takes several weeks. Decisions should be rendered by mid-March via email.

DECISION DEADLINE FOR ADMITTED STUDENTS - APRIL 15

Admitted students will have until April 15 to accept our office. This is the spirit of the Council of Graduate School Resolution. If the student has not accepted our offer by April 15, we will withdraw our offer of acceptance.

FINANCIAL AWARDS

All completed applications reviewed by the admissions review committee are considered for financial awards which the Luddy School may be offering. If you are admitted, the admit letter will detail the financial award, if any. Every year we have limited funds to distribute. The majority of our master's students receives no funding. Some students find part-time employment to help offset the cost of their education, to gain experience in their field of study, or simply to earn some money. Ph.D. students receive an appointment as as Assistant Instructor or Research Assistant stipend, tuition fee remission, health insurance, and a travel allowance.

UNIVERSITY GRADUATE SCHOOL FELLOWSHIPS AND AWARDS

The University Graduate School offers several internal and external fellowships and awards. The application process and deadlines vary by fellowship and award, so be sure to read the requirements carefully.

TUITION AND FEES

Indiana University is committed to keeping its degrees affordable for in-state and out-of-state students. We encourage you to review the Office of the Bursar's listing of tuition and fees and mandatory fees. To determine approximate enrollment costs, use the tuition estimator by selecting the term, residency, level, program, and number of hours to estimate the cost of tuition and associated fees. For international students, the Office of International Services outlines the tuition and fees for International students.

CONTACT INFORMATION AND RESOURCES

Luddy Homepage - information on all programs, faculty, research, and happenings at the Luddy School of Informatics, Computing, and Engineering

The Luddy "How to Apply" page contains the most up-to-date and comprehensive information regarding each step of the admissions process. Read in its entirety and use the included Application Checklist when completing your application. Any admissions questions not covered in our "How to Apply" content, email goluddy@iu.edu.

To get a glimpse into our programs, watch this video.

For a link to our Data Science Residential resource page, please check out this page.

Questions regarding immigration, financial documentation, 120, etc., email newtoiu@indiana.edu

We have a great school with lots of opportunities for students and we hope you will consider applying to our program. We look forward to hearing from you. Please email us at goluddy@iu.edu if you have any questions.

Courses

Computer Science

Data Science

Engineering

Informatics

Information and Library Science

Computer Science

CSCI-A courses are non-major courses and are listed first regardless of the course level.

CSCI-A 592 Introduction to Software Systems (3 cr.) Programming experience recommended.
Design of computer software systems and introduction to programming. Topics include the C++ programming language and its data structure facilities; building and maintaining large projects; shell tools and system calls. Introduction to object-oriented programming. Lecture and laboratory. Credit given for only one of CSCI-A 592, CSCI-C 212 or CSCI-H 212

CSCI-A 504 Introductory C++ Programming (2 cr.) Programming experience recommended. Topics include aspects of C++ that are not object-oriented, basic data structures, standard libraries, and Unix tools for project management. Credit given for only one of CSCI-A 504, A 304, A 597, A 592, C 212, or BUS-K 201.

CSCI-A 506 Object-Oriented Programming in C++ (2 cr.) CSCI-A 201, A 304, A 504, or A 597 recommended. Topics include objects, classes, encapsulation, inheritance, polymorphism, templates and exceptions. Credit given for only one of CSCI-A 506, A 306, A 202, A 592, A 598, or C 212.

CSCI-A 521 Computing Tools for Scientific Research (3 cr.) MATH-M 118 or higher and MATH-M 211 recommended. Introduction to computer-based tools useful for analysis and understanding of scientific data. Basic methods of computation, data processing, and display systems such at Matlab combined with elementary practical C/C++ programming. Techniques to support customized scientific research tasks, with particular emphasis on biological, neural, and behavioral sciences. Lecture and laboratory.

CSCI-A 538 Network Technologies and Systems Administration (3 cr.) CSCI-A 110, EDUC-W 200, or equivalent computer literacy recommended. Introduction to network principles and current network technology, both hardware and software. Network administration tools and techniques. Laboratory provides practical experience. Credit not given for CSCI-A 547 and A 538.

CSCI-A 541 Computing and Technology Bootcamp (3 cr.) Basic mathematical and scientific sophistication, on par with basic introductory college level math and science courses recommended. A high-level introduction to the many information technologies that underlie modern society for students with non-technical backgrounds. Examples include basic ideas in computing, networking, embedded systems, GPS, SCADA , algorithms and machine learning. After completion, students should be able to partake in many high-level discussions with technical leads.

CSCI-A 542 Technical Foundations of Cybersecurity (3 cr.) P: CSCI-A 541. This course will enable students to build a technical foundation in cybersecurity by introducing concepts in secure systems design, cryptography, operating systems security, software security, and computer network security. The course will focus on developing a theoretical understanding of cybersecurity concepts and the ability to apply these concepts in practice.

CSCI-A 546 User-Interface Programming (3 cr.) CSCI-A 201, A 202, A 306, C 212, A 506, A 597, A 598, or equivalent experience recommended. Learn to prototype and build graphical user interfaces for computer applications. Contemporary software design methodology. Students design and implement prototype interfaces to applications provided by the instructor. Extensive use will be made of both commercial and experimental software tools. Credit not given for both CSCI-A 546 and A 346.

CSCI-A 548 Mastering the World-Wide Web (3 cr.) Two semesters of programming experience or equivalent, and some knowledge of operating systems recommended. Project-oriented course leading to ability to maintain a web site with full functionality. Topics include background on internet network protocols and programming, web server

administration, advanced web design and authoring, web protocols, interfacing services into the web. Credit not given for both CSCI-A 548 and A 348.

CSCI-A 581 Introduction to Computers and Programming (3 cr.) This course is an introduction, broadly, to algorithmic thinking and, specifically, to programming. It teaches the basics of programming using real world applications in natural, physical and social sciences. Students will develop ability to program by identifying problems in real world and then creating a program that solves the problem. Credit given for only one of CSCI-A 581, A 591, C 200, C 211, H 200, or H 211.

CSCI-A 590 Topics in Programming (1-2 cr.) Eight-week courses designed to provide foundations for using modern programming tools for applications and web development. May be repeated for a maximum of 6 credit hours.

CSCI-A 591 Introduction to Computer Science (3 cr.) A first course in computer science for those intending to take advanced computer science courses. Introduction to programming and to algorithm design and analysis. Using the Scheme programming language, the course covers several programming paradigms. Lecture and laboratory. Credit given for only one of CSCI-A 581, A 591, C 200, C 211, H 200, or H 211.

CSCI-A 593 Computer Structures (3 cr.) CSCI-A 592 recommended. Structure and internal operation of computers. The architecture and assembly language programming of a specific computer are stressed, in addition to general principles of hardware organization and low-level software systems. Lecture and laboratory. May be applied toward the Ph.D. minor. Credit given for only one of CSCI-A 593, C 335, or H 335.

CSCI-A 594 Data Structures (3 cr.) CSCI-C 241, CSCI-A 592 and A 593 recommended. Systematic study of data structures encountered in computing problems; structure and use of storage media; methods of representing structured data; and techniques for operating on data structures. Lecture and laboratory. May be applied toward the Ph.D. minor. Credit given for only one of CSCI-A 594, C 343, or H 343.

CSCI-A 595 Fundamentals of Computing Theory (3 cr.) CSCI-C 212 and C 241 recommended. Fundamentals of formal language theory, computation models and computability, the limits of computability and feasibility, and program verification. May be applied toward the Ph.D. minor, graduate credit available for CS M.S. candidates with special permission. Credit not given for both CSCI-A 595 and B 401.

CSCI-A 596 Programming Languages (3 cr.) CSCI-A 593 and A 594 recommended. Systematic approach to programming languages. Relationships among languages, properties and features of languages, and the computer environment necessary to use languages. Lecture and laboratory. May be applied toward the Ph.D. minor. Credit given for only one of CSCI-A 596, B 521 or C 311.

CSCI-A 597 Introduction to Programming I (3 cr.) Fundamental programming constructs, including loops, arrays, classes, and files. General problem-solving techniques. Emphasis on modular programming, user-interface design, and developing good programming style. Not intended for computer science majors. Credit not given for both CSCI-A 597 and A 201.

CSCI-A 598 Introduction to Programming II (3 cr.) CSCI-A 597, A 201, A 504, or A 304 recommended. Advanced programming techniques: user-defined functions and types, recursion versus iteration, parameter-passing mechanisms. Classic abstract data types and algorithms. Programming style. Object-oriented programming. Not intended for computer science majors. Credit not given for both CSCI-A 598 and A 202.

CSCI-B 501 Theory of Computing (3 cr.) CSCI-C 241 and CSCI-C 343 recommended. Deterministic and nondeterministic automata, regular expressions, pumping lemmas; context-free languages, parsing, pushdown automata, context-sensitive languages, LBA, LR(k) languages, closure and decidability of language classes. Turing machines, random access machines, grammars, general recursive functions, equivalence of computation models, universal machines, relative computing. Unsolvability, semi-recursive sets, Rice's Theorem. Space and time complexity, NP completeness.

CSCI-B 502 Computational Complexity (3 cr.) P: CSCI-B 501. Study of computational complexity classes, their intrinsic properties, and relations between them. Topics include time and space computational complexity, reducibility and completeness of problems within complexity classes, complexity of optimization problems, complexity hierarchies, relativization of the P =? NP conjecture, parallel computation models and the class NC.

CSCI-B 503 Algorithms Design and Analysis (3 cr.) CSCI-C 343 recommended. Models, algorithms, recurrences, summations, growth rates. Probabilistic tools, upper and lower bounds; worst-case and average-case analysis, amortized analysis, dynamization. Comparison-based algorithms: search, selection, sorting, hashing. Information extraction algorithms (graphs, databases). Graphs algorithms: spanning trees, shortest paths, connectivity, depth-first search, breadth-first search. Credit not given for both CSCI-B 503 and B 403.

CSCI-B 504 Introduction to Cryptography (3 cr.) Familiar with basic algebra, combinatorics and probability theory recommended. The course provides students with a foundational introduction to cryptography. Students learn the basic primitives used in cryptography such as symmetric encryption, public-key encryption, message authentication codes, digital signatures, cryptographic hashes and related material. Computational aspects of modern cryptography are stressed, as are appropriate security models, and computational security reductions.

CSCI-B 505 Applied Algorithms (3 cr.) The course studies the design, implementation, and analysis of algorithms and data structures as applied to real world problems. The topics include divide-and-conquer, optimization, and randomized algorithms applied to problems such as sorting, searching, and graph analysis. The course teaches trees, hash tables, heaps, and graphs.

CSCI-B 510 Introduction to Applied Logic (3 cr.) Structures: relations between structures, term structures. Description: notation and meaning, substitution operations, first order formulas, database languages, program verification conditions, semantics valuation,

normal forms, quantifier reduction, axiomatic theories. Proof: resolution, sequential calculi, natural deduction, automated theorem proving, semantic completeness. Limits of formalization: compactness, undecidability of truth, undecidability of canonical theories, non-formalizability of database theory.

CSCI-B 521 Programming Language Principles (3 cr.) Systematic approach to programming languages. Relationships among languages, properties and features of languages, the computer environment necessary to support language execution. Credit given for only one of CSCI-B 521, A 596 or C 311

CSCI-B 522 Programming Language Foundations (3 cr.) P: CSCI-B 510 and B 521. Introduction to denotational, operational, and axiomatic approaches to programming language semantics. Semantic analysis of major programming language features. Logics of programs.

CSCI-B 524 Parallelism in Programming Languages and Systems (3 cr.) P: CSCI-B 521 and P 536. Fundamentals of parallel computation, with an emphasis on parallel programming methodology and programming languages. Topics include: Parallel algorithms. Major paradigms for parallel software construction: data parallelism, task/thread parallelism and CSP. Compiling programs for parallel computers.

CSCI-B 534 Distributed Systems (3 cr.) P: CSCI-P 536. B534 is a balanced treatment of fundamentals and practice of distributed systems. The foundational models, algorithms, and principles upon which distributed systems are based are studied in detail. These fundamentals are placed in the context of practical implementations by means of reading and critical analysis of research papers. Credit given for only one of CSCI-B 534 , P 434, ENGR-E 410, or E 510.

CSCI-B 541 Hardware System Design I (3 cr.) CSCI-C 335 and C-343 recommended. Structured approach to hardware design, exposing performance factors as well as target technologies and their influence on the design process. Basic training in the use of design and simulatin software. Lecture and laboratory. Credit not given for both CSCI-B 541 and B 441.

CSCI-B 543 Computer Architecture (3 cr.) CSCI-C 335 and C 343 recommended. Fundamentals of computer design, instruction processing and performance analysis. Architecture of single-processor systems, focusing on pipelining, memory and memory hierarchies, and interconnect technology. Exploration of architecture classes such as high-performance multiprocessors, massively parallel computers, embedded systems. Credit not given for both CSCI-B 543 and B 443.

CSCI-B 544 Security for Networked Systems (3 cr.) This course is an extensive survey of system and network security. Course materials cover the threats to information confidentiality, integrity and availability and the defense mechanisms that control such threats. The course provides the foundation for more advanced security courses and hands-on experiences through course projects.

CSCI-B 546 Malware Epidemic: Threat and Defense (3 cr.) One semester of programming or equivalent recommended. This course looks at systems and protocols, how to design threat models for them and how to use a large number of current security technologies and concepts to block specific vulnerabilities. Students will use a large number of systems and programming security tools in the laboratories.

CSCI-B 547 Systems and Protocol Security and Information Assurance (3 cr.) Some previous programming background and general computer networking and operating systems literacy recommended. This course covers the design and analysis of secure systems, including identifying security goals and risks, threat modeling, defense, integrating different technologies to achieve security goals, developing security protocols and policies, implementing security protocols and secure coding. Some real world scenarios that have many security requirements will be studied.

CSCI-B 548 Privacy in Pervasive Computing (3 cr.) This course prepares graduate students towards a successful research career in wearable and sensor-based computing. This course combines both lectures on the research process and student-led round-table discussions of seminal and influential papers in the field.

CSCI-B 551 Elements of Artificial Intelligence (3 cr.) CSCI-C 343 recommended. Introduction to major issues and approaches in artificial intelligence. Principles of reactive, goal-based, and utility-based agents. Problem-solving and search. Knowledge representation and design of representational vocabularies. Inference and theorem proving, reasoning under uncertainty, and planning. Overview of machine learning.

CSCI-B 552 Knowledge Based Artificial Intelligence (3 cr.) P: CSCI-B 551. Knowledge-based methods for artificial intelligence systems: knowledge representation, organization, and application. Typical content includes: Principles of memory organization, indexing and retrieval. Memory-based, analogical, and case-based reasoning. Applications to understanding, explanation, planning, and advisory systems.

CSCI-B 553 Neural and Genetic Approaches to Artificial Intelligence (3 cr.) P: CSCI-B 551. Approaches to the design of intelligent systems inspired by nervous systems, evolution, and animal behavior. Distributed and perceptually grounded representations. Temporal processing. Perception and action. Genetic search. Unsupervised and reinforcement learning. Comparison of symbolic, subsymbolic, and hybrid approaches to intelligence.

CSCI-B 554 Probabilistic Approaches to Artificial Intelligence (3 cr.) CSCI-B 403, MATH-M 301 and MATH-M 365 recommended. Theory and practice of computational and mathematical foundations of probabilistic models for artificial intelligence and other areas of computing. Topics include: random variables and independence; graphical models including Bayesian and Markov networks; exact and approximate inference algorithms; constrained, unconstrained and stochastic optimization algorithms; parameter and structure estimation; temporal models; applications.

CSCI-B 555 Machine Learning (3 cr.) Theory and practice of constructing algorithms that learn functions and choose optimal decisions from data and knowledge.

Topics include: mathematical/probabilistic foundations, MAP classification/regression, linear and logistic regression, neural networks, support vector machines, Bayesian networks, tree models, committee machines, kernel functions, EM, density estimation, accuracy estimation, normalization, model selection.

CSCI-B 557 Music Information Processing: Audio (3 cr.) This course discusses music analysis and processing problems that use sampled audio as the primary data representation. Digital signal processing is discussed, along with filtering and its relationship to Fourier techniques. Applications considered include score following, automatic music transcription and annotation from audio, musical accompaniment systems, and audio effects.

CSCI-B 561 Advanced Database Concepts (3 cr.) CSCI-C 241, C 335 and C 343 recommended. Database models and systems: especially relational and object-oriented; relational database design theory; structures for efficient data access; query languages and processing; database applications development; views. Transaction management: concurrency and recovery. Credit not given for both CSCI-B 561 and B 461.

CSCI-B 563 Bioinformatics Algorithms (3 cr.) Basic undergraduate algorithms and one programming class or equivalent programming experience in C/C++, Java, or Python recommended. No biology background will be assumed. This course is on algorithmic techniques for solving problems in molecular biology, genetics and genomics. It covers basic algorithmic/combinatorial optimization techniques for alignment, mapping, search and assembly of genomes, resolving mapping ambiguity and genotyping, modeling evolution of genomes (e.g. cancer genomes) and detecting structure and interaction partners of biomolecules.

CSCI-B 565 Data Mining (3 cr.) Algorithmic and practical aspects of discovering patterns and relationships in large databases. The course also provides hands-on experience in data analysis, clustering and prediction. Topics include: data preprocessing and exploration, data warehousing, association rule mining, classification and regression, clustering, anomaly detection, human factors and social issues in data mining.

CSCI-B 581 Advanced Computer Graphics (3 cr.) CSCI-C 343, MATH-M 301, or M 303 recommended. Introduction to graphics hardware and software. Two-dimensional graphics methods, transformations, and interactive methods. Three-dimensional graphics, transformations, viewing geometry, object modeling and interactive manipulation methods. Basic lighting and shading. Video and animation methods. Credit not given for both CSCI-B 581 and B 481.

CSCI-B 582 Image Synthesis (3 cr.) P: CSCI-B 581. MATH-M 215 recommended. Raster image display: color theory, gamma correction, and filtering. Advanced shading methods: local illumination models, global illumination models. Surface display, including ray tracing and Z-buffering. Solid modeling; spline surfaces, CSG, superquadrics, and deformations. Scientific visualization: isosurfaces and volume rendering.

CSCI-B 590 Topics in Computer Science (1-6 cr.) Special topics in computer science. May be repeated 2 times for a maximum of 6 credit hours.

CSCI-B 599 Teaching in Computer Science (1 cr.) General principles of teaching and practical experiences that relate to teaching computer science. An important feature of the course is the micro-teaching, in which each participant prepares and delivers short lectures to the seminar participants. Each presentation is followed by critical analysis and discussion.

CSCI-B 603 Advanced Algorithms Analysis (3 cr.) P: CSCI-B 503. Advanced topics in analysis of algorithms, including fast algorithms for classical problems, lower bounds results, and statistical behavior.

CSCI-B 607 Philosophy of Computation (3 cr.) Permission of instructor. Critical examination of the conceptual foundations of computing. Several different views assessed with respect to conceptual, explanatory, and empirical criteria. Primary focus on formal symbol manipulation, recursive function theory, effective computability, computational complexity, digitality, and information processing. Some non-standard approaches also considered: connectionism, dynamics, and artificial life.

CSCI-B 609 Topics in Algorithms and Computing Theory (1-6 cr.) Special topics in algorithms and computing theory. May be repeated 2 times for a maximum of 6 credit hours.

CSCI-B 619 Topics in Applied Logic (1-6 cr.) Special topics in applied logic.

CSCI-B 621 Advanced Concepts in Programming Languages (3 cr.) P: CSCI-B 521. Discussion of current issues in the design of programming languages. Modularity, abstraction, and static analysis. Applicative and nonapplicative models. Single and multiple processing.

CSCI-B 622 Programming Language Type Systems (3 cr.) P: CSCI- B 521. Theoretical foundations and engineering techniques for modern type systems, focusing on polymorphism and subtyping in typed lambda-calculi; applications, including type systems for objects, abstract data types, and modules; issues in type checker implementation and polymorphic type inference.

CSCI-B 629 Topics in Programming Languages (1-6 cr.) Special topics in programming languages. May be repeated 1 time for a maximum of 6 credit hours.

CSCI-B 639 Topics in Software (1-6 cr.) Special topics in software systems. May be repeated 2 times for a maximum of 12 credit hours.

CSCI-B 644 Very Large Scale Integration (3 cr.) P: CSCI-B 541. Basic theory and practice required to convert hardware algorithms and architecture to silicon structures. Use of state-of-the-art design tools for integrated circuits.

CSCI-B 649 Topics in Systems (1-6 cr.) Special topics in systems. May be repeated 1 time for a maximum of 12 credit hours.

CSCI-B 651 Natural Language Processing (3 cr.) P: CSCI-B 551, B 552, or B 553. Theory and methods

for natural language processing. Algorithms for sentence parsing and generation. Context-free and unification grammars. Question-and-answer systems. Analysis of narratives. Finite-state approaches to computational phonology and morphology. Machine translation. Machine learning of natural language. Speech recognition. Neural-network and statistical alternatives to symbolic approaches.

CSCI-B 652 Computer Models of Symbolic Learning (3 cr.) P: CSCI-B 552. Symbolic artificial intelligence methods for learning. Inductive and explanation-based generalization. Failure-driven learning. Case-based learning. Typical content includes: Operationality of explanations and utility of learning. Goal-driven learning. Criteria for when, what, and how to learn. Learning in integrated architectures.

CSCI-B 656 Web Mining (3 cr.) Machine learning techniques to mine the Web and other unstructured/ semistructured, hypertextual, distributed information repositories. Crawling, indexing, ranking and filtering algorithms using text and link analysis. Applications to search, classification, tracking, monitoring, and Web intelligence. Group project on one of the topics covered in class.

CSCI-B 657 Computer Vision (3 cr.) P: CSCI-B 551. Concepts and methods of machine vision as a branch of artificial intelligence. Basics of digital image processing. Local and global tools for deriving information from image data. Model-based object recognition and scene understanding.

CSCI-B 659 Topics in Artificial Intelligence (1-6 cr.) Special topics in artificial intelligence. May be repeated for a maximum of 12 credit hours.

CSCI-B 661 Database Theory and Systems Design (3 cr.) P: CSCI-B 561. Theory and methods for natural language processing. Algorithms for sentence parsing and generation. Context-free and unification grammars. Question-and-answer systems. Analysis of narratives. Finite-state approaches to computational phonology and morphology. Machine translation. Machine learning of natural language. Speech recognition. Neural-network and statistical alternatives to symbolic approaches.

CSCI-B 662 Database Systems and Internal Design (3 cr.) P: CSCI-B 561. This course deals with database management systems and their modern applications. We will discuss various issues to be considered and design decisions to be made in these systems. Topics include storage management, access methods, query processing and optimization strategies, concurrently control techniques, data warehousing, data mining, semi-structured data management, etc.

CSCI-B 665 Software Engineering Management I (3 cr.) P: CSCI-B 561 or BUS-S 560. Symbolic artificial intelligence methods for learning. Inductive and explanation-based generalization. Failure-driven learning. Case-based learning. Typical content includes: operationality of explanation and utility of learning. Goal-driven learning. Criteria fo when, what, and how to learn. Learning in integrated architectures.

CSCI-B 666 Software Management Implementation II (1-3 cr.) P: CSCI-B 665. Continuation of projects from CSCI-B 665. Periodic reports and a final paper required. If taken for two or more credits, an additional project or paper is required.

CSCI-B 669 Topics in Database and Information Systems (1-6 cr.) Special topics in database and information systems. May be repeated for a maximum of 12 credit hours.

CSCI-B 673 Advanced Scientific Computing (3 cr.) P: CSCI-P 573. MATH-M 471 recommended. Multiprocessor organization: vectorization, memory organization, processor topologies and architectures. Models of parallelism. Programming language and systems for scientific and high performance computing. Environments for interactive scientific experiments and databases. Distributed programming tools. Parallelism in scientific problems: Parallel algorithmic techniques, parallel algorithms and models, parallel performance analysis and debugging.

CSCI-B 679 Topics in Scientific Computing (1-6 cr.) Special topics in scientific computing. May be repeated 1 time for a maximum of 12 credit hours.

CSCI-B 689 Topics in Graphics and Human Computer Interaction (1-6 cr.) Special topics in graphics and human computer interaction. May be repeated for a maximum of 6 credit hours.

CSCI-B 690 Research Topics in Computer Science (1-6 cr.) Research topics in computer science. May be repeated 2 times for a maximum of 6 credit hours.

CSCI-C 532 Navy Cyber Operations (3 cr.) Students in Navy MSc. Introduce students to basic computing and networking infrastructure, the ubiquity of computing and networks in the modern battlefield, and core principles of cybersecurity. Understanding digital terrain, its relation to traditional battlefields, and intelligence and joint targeting. All previous topics will be combined to discuss CyberOperation Planning, attacking and defending.

CSCI-C 533 Applied Secure Networking Operations and Forensics (3 cr.) Students in Navy MSc. Secure network and systems operations, defense and forensics. Students will explore a variety of topics such as threat analysis, victim categorization, and mitigation effectiveness. Students will practice hands¬on design, deployment, and use, of network attack monitoring and mitigation capabilities. Network and systems forensics techniques and tools will be introduced.

CSCI-P 515 Specification and Verification (3 cr.) CSCI-C 311 recommended. Tools and techniques for rigorous reasoning about software and digital hardware. Safety, reliability, security, and other design-critical applications. Decision algorithms, projects involving the use of automated reasoning, such as model checkers, theorem provers, and program transformation. Credit not given for both CSCI-P 515 and P 415.

CSCI-P 523 Programming Language Implementation (3 cr.) P: CSCI-B 521. Implementation of traditional and nontraditional computer programming languages. Compilation, including lexical analysis, parsing, optimization, code generation, and testing. Run-time support, including run-time libraries, storage management, input-output. Comparison of implementation techniques.

Extensive laboratory exercises. Credit given for only one of CSCI-P 523, P 423, ENGR-E 313, or E 513.

CSCI-P 532 Object-Oriented Software Development (3 cr.) Proficiency in Java recommended. This course will help turn motivated students into superior contributors to any small- to mid-sized commercial or open-source software project. It takes a hands-on, learning-by-doing approach. Students are introduced to design patterns, tools, and teamwork strategies from the first assignment to the last project.

CSCI-P 535 Pervasive Computing (3 cr.) Object oriented programming recommended. Topics in pervasive computing, such as: sensors, mobility, tangibles, ambient displays, middleware, location and context-awareness. User-centered design methods, such as: requirements gathering, design, prototyping and evaluation. Labs cover current technologies, such as sensors and mobile devices. Lecture and laboratory.

CSCI-P 536 Advanced Operating Systems (3 cr.) CSCI-C 335 and C 343 recommended. Advanced topics in operating systems, such as: multi-tasking, synchronization mechanisms, distributed system architecture, client-server models, distributed mutual exclusion and concurrency control, agreement protocols, load balancing, failure recovery, fault tolerance, cryptography, multiprocessor operating systems. Credit given for only one of CSCI-P 536, P 436, ENGR-E 319, or E 519.

CSCI-P 538 Computer Networks (3 cr.) Operating systems or networking course recommended. Layered TCP/IP architecture. LAN technologies (Ethernet, wireless, token ring). Switching. Internet addressing (IPv4, IPv6). Routing protocols. Congestion control (TCP, UDP). Applications (DNS, HTTP, peer-to-peer networks). Selection of topics including DHCP, ICMP, VPNs, multicast, security. Credit given for only one of CSCI-P 538, P 438, ENGR-E 318, or E 518.

CSCI-P 542 Hardware System Design II (3 cr.) P: CSCI-B 541. Lab fee. Structured approach to hardware design, exposing performance factors as well as target technologies and their influence on the design process. Basic training in the use of design and simulation software. Lecture and laboratory.

CSCI-P 545 Embedded and Real-Time Systems (3 cr.) Any 400-level “systems” course (middle digit 3 or 4) recommended. Design and implementation of purpose-specific, locally distributed software systems. Models and methods for time-critical applications. Real-time operating systems. Testing, validation, and verification. Safety-critical design. Related topics, such as resiliency, synchronization, sensor fusion, etc. Lecture and laboratory.

CSCI-P 556 Applied Machine Learning (3 cr.) The main aim of the course is to provide skills to apply machine learning algorithms on real applications. We will consider fewer learning algorithms and less time on math and theory and instead spend more time on hands-on skills required for algorithms to work on a variety of data sets.

CSCI-P 565 Software Engineering I (3 cr.) CSCI-C 343 recommended. Analysis, design and implementation of software systems. Requirements specification: data and process modeling. Software design methodologies. Software quality assurance: testing and verification. Software development processes. Credit not given for both CSCI-P 565 and P 465.

CSCI-P 566 Software Engineering II (3 cr.) P: CSCI-B 561. Analysis, design and implementation of software systems. Requirements specification: data and process modeling. Software design methodologies. Software quality assurance: testing and verification. Software development processes. Credit not given for both CSCI-P 566 and CSCI-P 466.

CSCI-P 573 Scientific Computing (3 cr.) CSCI-C 212, MATH-M 301 or M 303 and M 343 recommended. For students from all scientific, engineering, and mathematical disciplines, this course provides an overview of computer hardware, software, and numerical methods that are useful on scientific workstations and supercomputers. Topics include high-performance computer architectures, software tools and packages, characteristics of numerical methods in common use, graphical presentation of results, and performance analysis and improvement.

CSCI-P 632 Object-Oriented Software Management (3 cr.) Permission of instructor. This course will help turn motivated students into superior managers of any small- to mid-sized commercial or open-source software project. It takes a hands-on, learning-by-doing approach. Students are introduced to the main management concerns of managing smallish design and development teams.

CSCI-T 599 Topics in Computer Science Education (1-6 cr.) Special topics in Computer Science education. May be repeated 2 times for a maximum of 12 credit hours.

CSCI-Y 790 Graduate Independent Study (1-6 cr.) Independent study under the direction of a faculty member, culminating in a written report. The different departmental options for independent study are: Research and Reading, Software System Development, Master's Research Project, Master's Software Project, and a University Master's Thesis. May be repeated for a maximum of 9 credit hours.

CSCI-Y 791 Graduate Independent System Development (1-6 cr.) System development culminating in written report and a publicly available system. May be repeated for credit.

CSCI-Y 792 Master's Thesis (1-6 cr.) Readings and research under the supervision of the master's thesis advisor, leading to a thesis at a level admissible as a departmental technical report. May be repeated for a maximum of 6 credit hours of CSCI-Y 792 and Y 793.

CSCI-Y 793 Master's Software Thesis (1-6 cr.) A major software development project, possibly performed jointly with other students, documented in the public domain and with final approval by three graduate faculty. May be repeated for a maximum of 6 credit hours of CSCI-Y 792 and Y 793.

CSCI-Y 798 Professional Practicum/Internship (0-6 cr.) Current enrollment in graduate degree program in computer science. Provides for participation in graduate level professional training and internship experience.

CSCI-Y 799 Computer Science Colloquium (1 cr.) A series of talks by researchers in computer science and

closely related areas presenting their recent research. A minimum of 75% attendance and course work in the form of a written report based on the talk by any colloquium speaker are required for credit. May be repeated for a maximum of 3 credit hours.

CSCI-Y 890 Thesis Readings and Research (1-12 cr.) Research under the direction of a member of the graduate faculty leading to a Ph.D. dissertation.

CSCI-G 901 Advanced Research (6 cr.) Ph.D. dissertation research after the completion of all course requirements. May be repeated a maximum of 6 times.

Data Science

DSCI-D 532 Applied Database Technologies (3 cr.) This course aims to provide the basic overview of the current database landscape, starting with relational databases, SQL, and moving to several different NoSQL databases, such as XML database, MongoDB, Neo4j, Cassandra, and HBase.

DSCI-D 590 Topics in Data Science (1-3 cr.) Must be a student in the Data Science graduate program or instructor's permission. Variable topic. Emphasis on new developments and research in Data Science. May be repeated with different topics 3 times for a maximum of 12 credit hours.

DSCI-D 591 Graduate Internship (0-3 cr.) Department Approval. Students gain professional work experience in an industry or research organization setting using skills and knowledge acquired in Data Science coursework. A written report will be required upon completion of the experience. May be repeated for a maximum of 6 credit hours.

DSCI-D 592 Data Science in Practice (3 cr.) Students are organized into teams to carry out real world projects in conjunction with project sponsors, while learning about methodologies for data science consulting.

DSCI-D 699 Graduate Independent Study in Data Science (1-6 cr.) Must be a student in the Data Science graduate program. Independent Study under the direction of a faculty member, culminating in a written report and/or database development and/or documented laboratory experience. May be repeated 2 times for a maximum of 9 credit hours.

Engineering

ENGR-E 500 Introduction to the Intelligent Systems Engineering Program (1 cr.) This course provides an introduction to Intelligent Systems Engineering and an overview of the various degree specializations that are available. ISE is a set of modern Systems Engineering areas with various interrelations. This course provides a broad introduction and details of faculty research areas.

ENGR-E 501 Introduction to Computer Engineering (3 cr.) This course covers computer engineering and parallel computer architecture for HPC in intelligent systems engineering. Topics include multi-core processors, cache coherence, data centric computing, SIMD, GPU, FPGA, accelerators, and heterogeneous computing architecture. The course will focus on fundamental parallel computer architectures, evaluation and the tradeoffs in design, and their use.

ENGR-E 502 Introduction to Cyber Physical Systems (3 cr.) This covers a broad range of CPS with both uses and component technologies. Robots and Smart systems are covered in some detail. Algorithms, security, control theory, software, device hardware and mechanical construction issues are covered. CPS laboratory experience will be an essential part of course. Current research opportunities are covered.

ENGR-E 503 Introduction to Intelligent Systems (3 cr.) Systems Engineering (SE) can refer to several different concepts, disciplines, and technical skills needed in designing and building systems of systems. This course covers fundamental principle and five use cases with special attention to challenges and opportunities coming from modern computing infrastructure, the internet of things and artificial intelligence.

ENGR-E 504 Introduction to Bioengineering (3 cr.) The course introduces the fields of bioengineering and biomedical engineering. Topics include biofabrication, biomanufacturing, bioinstrumentation, drug discovery and delivery, cellular and molecular bioengineering, with a focus on design of different types of instruments and sensors. How to merge the disciplines of engineering and biology for biomedical applications will be discussed. Credit not given for both ENGR-E 504 and E 304.

ENGR-E 505 Introduction to Nano-Engineering (3 cr.) Miniaturization of devices and systems to nanoscale boosted in the last couple of decades, enabling unattainable hitherto functionalities and bridging the quantum realm with the mainstream of technological paradigm. Current course provides a broad overview of the scientific background as well as the cutting-edge technological achievements of engineering on nanoscale.

ENGR-E 506 Introduction to Neuro-Engineering (3 cr.) One programming course, linear algebra and calculus are required. One AI or Machine Learning course recommended. Understand concepts of neuro-engineering with an applied mathematics focus. Learn the principles of building intelligent machines for neuro-engineering. This is an introductory course to ISE Masters and Ph.D. program in Neuro-Engineering. It will have guest lectures, and the basic material will be interleaved with talks on relevant Bloomington campus research.

ENGR-E 507 Introduction to Environmental Engineering Intelligent Systems (3 cr.) Develop a foundation in Environmental Engineering practices and challenges by exploring how engineered systems promote better predictions about water quality, climate and atmospheric conditions. This course will cover fundamental principles and three use cases to examine unique challenges and opportunities stemming from data analytics, internet of things and modern computing.

ENGR-E 510 Engineering Distributed Systems (3 cr.) Distributed systems are collections of independent elements that appear to users as a single system. This course considers fundamental principles in distributed system construction and explores the history of such systems from distributed operating systems to modern middleware and services. Examples and exercises from

current distributed systems. Credit given for only one of ENGR-E 510, E 410, CSCI-P 434, or B 534.

ENGR-E 511 Machine Learning for Signal Processing (3 cr.) Students should be accustomed to Calculus, Linear Algebra, Probability Theory, CSCI-B 555 and one of the scientific programming languages, MATLAB, Python, or R. The course discusses advanced signal processing topics as an application of machine learning. Hands-on signal processing tasks are introduced and tackled using a problem-solving manner, so students can grasp important machine learning concepts. The course can help students learn to build an intelligent signal processing system in a systematical way.

ENGR-E 512 Advanced Computer Architecture (3 cr.) ENGR-E 501 recommended. The course will cover advanced computer architecture topics for data centers regarding multi-core processor hardware, circuit level and micro-architecture level main memory modeling, circuit level and micro-architecture level storage design, GPU architecture, processing-in/near-memory, (convolutional neural network) accelerator design and data center architecture.

ENGR-E 513 Engineering Compilers (3 cr.) This course covers the engineering of a compiler, from scanning to parsing, semantic analysis and transformations to code generation and optimization. The emphasis of this course is on the hands-on implementations of various components using industry-standard tools. Credit given for only one of ENGR-E 513, E 313, CSCI-P 423, or P 523.

ENGR-E 514 Embedded Systems (3 cr.) This course covers Embedded and Real-Time Systems designed for real-time multiprocessing and distributed processing. It discusses theoretical and practical concepts in real-time systems emphasizing both hard and soft real-time distributed multi-processing. Several operating systems (e.g. Xinu, Linux, VxWorks), computer architectures and process scheduling methods will be used to illustrate concepts. Credit not given for both ENGR-E 514 and E 314.

ENGR-E 516 Engineering Cloud Computing (3 cr.) Experience with Windows or Linux using Java and scripts. This course covers basic concepts on programming models and tools of cloud computing to support data intensive science applications. Students will get to know the latest research topics of cloud platforms, parallel algorithms, storage and high level language for proficiency with a complex ecosystem of tools that span many disciplines.

ENGR-E 517 High Performance Computing (3 cr.) Beginner/intermediate C/C++ experience and familiarity with Linux/Unix command-line utilities recommended. Students will learn about the development, operation, and application of HPC systems prepared to address future challenges demanding capability and expertise. The course combines critical elements from hardware technology and architecture, system software and tools, and programming models and application algorithms with the cross-cutting theme of performance management and measurement. Credit not given for both ENGR-E 517 and E 317.

ENGR-E 518 Engineering Networks (3 cr.) This course will cover the engineering of computer networks, considering the architecture and protocols. This course focuses on hands-on implementation and network systems construction. Credit given for only one of ENGR-E 518, E 318, CSCI-P 438, or P 538.

ENGR-E 519 Engineering Operating Systems (3 cr.) Programming experience in C recommended. The objective of this class is to learn the fundamentals of computer operating systems. This class approaches the practice of engineering an operating system in a hands-on fashion, allowing students to understand core concepts along with implementation realities. Credit given for only one of ENGR-E 519, E 319, CSCI-P-436 or P 536.

ENGR-E 522 HPC and Cloud Computing for Large Scale Image Applications (3 cr.) ENGR-E 534, SPEA-E 519, GEOG-G 535, or GEOG-538 recommended. Java and Python will be used as programming languages. Understanding of machine learning and/or image processing is helpful. This course describes big data techniques for sensors and remote sensing explaining how one architects analysis systems for sensors and remote imagery. Algorithms, software systems, and storage issues are addressed. The impact of user interfaces is covered. Streaming and batch examples from satellite, internet of things and physics data.

ENGR-E 523 Internet of Things (3 cr.) Java, C, and Python will be used as programming languages. This course covers the Internet of Things (IoT) including the emerging Industrial IoT. Power, security, networking, system architecture from cloud to device are covered. Integration with big data and use cases are discussed. Laboratory sessions are integrated.

ENGR-E 531 Physical Optimization (3 cr.) Java and/or Python will be used as programming languages. This course describes applications of optimization based on physical analogies: genetic algorithms, swarm intelligence, simulated and deterministic annealing, neural networks. They are related to statistical physics, variational methods, evolution, information theory, agent-based systems, cellular automata, complex systems and placed in a broad context of physical computation and other optimization approaches.

ENGR-E 532 Systems Engineering (3 cr.) Python will be used as programming language. This course covers methodologies and tools used to deal with large complex interactive multi-disciplinary systems of systems and to deliver performance that meet user requirements in an eco-friendly fashion. Students will see several examples and apply SE to an example of their own.

ENGR-E 533 Deep Learning Systems (3 cr.) This course teaches the pipeline for building state-of-the-art deep learning-based intelligent systems. It covers general training mechanisms and acceleration options that use GPU computing libraries and parallelization techniques running on high performance computing systems. The course also aims at deploying the networks to the low-powered hardware systems.

ENGR-E 534 Big Data Applications (3 cr.) Java and/or Python will be used as programming languages. This is an overview course of Big Data Applications covering a broad range of problems and solutions. It covers cloud computing technologies and includes a project. Algorithms

are introduced and illustrated. Credit given for only one of ENGR-E 534, E 434, INFO-I 423, or I 523.

ENGR-E 535 Image Processing for Medical Applications (3 cr.) One programming course, linear algebra and calculus are required. Any machine learning or computer vision course would be helpful, but not necessary. Learn how to build intelligent algorithms and software for medical imaging that can help medical doctors to treat their patients and researchers to understand how the body works. Students will be familiarized with algorithmic techniques such as tracking, denoising, warping, segmentation, model fitting, optimization and interactive visualization of medical datasets.

ENGR-E 536 High Performance Graph Analytics (3 cr.) P: Python and C++ recommended. This course covers theoretical and practical concepts in graph analytics, with applications to social networks, computational biology, machine learning and scientific computing. It will demonstrate graph algorithms by analyzing large-scale social and biological networks using high-performance graph analytics frameworks. Design principles for efficient graph algorithms will be discussed.

ENGR-E 537 Rapid Prototyping for Engineers (3 cr.) Permission of instructor. Protoyping - materialization of concepts - is essential for design and engineering of a product. The course overviews the modern computer aided design (CAD) - computer aided manufacturing (CAM) approach to prototyping. Students will perform a case study practicum, characterizing performance envelope of fused deposition modeling (FDM) 3D printer.

ENGR-E 538 REVERSE ENGINEERING EMBEDDED SYSTEMS (3 cr.) This course provides an introduction to embedded systems reverse engineering. Focus is on the process of reverse engineering using tools and techniques relevant to embedded systems. The course will explore embedded systems architectures, from those based on 8-bit microcontrollers to those based on microprocessors running embedded multitasking operating systems. Credit not given for both ENGR-E 538 and E 438.

ENGR-E 540 Computational Methods for 3-D Biomaterials (3 cr.) This computational engineering course teaches key biophysics and numerical concepts needed to simulate 3-D biological tissues, including finite element methods, conservation laws, biotransport, fluid mechanics, and tissue mechanics. The entire course will combine lectures with hands-on lab projects to simulate 3-D biological materials, and prepare students for computational tissue engineering. Credit not given for both ENGR-E 540 and E 440.

ENGR-E 541 Simulating Cancer as an Intelligent System (3 cr.) Familiarity with advanced engineering mathematics. This course explores cancer as an adaptive intelligent system, where renegade cells break the rules, reuse the body's natural processes to re-engineer their environments and evade treatments. We will use computational models to explore this system and the potential for future clinicians to plan treatments with data-driven models. Credit not given for both ENGR-E 541 and E 441.

ENGR-E 542 Introduction to Computational Bioengineering (3 cr.) This course introduces key computational modeling techniques for bioengineering, with a focus on cell population kinetics, cell signaling, receptor trafficking, pharmacokinetics/pharmacodynamics, and compartmental and systems physiology methods. Concepts in control theory and optimization will also be applied to steer the modeled biological systems towards design objectives. Credit not given for both ENGR-E 542 and E 340.

ENGR-E 543 Computational Modeling Methods for Virtual Tissues (3 cr.) Mechanism-based modeling of biological phenomena (virtual-tissues), a growing field, which addresses problems outside the reach of data-based methods. This project-based course includes modeling the biology of cell behaviors and interactions, formulation of meaningful quantitative models and translation into executable simulations, and will use Python scripting in the CC3D modeling environment. Credit not given for both ENGR-E 543 and E 443.

ENGR-E 545 Wearable Sensors (3 cr.) The purpose of this course is to give you hands-on experience with wearable sensors and a foundation to understand their design and operation. The course will also serve as a partial survey of sensor designs in human physiological and behavioral monitoring. Credit not given for both ENGR-E 345 and E 545.

ENGR-E 548 Computational Multicellular Systems Biology (3 cr.) This course covers agent-based modeling and multiscale simulation of multicellular biological systems. After introducing background biology, students explore examples in cancer, tissue engineering, bacterial consortia, and infectious diseases including SARS-Co-V-2 (COVID-19). Students showcase their final projects as interactive, cloud-hosted models. We also demonstrate using HPC and AI for large-scale studies. Credit not given for both ENGR-E 548 and E 448.

ENGR-E 551 Simulating Nanoscale Systems (3 cr.) Familiarity with a programming language recommended. Students will learn how to model and simulate material behavior at the nanoscale. Analysis and control of shape, assembly, and flow behavior in soft nanomaterials will be discussed. Applications to engineering problems at the nanoscale will be emphasized. Optimization methods, nonequilibrium systems, and parallel computing will be covered. Credit not given for both ENGR-E 551 and E 451.

ENGR-E 564 Functional Neuroimaging (3 cr.) Functional neuroimaging tools present researchers with an extraordinary opportunity to examine the neurobiological correlates of behavior, expanding research to areas like development, aging and neurological diseases. This course will discuss the physical principles, instrumentation and data analysis methods of the main neuroimaging techniques such as fMRI, NIRS, EEG/MEG, among others. Credit not given for both ENGR-E 564 and E 464.

ENGR-E 570 Advanced Bioengineering (3 cr.) P: ENGR-E 504. The course introduces tissue engineering and regenerative medicine, neuro-engineering, synthetic biology and computational synthetic biology. Each topic contains a discussion on how to alter and use biological systems for bioengineering applications. Credit not given for both ENGR-E 570 and E 470.

ENGR-E 571 Microfluidic Devices and Systems (3 cr.) This course gives a fundamental introduction to the science and technology of miniaturization and its applications in creating microfluidic and nanofluidic devices. It discusses methods, tools and measuring devices to design and create micro-/nano-systems, and biomedical applications of these devices and systems such as pressure sensors, mixing devices. Credit not given for both ENGR-E 571 and E 471.

ENGR-E 572 Biomedical Devices and Sensors (3 cr.) This course covers nano/micro design and fabrication, actuators, sensors, microfluidics, implanted devices, lab-on-a-chip devices, drug delivery systems, detection and measurement systems, and their biomedical applications relevant for clinical medicine, food safety, environmental health, and homeland security. The discussions and projects are designed to address practical problems with engineering solutions.

ENGR-E 583 Information Visualization (3 cr.) This course provides students with a working knowledge on how to visualize abstract information and hands-on experience in the application of this knowledge to specific domains, different tasks, and diverse, possibly non-technical users. Credit not given for both ENGR-E 583 and E 483.

ENGR-E 584 Scientific Visualization (3 cr.) Teaches basic principles of human cognition and perception; techniques and algorithms for designing and critiquing scientific visualizations in different domains (neuro, nano, bio-medicine, IoT, smart cities); hands-on experience using modern tools for designing scientific visualizations that provide novel and/or actionable insights; 3D printing and augmented reality deployment; teamwork/project management expertise. Credit not given for both ENGR-E 584 and E 484.

ENGR-E 591 Graduate Internship (1-6 cr.) Department approval. Students gain professional work experience in an industry or research organization setting, using skills and knowledge acquired in Intelligent Systems course work. May be repeated for a maximum of 6 credit hours.

ENGR-E 599 Topics in Intelligent Systems Engineering (1-3 cr.) Graduate standing. Variable topic course. Emphasis is on new developments and research in Intelligent Systems Engineering. May be repeated with different topics.

ENGR-E 616 Advanced Cloud Computing (3 cr.) Java and Python will be used as programming languages. This course describes Cloud 3.0 in which DevOps, Microservices, and Function as a Service is added to basic cloud computing. The discussion is centered around the Apache Big Data Stack and a major student project aimed at demonstrating integration of cloud capabilities.

ENGR-E 621 Software Defined Systems (3 cr.) P: ENGR-E 516 or E 616. Java and Python will be used as programming languages. This course describes the emerging world of distribute intelligent systems where each system component has internal and external sources of intelligence that are subject to collective control. Examples are given from computers, networks, vehicle systems, digital manufacturing, and robotics. Performance and fault tolerance and system management are discussed.

ENGR-E 623 Applied Streaming Data Systems (3 cr.) Java, C, and Python will be used as programming languages. This course covers the software and algorithm engineering of streaming data systems in the cloud with an emphasis on use in industry and the internet of things.

ENGR-E 687 Graduate Independent Studies in Intelligent Systems Engineering (1-6 cr.) Independent study under the direction of a faculty member, culminating in a written report and/or software development and/or systems/hardware development and/or documented laboratory experience. May be repeated for credit.

ENGR-E 788 Master's Thesis (1-6 cr.) Readings and research under the supervision of the master's thesis advisor, leading to a thesis at a level admissible as a departmental technical report. May be repeated for a maximum of 6 credit hours.

ENGR-E 790 Engineering Capstone Design I (1-3 cr.) This course is the first of two capstone offerings for Intelligent Systems Engineering students. Students will design engineering projects based on their areas of concentration, which will be supported by dedicated faculty members. Students may choose to conduct advanced research, develop prototypes, design new products or redesign existing products.

ENGR-E 791 Engineering Capstone Design II (1-3 cr.) This course is the second of two capstone offerings for Intelligent Systems Engineering students. Students will design engineering projects based on their areas of concentration, which will be supported by dedicated faculty members. Students may choose to conduct advanced research, develop prototypes, design new products or redesign existing products.

ENGR-E 890 Thesis Readings and Research (1-6 cr.) Department approval. Research under the direction of a member of the graduate faculty leading to a Ph.D. dissertation. May be repeated for a maximum of 6 times or 36 credit hours.

ENGR-G 901 Advanced Research (6 cr.) Ph.D. dissertaion research after the completion of all course requirements. May be repeated a maximum of 6 times.

Informatics

INFO-I 500 Fundamental Computer Concepts for Informatics (3 cr.) An introduction to fundamental principles of computer concepts for Informatics study, including an overview of computer architecture, computer algorithms, fundamentals of operating systems, data structure, file organization and database concepts. INFO-I 500 is expected to impart the required level of competency in computer science. This course may be waived in lieu of six undergraduate credit hours of computer science or informatics coursework, covering areas of programming, discrete structures, and data structures.

INFO-I 501 Introduction to Informatics (3 cr.) The course deals with the foundations of Informatics as an interdisciplinary field. We will study concepts such as Information, Technology, Knowledge, Modeling, and their impact on science and society. The course will also

attempt to define and understand what computational and systems thinking can bring to science and society.

INFO-I 502 Human-Centered Research Methods in Informatics (3 cr.) This course surveys a broad range of research methods employed in Informatics, exploring their meta-theoretical underpinnings and exemplifying their application to specific research questions. This course is intended for students in Informatics graduate programs, especially Ph.D. students, who need a grounding in research methods.

INFO-I 504 Social Dimensions of Science Informatics (3 cr.) Examines ethical, legal, and social issues surrounding contemporary research and practice in science informatics. Topics include the nature of science and technology, the ramifications of recent advances in science informatics, and relevant science policy and research ethics. General knowledge of science informatics is assumed.

INFO-I 505 Social Media Informatics (3 cr.) Social media platforms and research on social media are both defined by their applications of algorithms and interpretations of human agents. This course emphasizes the interplay of these elements, drawing on techniques from linguistics and computational approaches such as natural language processing, network modeling and analysis, and vector space modeling.

INFO-I 506 Globalization and Information (3 cr.) Explores the processes that promote and impede movement of human action and informational activities to the most general levels, e.g., the level of the world as a whole. Surveys diverse theories of globalization to identify the best approaches for professional informatics career planning and making information globally accessible.

INFO-I 507 Introduction to Health Informatics (3 cr.) This is a combined advanced undergraduate and graduate course that provides an introduction to health informatics. By the end of the course, students will be able to describe and apply informatics methods that improve health and well being.

INFO-I 511 Animal-Computer Interaction Methods (3 cr.) This courses introduces cutting-edge Animal-Computer Interaction methods with a focus on how they are used to enhance animal welfare, enrichment, husbandry, and cognitive research opportunities. It will also take a critical approach and consider key challenges relating to access, ethics, implementation, scale, and evaluation of ACI methods.

INFO-I 512 Direct Observation and Design (3 cr.) Research methods course focused on the skills of direct observation; the collection, analysis, and representation of observation-based data and its uses in user-centered design. Students carpool for classes held weekly at Indy Zoo, observing orangutans.

INFO-I 513 Usable Artificial Intelligence (3 cr.) Proficiency in basic programming (Python, C, C++, Java, or equivalent) recommended. Building foundational skills in machine learning, natural language processing, and artificial intelligence for data collection, data analysis, data visualization, and decision-making.

INFO-I 514 Seminar on Tech for Animals (3 cr.) This exploratory seminar is an introduction to ACI. We will draw on faculty and student selected readings, multimedia materials, and guest lectures from current ACI practitioners to see what we think about the ethics, history, state-of-the art, and possible futures for this broad field of practice.

INFO-I 516 Informatics in Disasters and Emergency Response (3 cr.) This course teaches students the skills needed to design and deploy informatics technologies in emergency response and disaster situations, including practical applications. Specific areas include technology design, situational awareness, threat modeling, and data science. Credit not given for both INFO-I 516 and I 426.

INFO-I 519 Introduction to Bioinformatics (3 cr.) One semester programming course or equivalent recommended. Sequence alignment and assembly; RNA structure, protein and molecular modeling; genomics and protenomics; gene prediction; phylogenic analysis; information and machine learning; visual and graphical analysis bioinformatics; worldwide biologic databases; experimental design and data collection techniques; scientific and statistical data analysis; database and data mining methods; and network and Internet methods.

INFO-I 520 Security for Networked Systems (3 cr.) This course is an extensive survey of system and network security. Course materials cover the threats to information confidentiality, integrity and availability and the defense mechanisms that control such threats. The course provides the foundation for more advanced security courses and hands-on experiences through course projects. Credit not given for both INFO-I 520 and I 430.

INFO-I 521 Malware Epidemic: Threat and Defense (3 cr.) One semester programming course or equivalent recommended. This course is designed to be research and hands-on oriented. Students are required to read and present research papers that reflect the state of the art in malware-related research and participate in course projects that expose them to the cutting-edge technologies on malware defense.

INFO-I 523 Big Data Applications and Analytics (3 cr.) The Big Data Applications & Analytics course is an overview course in Data Science and covers the applications and technologies (data analytics and clouds) needed to process the application data. It is organized around rallying cry: Use Clouds running Data Analytics Collaboratively processing Big Data to solve problems in X-Informatics. Credit given for only one of INFO-I 523, I 423, or ENGR-E 534.

INFO-I 524 Big Data Software and Projects (3 cr.) This course studies software HPC-ABDS used in either High Performance Computing or the open source commercial Big Data cloud computing. The student builds analysis systems using this software on clouds and then to use it on a project either chosen by student or selected from list given by instructor. Credit not given for both INFO-I 524 and I 424.

INFO-I 525 Organizational Informatics and Economics of Security (3 cr.) Security technologies make explicit organizational choices that allocate power. Security implementations allocate risk, determine authority, reify or alter relationships, and determine trust extended to organizational participants. The course begins with an introduction to relevant definitions (security, privacy, trust)

and then moves to a series of timely case studies of security technologies.

INFO-I 526 Applied Machine Learning (3 cr.) The main aim of the course is to provide skills to apply machine learning algorithms on real applications. We will consider fewer learning algorithms and less time on math and theory and instead spend more time on hands-on skills required for algorithms to work on a variety of data sets.

INFO-I 527 Mobile and Pervasive Design (3 cr.) The aim of this course is to provide students with the ability to design and implement novel interactions with mobile and pervasive technologies. We will discuss interaction paradigms and explore different technologies. Students will design, build, implement and refine mobile and pervasive computing applications for their domain of interest.

INFO-I 528 Participatory Design (3 cr.) Participatory Design is a design approach that democratizes the design process by involving end-users. This course has two objectives: we will survey PD's emergence in the creation of computing systems; we will also explore what participation means in technology design today, in contexts such as international development, citizen science, etc.

INFO-I 529 Machine Learning in Bioinformatics (3 cr.) INFO-I 519 or equivalent knowledge recommended. The course covers advanced topics in Bioinformatics with a focus on machine learning. The course will review existing techniques such as hidden Markov models, artificial neural networks, decision trees, stochastic grammars, and kernel methods. Examine application of these techniques to current bioinformatics problems including: genome annotation and comparison, gene finding, RNA secondary structure prediction, protein structure prediction, gene expression analysis, proteonmics, and integrative functional genomics.

INFO-I 530 Field Deployments (3 cr.) Lab fee. The aim of this course is to provide students with the ability to design, facilitate and analyze in situ user studies with pervasive systems. We will discuss study designs based on the type of systems, in situ evaluation methods, and how to analyze the study data.

INFO-I 531 Seminar in Health Informatics (1-3 cr.) Variable topic. Emphasis is on advanced topics and research in health informatics. May be repeated with different topics, subject to approval of the Dean.

INFO-I 532 Seminar in Bioinformatics (1-3 cr.) Variable topic. Emphasis is on advanced topics and research in bioinformatics. May be repeated with different topics, subject to approval of the Dean.

INFO-I 533 Systems and Protocol Security and Information Assurance (3 cr.) This course looks at systems and protocols, how to design threat models for them and how to use a large number of current security technologies and concepts to block specific vulnerabilities. Students will use a large number of systems and programming security tools in the laboratories. Credit not given for both INFO-I 533 and I 433.

INFO-I 534 Seminar in Human-Computer Interaction (1-3 cr.) Variable topic. Emphasis is on advanced topics and research in human-computer interaction. May be repeated once with a different topic, subject to approval of the program director.

INFO-I 535 Management, Access, and Use of Big and Complex Data (3 cr.) Innovation today is emerging from a preponderance of data from sensors, social media, and the Internet. This course covers knowledge representation, data process, and data management for big and complex data. Specific topics include data integration, semantics, and provenance; workflows and pipelines; and distributed noSQL stores. Credit not given for both INFO-I 535 and I 435.

INFO-I 536 Foundational Mathematics of Cybersecurity (3 cr.) Students will learn mathematical tools necessary to understand modern cyber security. The course will cover introductory mathematical material from a number of disparate fields including probability theory, computational theory, complexity theory, group theory, and information theory.

INFO-I 537 Legal and Social Informatics of Security (3 cr.) This is a case-based course on privacy and security in social contexts. Cases will particularly address the specific designs of technologies (e.g., P3P, PICS) and discuss how different technically feasible design choices would result in distinct regulartory regimes, business strategies, or support different forms of social interaction. This course will focus on specific security and privacy technologies as socio-technical systems.

INFO-I 538 Introduction to Cryptography (3 cr.) Introduction to the foundational primitives of cryptography and implemenations. A primary goal of this course will be to understand the security definitions for each primitive, and how they are used in cryptographic protocols. The ethics of insecure or on-the-fly- protocol design will be discussed.

INFO-I 539 Cryptographic Protocols (3 cr.) Provides a basic understanding of computer security by looking at how things go wrong and how people abuse the system. Once it is understood how computer systems are attacked, it is possible to propose ways to make the system secure.

INFO-I 540 Human Robot Interaction (3 cr.) This course surveys the field of human-robot interaction (HRI), which involves understanding how people perceive and respond to robots and creating robots that interact naturally with people. We will discuss the design, evaluation and societal significance of interactive robots from a human-centered perspective through readings, discussion and developing HRI prototypes. Credit given for only one of INFO-I 540, I 440 or H 440.

INFO-I 541 Introduction to HCI/d (3 cr.) Human-Computer Interaction Design refers to designing interactive products, services, and experiences. This course offers a holistic and practice-oriented introduction to the field. Working individually and in teams, students will take on an authentic design problem and follow a creative process to achieve design outcomes.

INFO-I 542 Foundations of HCI (3 cr.) "Foundations of HCI" offers a survey overview of the field of Human-Computer Interaction Design. It introduces the main themes of HCI set generally in a historical context. Themes include interaction design, cognitive modeling,

distributed cognition, computer-supported cooperative work, data visualization, ubiquitous computing, affective computing, and domestic computing, among others.

INFO-I 543 Interaction Design Methods (3 cr.) Students will learn basic concepts and methods for usability studies and evaluation of interactive systems as well as apply those methods to actual system design evaluations. This course is not only for understanding the basics and traditional approaches in this area, but also for exploring new ways of evaluating the usability of state-of-the-art technology-based systems such as systems in ubiquitous computing, CSCW, tangible and social computing areas.

INFO-I 544 Experience Design (3 cr.) Accompanying its move from workplace productivity into culture-at-large, HCI is increasingly concerned with designing engaging user experiences. "Experience Design" is an interdisciplinary course that brings anthropological, philosophical, design, and technological perspectives together to explore novel ways to research, design, and evaluate qualities of user experience.

INFO-I 545 Music Information Representation, Search, and Retrieval (3 cr.) A comprehensive, comparative study of computer-based representation schemes for music, including those oriented toward music notation, music performance, and music analysis. Overview of musical metadata. Techniques and tools for search and retrieval of music information. Credit not given for both INFO-I 545 and MUS-N 564.

INFO-I 546 Music Information Processing: Symbolic (3 cr.) This course deals with both methodology and specific applications that attempt to algorithmically annotate, understand, recognize, and categorize music in symbolic (score like) form. Particular applications will include key finding, harmonic analysis, note spelling, rhythm recognition, meter induction, piano fingering, and various classification problems such as genre or composer identification. The methodology we will employ will be probabilistic and will include ideas from Machine Learning such as optimal classifiers, hidden Markov models, and Bayesian networks. Students will have computing assignments, present papers, and be expected to implement solutions to problems using a high-level language such as R or Matlab.

INFO-I 547 Music Information Processing: Audio (3 cr.) This course deals with various music analysis and processing problems that use sampled audio as the primary data representation. We discuss digital signal processing, including filtering and its relationship to Fourier techniques. Topics include synthesis, effects processing, score following, and blind music recognition, and accompaniment systems.

INFO-I 548 Introduction to Music Informatics (3 cr.) History, issues, and applications in music information technology. Survey of various types of musical information. Introduction to digital musical media, including data standards and processing; database structure and organization standards and processing; database structure and organization of audio-, score-, and text file objects; and discussion of copyright issues.

INFO-I 549 Advanced Prototyping (3 cr.) INFO-I 540 recommended. Lab fee. Prototyping is the activity of exploring a design space and developing design ideas. The course will cover issues surrounding the construction of prototypes (e.g., breadth, depth, look, interaction, low/high, vertical/horizontal, etc.). Students will practice manipulating different prototyping materials, both physical and digital, and learn about different prototype evaluation techniques.

INFO-I 552 Ind Study in Bioinformatics (1-3 cr.) Permission of instructor and completion of at least one 500-level informatics course. Independent readings and research under the direction of a faculty member culminating in a written report. May be repeated for a maximum of 3 times and 9 credit hours.

INFO-I 553 Ind Study in Chem Informatics (1-3 cr.) Permission of instructor and completion of at least one 500-level informatics course. Independent readings and research under the direction of a faculty member, culminating in a written report. May be repeated for a maximum of 3 times and 9 credit hours.

INFO-I 554 Ind St Human Computer Interaction (1-3 cr.) Permission of instructor and completion of at least one 500-level informatics course. Independent readings and research under the direction of a faculty member, culminating in a written report. May be repeated for a maximum of 3 times and 9 credit hours.

INFO-I 561 Meaning and Form in HCI (3 cr.) INFO-I 541 recommended. This course is a continuation of Human-Computer Interaction Design I, emphasizing the justification of design effectiveness.

INFO-I 566 Technology Innovation (3 cr.) This course teaches students the process of innovation, specifically in respect to technological innovation. Students are required to ideate technological concepts given a set of constraints and an opportunity space. The focus of the course is on students inventing and implementing without considering the commercial potential of their innovations. Credit not given for both INFO-I 566 and I 436.

INFO-I 567 Design Strategy (3 cr.) Permission of instructor. The course requires students to apply "the" design process to better understand the factors affecting the success or failure of a design beyond the target audience and problem space in order to iterate on the design to propose solutions to avoid its failure, a process known as strategic design.

INFO-I 568 Technology Entrepreneurship (3 cr.) This course will teach students the importance of systems and design thinking as they relate to building and managing a startup holistically. Students will be required to take a business concept from inception to implementation, at least to the degree required to have a minimum viable product (MVP). Credit not given for both INFO-I 568 and I 438.

INFO-I 569 Collective Intelligence (3 cr.) This course examines the phenomenon of Collective Intelligence from a computational perspective, with theory and applications in the biological, cultural, and economic domains. We will, in particular, focus on the role of social media which is enabling collective intelligence applications at previously unimagined scales.

INFO-I 571 Introducing Cheminformatics (3 cr.) Overview of chemical informatics techniques, including chemical structure coding, chemical data representation,

chemical database and search systems, molecular visualization and modeling techniques, and the development of chemical informatics software.

INFO-I 572 Computational Chemistry and Molecular Modeling (3 cr.) This course has two main objectives. 1) To give you a thorough introduction to computational chemisty and modern methods of electronic structure theory that form the basis of molecular modeling today. Mainly, we will concentrate on quantum mechanical methods and pay special attention to Density Functional Theory. Instead of digging deep into the mathematics of quantum chemistry, we will concentrate on practical aspects and examine in detail how computational chemistry can be used to explain chemical reactions and electronic properties. 2) To get your 'Hands Dirty' and conduct real and original research designed to allow you to see the knowledge obrained from the first part of the course in action and apply a wide range of state-of-the-art methods to solve a specific chemcial research problem at a high level of scientific rigor.

INFO-I 573 Programming for Chemical & Life Science Informatics (3 cr.) Students will receive a thorough understanding of software development for chem- and bioinformatics, and broaden experience of working in a scientific computing group. Topics include programming for the web, depiction of chemical and biological structures in 2D and 3D, science informatics tool kits, software APIS, AI and machine-learning algorithm development, high performance computing, database management, managing a small software development group, and design and usability of science informatics software.

INFO-I 585 Bioinspired Computing (3 cr.) Biologically-inspired computing is an interdisciplinary field devoted to computational methods modeled after natural design principles. The goal is to produce informatics tools with enhanced robustness, scalability, flexibility and natural human-machine interaction. Topics include: Self-organization, Evolutionary Systems, Cellular Automata, Boolean Networks, L-Systems, Collective and Swarm Behavior, Artificial Immune Systems, Complex Networks. Credit not given for both INFO-I 585 and I 485.

INFO-I 586 Artificial Life (3 cr.) Artificial life is a broad discipline encompassing the origins, modeling, and synthesis of natural and artificial living entities and systems. Artificial intelligence, as a discipline, tries to model and understand intelligent systems and behavior, typically at the human level. Credit not given for both INFO-I 586 and I 486.

INFO-I 587 Introduction to Virtual Heritage (3 cr.) This course focuses on how digital technology can represent, restore, disseminate, and help with analysis of artifacts such as vases, furniture, sculpture, monuments, and buildings. Other topics covered include the history and methodologies of Virtual Heritage. Each semester a different case study will provide the focus for the course. Credit not given for both INFO-I 587 and I 487.

INFO-I 588 Advanced Topics in Virtual Heritage (3 cr.) This course teaches students how to create simulations of complex cultural heritage environments such as a room and its furnishings, a building, or a settlement. Also covered are the principles of restorations of art, technologies to disseminate 3D models, and the use of simulations as tools of scientific discovery. Credit not given for both INFO-I 588 and I 488.

INFO-I 590 Topics in Informatics (3 cr.) Variable topic. Emphasis is on new developments and research in informatics. May be repeated with different topics, subject to approval of the Dean.

INFO-I 591 Graduate Internship (0-6 cr.) Department approval. Students gain professional work experience in an industry or research organization setting, using skills and knowledge acquired in Informatics course work. May be repeated for a maximum of 6 credit hours.

INFO-I 601 Introduction to Complex Systems (3 cr.) The course will cover fractals, emergent behavior, chaos theory, cooperative phenomena, and complex networks. Students will learn how to think differently about complexitalities, finding ways to understand their complexity and addressing the problems they pose.

INFO-I 602 Music Info Processing: Audio (3 cr.) This course deals with various music analysis and processing problems that use sampled audio as the primary data representation. Digital signal processing including filtering and its relationship to Fourier techniques. Focus on applications including score following, automatic music transcription and annotation from audio,musical accompaniment systems, as well as some useful audio effects.

INFO-I 604 Human Computer Interaction Design Theory (3 cr.) The course will explore, analyze, and criticize underlying assumptions and the rationale behind some of the most influential theoretical attempts in HCI and related fields. The purpose of the course is to make students aware of how theories can influence practice and to develop critical thinking around the role, purpose, and function for theories.

INFO-I 605 Social Foundations of Informatics (3 cr.) Topics include the economics of information businesses and information societies, legal and regulatory factors that shape information and information technology use, the relationship between organization cultures and their use of information and information technology, and ownership of intellectual property.

INFO-I 606 Network Science (3 cr.) Requires strong working knowledge of mathematics and programming, specifically, proficiency in the topics such as probability, statistics, linear algebra, data structures, and algorithms. Python is the main programming language. This course teaches the fundamental theories, algorithms, and key applications of network science across social and biological systems.

INFO-I 609 Advanced Seminar I in Informatics (3 cr.) Ph.D. student introduction to major historical and emerging theories, methods, technologies, and applications in Informatics. Provides students with opportunities to explore relevant research literature, results, and applications. Students will develop a profound understanding of leading research approaches and paradigms in their research area.

INFO-I 611 Mathematical and Logical Foundations of Informatics (3 cr.) Basic discrete mathematics equivalent to MATH-M 118 recommended. An introduction to mathematical methods for information modeling, analysis,

and manipulation. The topics include proof methods in mathematics, models or computation, counting techniques and discrete probability, optimization, statistical inference and ore advanced topics that include but are not limited to Markov chains and random walks, random graphs, and Fourier analysis.

INFO-I 617 Informatics in Life Sciences and Chemistry (3 cr.) Introduces the fundamental notions in genome and proteome informatics and chemical informatics focusing on the design and organizing issues in information systems used in those areas. The course is designed for students with no biology or chemistry background, but some knowledge in informatics, who want to learn basic topics in bioinformatics and chemical informatics.

INFO-I 619 Structural Bioinformatics (3 cr.) The course will cover informatics approaches, based on the sequence and 3D structure of biological macromolecules, whose objective is to improve our understanding of the function of these molecules.

INFO-I 621 Computational Techniques in Comparative Genomics (3 cr.) Summarizes computational techniques for comparing genomes on the DNA and protein sequence levels. Topics include state of the art computational techniques and their applications: understanding of hereditary diseases and cancer, genetic mobile elements, genome rearrangements, genome evolution, and the identification of potential drug targets in microbial genomes.

INFO-I 651 Ethnography of Information (3 cr.) Introduces ethnography as a social science methodology and way of knowing with which to study information and its social contexts. Places ethnography in the Informatics knowledge base. Trains students in the use of a broad range of ethnographic techniques relevant to study of automated information technology in use. Designed to be open to students from other programs with sufficient methodological and substantive background.

INFO-I 667 Seminar in Health Informatics I (3 cr.) INFO-I 531 recommended. This course provides graduate students with advanced knowledge on a wide range of technical and analytical topics in health informatics. The course involves a combination of lectures, practicums, and discussions to engage students in the various aspects of an informatisist's role. The topics and presenters will be different each semester.

INFO-I 690 Topics in Informatics (1-3 cr.) Variable topic. Emphasis on new developments and research in informatics. Course is intended for Ph.D. students in the School of Informatics, Computing, and Engineering. May be repeated with different topics, subject to approval of the Dean.

INFO-I 692 Thesis/Project Bioinformatics (1-6 cr.) Department approval. The student prepares and presents thesis or project in an area of bioinformatics. The product is substantial, typically a multi-chapter paper or carefully designed and evaluated application, based on well-planned research or scholarly project. Details are worked out between student and sponsoring faculty member. May be repeated for a maximum of 6 credit hours.

INFO-I 694 Thesis/Project in Human-Computer Interaction I (3 cr.) P: INFO-I 541, I 542, I 543, I 544 and I 561. The student prepares and presents a thesis or project in an area of human-computer interaction. The product is substantial, typically multi-chapter paper, or a carefully designed and evaluated application, based on well-planned research or scholarly project. Details are worked out between the student and sponsoring faculty member.

INFO-I 698 Research in Informatics (1-12 cr.) Research not dissertation related under the direction of a member of the graduate faculty May be repeated for a maximum of 30 credit hours.

INFO-I 699 Independent Study in Informatics (1-3-12 cr.) Independent readings and research for Ph.D. students under the direction of a faculty member, culminating in a written report. May be repeated for a maximum of 12 credit hours.

INFO-I 709 Advanced Seminar II in Informatics (3 cr.) Ph.D. student introduction to major historical and emerging theories, methods, technologies, and applications in Informatics and its sub-areas. Provides students with opportunities to explore relevant research literature, results, and applications. Seminar II, unlike Seminar I, focuses on recent advances in sub-areas of Informatics.

INFO-I 790 Informatics Research Rotation (3 cr.) Working with faculty to investigate research opportunities. May be repeated for a maximum of 6 credit hours.

INFO-I 798 Professional Practicum/Internship (0 cr.) Current enrollment in the graduate degree program in Informatics. Participation in graduate level professional training and internship experience.

INFO-I 890 Thesis Readings and Research (1-12-36 cr.) Research under the direction of a member of the graduate faculty leading to a Ph.D. dissertation. May be repeated for a maximum of 36 credit hours.

INFO-G 599 Thesis Research (0 cr.) Master's students who have enrolled in 30 or more hours of graduate course work applicable to the degree and who have completed all other requirements of the degree except the thesis of final project of performance may enroll in INFO-G 599. Requires section authorization.

INFO-G 901 Advanced Research (6 cr.) Ph.D. dissertation research after the completion of all course requirements. May be repeated a maximum of 6 times.

INFO-I 695 THESIS/PROJECT IN HUMAN-COMPUTER INTERACTION II (3 cr.) P: Prerequisite: INFO-I 694 The student prepares and presents a thesis or project in an area of human-computer interaction. The product is substantial, typically multi-chapter paper, or a carefully designed and evaluated application, based on well-planned research or scholarly project. Details are worked out between the student and sponsoring faculty member. NO

Information and Library Science

ILS-Z 501 Reference (3 cr.) This course introduces students to the basic information sources and services among different types of libraries and information centers, including academic, public, special, and school media.

ILS-Z 502 Collection Development and Management (3 cr.) Theoretical and pragmatic aspects of the selection, evaluation, and management of collections in all types of libraries. Acquisitions, publishers, and publishing, policy making, and intellectual freedom and censorship are also covered.

ILS-Z 503 Representation and Organization (3 cr.) Introduces students to common themes in disciplinary approaches to understanding, organizing, representing, and using knowledge and information. Criteria are identified for evaluating and improving ways to organize and represent information for future retrieval using library and information center systems as examples. Emphasis is on concepts and ideas, terminology, and technology.

ILS-Z 504 Cataloging (3 cr.) Historical development and principles essential to the understanding of the conceptual foundations of providing bibliographic access and control of materials and information. Discussion and examples in the application of AACR2r will be presented to illustrate and reflect current practice. Emphasis is on monographic publications.

ILS-Z 505 Evaluation of Resources and Services (3 cr.) Examines applied evaluation of library resources and services: collections, document delivery, technical and reference services, and overall library performance. Emphasis on developing data collection and analysis skills broadly applicable in ILS contexts, including interviewing, observational and ethnographic techniques, textual analysis, collections evaluation, user experience methods, and methodological and ethical issues.

ILS-Z 506 Introduction to Research (3 cr.)
9 credit hours for the MLS program must be completed. The research process, including concepts, design, conduct, and evaluation. Principles and characteristics of approaches and methodologies relevant to research in the field.

Examples of data sources and introduction to methods of statistical description and analysis; ethical issues.

ILS-Z 510 Introduction to Information Studies (3 cr.) This course surveys the dynamic and shifting information professions, and emerging careers in the information field. Students learn about information architecture, human-computer interaction, information retrieval, data science, and information technology leadership. Issues in information management, user-oriented systems design, socio-technical concepts, and usability are major themes discussed in the course.

ILS-Z 511 Database Design (3 cr.) This course provides students with a deep understanding of various database models, including relational and non-relational databases. Students will learn essential skills such as database modeling, design, implementation, and querying. The final project serves as a capstone, allowing students to apply their knowledge in designing and manipulating a real-world databases.

ILS-Z 512 Information Systems Design (3 cr.) Students identify, design, and implement a significant information design project, such as the redesign of a complex Web site for a local business, library, or nonprofit. Principles and practices of project management are discussed in the context of team-based web site redesign.

ILS-Z 513 Organizational Informatics (3 cr.) Introduces information, technology, and social behavior in the organizational context. Concepts of organization theory, organization behavior, knowledge and information management, and organizational intelligence provide a critical foundation for managing information, people, and information and communication technologies in rapidly changing and dynamic environments.

ILS-Z 514 Social Aspects of Information Technology (3 cr.) This course helps students think critically and constructively about information and communication technology (ICT) and its relationship to work, leisure, and society. It covers concepts and analytical devices as well as empirical case studies related to social consequences of ICT when shaped and used by individuals, public agencies, and businesses.

ILS-Z 515 Information Architecture (3 cr.) Effective information system design integrates knowledge of formal structures with understanding of social, technological, and cognitive environments. Drawing from a range of disciplines, this course investigates how people represent, organize, retrieve, and use information to inform the construction of information architectures that facilitate user understanding and navigation in conceptual space.

ILS-Z 516 Human-Computer Interaction (3 cr.) Examines human factors associated with information technology provides students with knowledge of the variables likely to influence the perceived usability, and hence the acceptability, of any information technology. In so doing it will enable students to progress further towards specialist's work in the important field of human-computer interaction.

ILS-Z 517 Web Programming (3 cr.) The main focus of this course is to instruct students to develop and implement dynamic and interactive web applications. In order to do so, students will learn the basics of an open source programming language both through lectures and hands-on exercises in the lab.

ILS-Z 518 Communication in Electronic Environments (3 cr.) Examines conceptual perspectives on information in organizations, covering topics such as types of information, information activities, organizational culture and information technology, communication as information flow, obtaining and using information from the environment, managing information in specialized extended communities, and ethical and quality issues. Focus varies by type of community studied.

ILS-Z 519 Evaluation of Information Systems (3 cr.) Theoretical and practical exploration of the issues surrounding contemporary information systems. A specific focus will be on evaluating information systems from the user perspective. This evaluation approach will cut across disciplinary frameworks: behavioral, cognitive, and social sciences. The approach will also touch on multiple research methods: online surveys, sense-making, critical incident, and network analysis.

ILS-Z 520 Information Seeking and Use (3 cr.) This course introduces students to the concepts of information

analysis from a human perspective, focusing particularly on the theoretical models and practical techniques that underpin the field. Sociological and psychological perspectives will be examined in order to develop an approach to the assessment of users' information needs.

ILS-Z 521 Humanities Information (3 cr.) P: S501, or consent of instructor. Introduction to information sources and services in the disciplines of performing arts, music, fine arts, literature, language, philosophy, and religion. In addition, the course addresses information needs and behavior patterns of users seeking these types of information.

ILS-Z 522 Social Science Information (3 cr.) P: S401, S501, or consent of instructor. Study of the core information tools in the fields of anthropology, economics, history, political science, psychology, and sociology. Includes key bibliographic databases and electronic network tools. Evaluation of research dealing with information channels in these fields.

ILS-Z 523 Science and Technology Information (3 cr.) General materials, reference books, periodicals, government documents, nonbook media in the individual literature of individual disciplines; patents and report literature. Examination of production, publication, distribution, and forms of scientific and technical literature.

ILS-Z 524 Adult Readers Advisory (3 cr.) A review and discussion of trends reflected in subject content and use of book and nonbook materials for patrons in secondary school and public libraries in relation to changing young adult and adult needs, and the role of libraries in meeting such needs.

ILS-Z 525 Government Information (3 cr.) Survey of government information dissemination in all formats and at all levels of government. Consideration of government information policy. Primary emphasis given to U.S. government information but with some consideration given to state and local publications in the United States, and those of international organizations.

ILS-Z 526 Business Information (3 cr.) Introduction to basic business materials. Includes resources, research methods, current developments, automated systems, and databases.

ILS-Z 531 Subject Access Systems (3 cr.) Principles, development, characteristics, and internal structures of subject access systems. Evaluation of the strengths and weaknesses of the major classification schemes and current subject heading systems.

ILS-Z 532 Information Architecture for the Web (3 cr.) The course introduces beginning web developers to a series of foundational front-end and back-end web technologies, including HTML, CSS, JavaScript/jQuery, Bootstrap, PHP, and MySQL (subject to change over time). Deliverables include personal and group web development projects.

ILS-Z 533 Online Searching (3 cr.) Principles, methods, and techniques of advanced online information retrieval (IR). Characteristics of, and search strategies for, the use of bibliographic, referral, citation, fact, numeric, and full text databases and search systems. Considers standards, use of communications software, front-ends and micro-based IR systems, and creation of in- house databases.

ILS-Z 534 Search (3 cr.) The success of commercial search engines shows that Information Retrieval is a key in helping users find the information they seek. This course provides an introduction to information retrieval theories and concepts underlying all search applications. We investigate techniques used in modern search engines and demonstrate their significance by experiment.

ILS-Z 541 Information Policy (3 cr.) Data creation, publication, dissemination, and use occur in complex social contexts. This course explores U.S. and international legal and regulatory structures intended to control these processes in the information industries. Covers topics such as copyright of electronic information or transborder data flow. May be repeated for credit when topic varies. May be repeated for credit when topic varies.

ILS-Z 542 International Information Issues (3 cr.) Comparison of information policies, information standards, and library systems as they affect commercial, scholarly, scientific, and political information contexts.

ILS-Z 543 Computer-Mediated Communication (3 cr.) Computer-mediated communication (CMC) is human-to-human interaction via computer networks such as the Internet. This course examines potentials and constraints of several types of CMC, and considers how content and dynamics are influenced by the systems' technical properties and the cultures that have grown up around their use.

ILS-Z 544 Gender and Computerization (3 cr.) This course explores the relationship between information communication technologies (ICTs) and the gender of the people who design, use, administer, and make policy concerning computer systems and computer networks such as the Internet.

ILS-Z 550 Information Institutions and their Management (3 cr.) Information institutions preserve, conserve, and disseminate information objects. In this course students will learn about libraries, archives, museums, and related organizations, examining their commonalities and differences. Students will study relevant management issues including planning, leading and organizing. They will explore information policies, workflows, ethics, intellectual freedom, laws, and social norms.

ILS-Z 552 Academic Library Management (3 cr.) Background and current trends in the management of academic libraries.

ILS-Z 553 Public Library Management (3 cr.) Background and current trends in the management of public libraries.

ILS-Z 554 Library Systems (3 cr.) Principles for the design, selection, implementation, and management of automated systems in libraries, including technical services processing, reference and user services, and management. Focus is on present and future applications of technology and their implications for library services and management. When possible, practical experience with particular applications will be provided

ILS-Z 555 Strategic Intelligence (3 cr.) Introduces different concepts of strategic intelligence, and different contexts in which these are applied; the idea of intelligence is not restricted to national security, or corporate competition: it can apply at the level of the individual citizen, company, community, or country.

ILS-Z 556 Systems Analysis and Design (3 cr.) This course introduces the basic concepts underlying systems analysis and design, focusing on contextual inquiry/ design and data modeling, as well as the application of those analysis techniques in the analysis and design of organizational information systems.

ILS-Z 561 User Interface Design for Information Systems (3 cr.) This course focuses on established principles and methods to design effective interfaces for information systems, emphasizing document retrieval, filtering, visualization, correlation, analysis, and research.

ILS-Z 571 Materials for Youth (3 cr.) Evaluation and use of books, magazines, recordings, films, radio and television broadcasts, and other sources of information and recreation.

ILS-Z 572 Youth Services (3 cr.) This course emphasizes the history, philosophy, current state, and future of children and young adult services in the public library focusing on the role of the youth services librarian from planning and evaluation to services and programs. Cooperation with appropriate services and programs such as school media centers is discussed.

ILS-Z 573 Education of Information Users (3 cr.) Reviews important educational theories for application to secondary school, college, and university settings which provide training and education programs to teach students skills leading to information literacy. Standards from AASL and ACRL are applied to instructional design and practice including lecture, collaboration with faculty, and evaluation of online tutorials.

ILS-Z 574 Information Inquiry for School Teachers (3 cr.) This course is intended to be an opportunity for teachers and future teachers (including school library media specialists as teachers) to practice methods in critically thinking about information/media, and to use that process as a means to teach their students to be critical reviewers and communicators as well.

ILS-Z 580 History of Libraries (3 cr.) Development of libraries and information services from earliest times to the present, with emphasis on the library in relation to social, economic, cultural, and political trends.

ILS-Z 581 Archives and Records Management (3 cr.) Introduces basic theories, methods, and significant problems in archives and records management. The course also discusses how archivists are responding to the challenge of managing and preserving electronic records.

ILS-Z 582 Preservation (3 cr.) Examines causes of library and archival materials deterioration. Develops conceptual framework and management perspective for preservation programs using technical standards, program development tools, scientific and administrative research reports, and advocacy literature. Explores the new information technologies and media as both preservation tools and challenges.

ILS-Z 583 Rare Book Librarianship (3 cr.) Introduction to the development, organization, and operation of rare book libraries and special collections. Includes an overview

of the fundamentals of book collecting, both private and institutional, the antiquarian book trade and auction market, and the profession and practice of rare book librarianship.

ILS-Z 584 Manuscripts (3 cr.) Introduction to the nature, functions, and methodology of the organization and administration of archives and manuscript collections. The course will consist of lectures, discussions, field trips, and special projects.

ILS-Z 585 Records Management (3 cr.) Records management is the management of documentary information for the purposes of supporting the goals and strategy of an organization. This requires understanding of business processes as well as statutes, regulations, the litigation process, disaster recovery and business continuity, and storage architecture.

ILS-Z 587 Introduction to Moving Image Preservation (3 cr.)
This class provides librarians and archivists skills, knowledge, and resources to properly handle moving image materials. It is also for those interested in preserving audiovisual media. Moving image archiving is in transition; the class addresses this transformation and how it affects practices, sites, and conceptions of film and video conservation.

ILS-Z 601 Directed Readings (1-6 cr.)
Permission of instructor. Readings and study in any area of library or information science. Normally Z 601 is sponsored by a full-time faculty member. Readings shall not duplicate content of any course now in the ILS curriculum. Students may enroll in Z601 twice in the same semester under different instructors.

ILS-Z 602 Directed Research (1-3 cr.) Permission of instructor. Individual research in a problem in the field of library and information science.

ILS-Z 603 Workshop in Library and Information Science (1-3 cr.) Permission of Instructor. Group study of specific problems in the library and information field. Generally includes a hands- on element. May be repeated for a maximum of 6 credit hours.

ILS-Z 604 Topics in Library and Information Science (1-4 cr.) Study of specific topics in librarianship and information science. May be repeated with different topics.

ILS-Z 605 Internship in Library and Information Science (2-6 cr.) Permission of instructor or faculty advisor. Internship in an information organization supervised by professionals. Students write journals and abstracts of publications, and give a final presentation. Each earned credit requires sixty on-site hours. Normally,

18 credits are required before enrollment. Guidelines and sites on the ILS Web site. Graded S/F.

ILS-Z 622 Resources and Services for People with Disabilities (3 cr.)
Access to information is essential for sustained independence of people with disabilities. This course studies materials, services, and assistive technologies to support this access.

ILS-Z 623 Genealogy and Local History (3 cr.) Focuses on developing collections and providing reference services in genealogy and local history.

ILS-Z 629 Topics in Information Sources and Services (3 cr.) Provides the opportunity for in-depth study of information sources related to area studies, specific academic disciplines, and/or library patron audiences. Examples include Slavic materials, Latin American bibliography, and international legal bibliography. Depending on the demand and the expertise of available faculty, there is a wide range of possible topics.

ILS-Z 631 Advanced Cataloging (3 cr.) P: ILS-Z 504. Provides extensive background in description and access for electronic and non-book resources.

ILS-Z 632 Technical Services (3 cr.) P: ILS-Z 550. Principles of organization and function of library technical services, including acquisition, cataloging, serials, circulation. Special emphasis on research and development in library systems and technology. Includes file organization, documentation system development, analysis, and evaluation for manual, mechanical, and automated applications.

ILS-Z 633 Indexing (3 cr.)
P: ILS-Z 504 or Z 515.Theoretical concepts of subject indexing and thesaurus construction for information retrieval. Examines alternative approaches to traditional indexing techniques. Evaluation and use of appropriate computer software.

ILS-Z 634 Metadata (3 cr.)
P: ILS-Z 503 or Z 515. Metadata is essential in designing and developing effective knowledge systems; it facilitates resource discovery, database documentation, and recording digital documents' textual and conceptual histories. This course introduces principles supporting the development and implementation of metadata schemes, focusing on issues of interoperability, internal and external standardization,

ILS-Z 635 Ontologies (3 cr.) P: S634 and authorization required. An ontology is a common semantic conceptualization of reality that is shared by members of a knowledge domain; it supports exchange of knowledge among participants. This course explores formal specifications for ontology construction among systems applications and software agents.

ILS-Z 636 Data Semantics (3 cr.) Explores the technologies of the Semantic Web by examining the application of technologies to WWW information delivery and the principles of formal logic and computation guiding their developments.

ILS-Z 637 Information Visualization (3 cr.) Introduces information visualization, highlighting processes which produce effective visualizations. Topics include perceptual basis of information visualization, data analysis to extract relationships, and interaction techniques.

ILS-Z 640 Seminar in Intellectual Freedom (3 cr.)
Normally nine ILS graduate credit must be completed before enrollment. Taught as a seminar, the class covers intellectual freedom issues in libraries, information organizations, the internet, and society. Topics typically include information access, social justice, information inequality, intellectual property, censorship, copyright, free and hate speech, surveillance capitalism, and ethics.

ILS-Z 641 Computer-Mediated Discourse Analysis (3 cr.) Computer-mediated discourse analysis (CMDA) adapts methods from linguistics, including corpus linguistics, pragmatics, conversation analysis, and sociolinguistics, to the analysis of computer-mediated communication. This course provides hands-on experience in applying empirical analytical methods.

ILS-Z 643 The Information Industry (1-3 cr.) This course examines various aspects of the information industry: products, producers, suppliers, trends, and market opportunities. Focus varies with the topic; for example, structural market characteristics, or technical developments and their impact. May be repeated for credit when topic varies.

ILS-Z 645 The Social and Organizational Information of Big Data (3 cr.) This course surveys organizational, legal, political, and social issues surrounding the creation, dissemination and use of big data from the perspective of social and organizational informatics. It focuses on ways in which the integration of big data is changing structure, culture, and work practices in private and public sector organizations.

ILS-Z 646 Seminar in Documents and Documentation (3 cr.) This seminar explores epistemological and genre assumptions of modern documentation and the different events and genre modes by which "information" in many various forms is produced through presentations of "fact." It involves an historical and social survey of the various types of collections of documents and their construction and use.

ILS-Z 650 Library Philanthropy (3 cr.) Introduces the role of private giving in support of libraries. Examines personal and corporate philanthropy and their applicability in libraries and information centers.

ILS-Z 651 Art Librarianship (3 cr.) Academic art library administration, collection development, reference services, technical services operations, facilities, and slide and photograph/picture collections will be emphasized.

ILS-Z 652 Digital Libraries (3 cr.) Examines the design and operation of digital libraries and related electronic publishing practices from a socio- technical perspective. Students develop understanding of major issues, concepts, and trends, enabling them to understand the socio- technical character of digital libraries that can and will be effectively supported and used by various groups.

ILS-Z 653 Health Sciences Librarianship (3 cr.) Health sciences library administration, materials organization, and information services. Emphasis on National Library of

Medicine classification, subject headings, printed indexes, and online databases.

ILS-Z 654 Law Librarianship (3 cr.) An introduction to basic legal materials and law librarianship. Primary and secondary resources; indexes; digests and citators; specialized research methods; current developments in automated legal research. History of law libraries in the U.S., their organization and administration. The role of law librarians in law schools and law firms.

ILS-Z 655 Music Librarianship (3 cr.) P: MUS M539. Academic music library administration, collection development, technical services operations, record and performing ensemble collections, and reference services will be emphasized.

ILS-Z 656 Digital Publishing Standards and Systems (3 cr.) P: S401.
Design and publish documents for the web and common eBook platforms, including ePub (iBook, etc.), AZW (Amazon Kindle), and KF8/AZW3 (Amazon Kindle). Covers XML-based document formats (TEI, DocBook, Office Open XML) and eXtensible Stylesheet Language Transformations (XSLT), a special-purpose programming language for transforming XML documents into XML and non-XML formats.

ILS-Z 672 Seminar on Literature for Youth (3 cr.) An advanced seminar, addressing such topics as: images of minority groups, societal problems (e.g., poverty and family patterns), or informational needs and materials including access and availability of print, nonprint, and computer resources.

ILS-Z 680 The Book to 1800 (3 cr.) P: Authorization required. Covers the introduction and development of writing and the history of the manuscript and printed book, from their beginnings to approximately the year 1800. Although there will be some coverage of the non-Western book, the emphasis will be on the history of the book in the West.

ILS-Z 681 The Book 1800 to the Present (3 cr.) Survey of the book from 1800 to the present, with emphasis on the development of the book in the West. Focuses on physical aspects of the book and some roles of the book in society during this period and on current scholarly trends in the history of the book.

ILS-Z 683 Reference Sources for Rare Books (3 cr.) Introduces and evaluates reference sources that are useful in working with rare books in many fields.

ILS-Z 684 Descriptive Bibliography (3 cr.) The development of the practice of printing, typefounding, and papermaking; the principles and practice of the bibliographical description of printed books, with emphasis on the period to 1880.

ILS-Z 685 Building Trustworthy Digital Repositories: Theory and Practice (3 cr.) Addresses the major issues and challenges facing the archival/records management professions in their quest to manage electronic records. Students will study and evaluate the impact automation has had on archival theory and practice, analyzing various models and strategies archivists have developed to manage electronic records.

ILS-Z 690 Capstone in Information Architecture Capstone (3 cr.) This course integrates theoretical and practical components of the specialization the student is completing. Working with the specialization director(s), the student will determine the scope and extent of the capstone project and publicly present and defend it upon completion

ILS-Z 638 Big Data Analytics for Web and Text (3 cr.) Basic programming skills recommended. Introduces fundamentals of big data analysis, focusing on theoretical and methodological aspects, including numerical and textual processing, statistical analysis, machine learning, and data retrieval, representation, semantics, and data storage. Open-source data-operation frameworks and tools (R, Hadoop, NoSQL) are introduced and demonstrated with real-world data sets.

ILS-Z 639 Social Media Mining (3 cr.) Basic Unix skills recommended. This course provides a graduate-level introduction to social media mining. Students gain hands-on experience mining social data for social meaning extraction (focus on sentiment analysis) using automated methods and machine learning technologies. We read, discuss, and critique claims and findings from contemporary research related to SMM.

ILS-Z 642 Content Analysis for the Web (3 cr.) Application of Content Analysis methods to multimodal web documents, including images, video, text, tags, and links.

ILS-Z 657 Digital Humanities (3 cr.)
This course explores computing in digital humanities, from electronic scholarly editing to the computational analysis of style, theme, and structure, its cultural impacts on scholarly discourse, publishing, and the academy. Students will work with eXtensible Markup Language (XML) and the Text Encoding Initiative to generate critical work on digital humanities.

ILS-Z 701 Introduction to Doctoral Research in Library and Information Science (3 cr.)
Provides a seminar-style survey of conduct of research in information and library science from the research question to publication; critical analysis of present state of knowledge in major domains in the field; discussion of the grounds of quantitative, qualitative, and mixed methodologies, and becoming a professional academic.

ILS-Z 702 Doctoral Research Practicum I (2 cr.)
Student acquires practical hands-on experience with the research process through involvement in a SLIS faculty member's research project.

ILS-Z 703 Doctoral Research Practicum II (2 cr.)
Student acquires practical, hands-on experience with the research process through involvement in a SLIS faculty member's research project. The S703 research project should differ substantially from the S702 project with which the student was involved.

ILS-Z 706 Introduction to Research (3 cr.) The research process, including concepts, design, conduct, and evaluation. Principles and characteristics of approaches and methodologies relevant to research in the field. Examples of data sources and introduction to

methods of statistical description and analysis; ethical issues.

ILS-Z 710 Doctoral Research Practicum III (3 cr.) P: ILS-Z 701, Z 702 and Z 703. The student applies methods of research under the supervision of a ILS faculty member. The research project may originate with the student or may be one on which the faculty member seeks student assistance.

ILS-Z 763 Research Problems and Methods in Information Science (3 cr.) P: Consent of instructor. Study of current problems and methodological approaches in information science research.

ILS-Z 764 Seminar in Information Science (3 cr.) The course aims to provide students with the experience of preparing and#submitting#the results of their in-depth scholarly work for publication, before taking their quals. Students will#submit#a scholarly paper in information science to a peer-reviewed journal or a full research paper to conference with published proceedings.

ILS-Z 765 Doctoral Research in Information Science (1-6 cr.) Independent research or study. A student may enroll for this course more than once in one semester under different instructors.

ILS-Z 790 Dissertation Proposal in Information Science (3 cr.) Must have successfully completed the qualifying exam. Contact PhD Recorder for permission to register. Doctoral students develop their plans for theses subject to criticism by other doctoral students and faculty.

ILS-Z 799 Ph.D. Thesis (arr. cr.) P: Must have been admitted to candidacy. See advisor for more information.

ILS-G 901 Advanced Research (6 cr.) Must have 90 credit hours completed. Contact PhD Recorder for permission to register. Please see advisor for more information on Advanced Research. May be repeated a maximum of 6 times.

ILS-Z 621 Audio and Video Sources (3 cr.) User-focused approach to decision making in the digital audio and video information environment. Emphasizes collection development in support of user services, including access to remote collections and evaluation of multimedia materials and delivery mechanisms, and issues related to emerging technologies. Scope includes adult and young adult audiences.

Graduate
Doctoral

Bulletins

The professional role of the information architect encompasses project management and the organization of work flows within a team-based approach to the design of information structures. The information architect is ultimately responsible for identifying the rationale and long-term objective(s) underlying the organization of a collection of data resources; for setting functional specifications and content requirements that address current and future objectives of the collection; for designing the structural organization of the collection, including its category structure and labeling scheme or controlled vocabulary; for mapping navigation pathways and information flows within the collection; and determining the metrics that will be used to measure the success of the resulting structure.

Students must complete 18 graduate credit hours; credits counted toward another degree may not be applied toward the certificate.

If a student has completed equivalent graduate coursework in one or more of the required content areas prior to admission to the program, [or the course has not been offered while the student is completing the certificate], this coursework may be applied to satisfy content requirements for the certificate.

Required courses:

- ILS-Z 512 Information Systems Design (3 cr.)
- ILS-Z 515 Information Architecture (3 cr.)
- ILS-Z 516 Human-Computer Interaction (3 cr.)
- ILS-Z 566 Systems Analysis and Design (3 cr.)
- ILS-Z 633 Indexing (3 cr.)
- ILS-Z 690 Capstone in Information Architecture (3 cr.)

Coursework must be completed within three (3) years of entering the certificate program. No credits may be transferred from another graduate or undergraduate program in order to satisfy content requirement for 18 credit hours of coursework. The student must maintain a GPA of 3.2 on a 4.0 scale with a minimum course grade of B. Any course in which the student earns a grade less than B must be repeated in the certificate program.

Elective courses:

If a student has completed equivalent graduate coursework in one or more of the required content areas prior to admission to the program, this coursework may be applied to satisfy content requirements for the certificate. The student may then select from a list of elective courses to meet the 18 credit hours of coursework required for the certificate.

- BUS-S 531 Advanced Web Applications Development (3 cr.)
- CSCI-A 548 Mastering the World Wide Web (3 cr.)
- CSCI-B 659 Topics in Artificial Intelligence (topic: Web Mining) (3 cr.)
- ILS-Z 503 Representation and Organization (3 cr.)
- ILS-Z 511 Database Design (3 cr.)
- ILS-Z 513 Organizational Informatics (3 cr.)
- ILS-Z 517 Web Programming (3 cr.)
- ILS-Z 519 Information Analysis (3 cr.)
- ILS-Z 520 Information Seeking and Use (3 cr.)
- ILS-Z 561 User Interface Design for Information Systems (3 cr.)
- ILS-Z 603 Workshop in Library and Information Science (3 cr.)
- ILS-Z 604 Topics in Library and Information Science (1-4 cr.)
- ILS-Z 634 Metadata (3 cr.)
- ILS-Z 635 Ontologies (3 cr.)
- ILS-Z 636 Data Semantics (3 cr.)
- ILS-Z 637 Information Visualization (3 cr.)
- ILS-Z 643 The Information Industry (3 cr.)
- ILS-Z 661 Concepts and Contemporary Issues in Human-Computer Interaction (3 cr.)

Master of Data Science - Online and 4+1 Master of Data Science-Online

Master of Data Science-Online

The M.S. in Data Science - Online (MSDSO) aims to enhance data skills for managers, practitioners, and domain scientists. Due to its asynchronous format, this program is fully online with no residency requirements. Students have up to - but no more than - five (5) years to complete the degree requirements through part-time or full-time enrollment. Students are required to complete **30** credit hours of graduate-level coursework for this degree.

Prerequisites

Students in this distance education program need to have programming experience in Python and R, as well as basic math (probability, linear algebra, calculus).

Students who lack the above prerequisites are encouraged to reach out to the Luddy Office of Online Education for recommendations.

Curriculum

Students are required to complete **6** credit hours of core coursework that covers **3** credit hours of Statistical Methods, and **3** credit hours of Machine Learning and Artificial Intelligence. Students will specialize in **6** credit hours of a Data Science Domain. The remaining **18** credit hours are **3** credit hours of capstone project and **15** credit hours of electives, selected to best suit individual interests, needs, and overall career goals.

Students may transfer no more than **9** graduate-level credit hours, with grades of B or higher, to the program from another institution or university. These credits may not have previously been utilized to award another degree or certificate; *the only exception is those who previously completed the Graduate Certificate in Data Science that is comprised of* **12** *credit hours, in which up to a total of* **21** *credit hours may be transferred.*

Statistical Methods (3 credit hours)

Select one course from the following:

- SPCN-V 506 Statistical Analysis for Effective Decision-making
- STAT-S 519 519 A Gentle Introduction to Statistics in R
  - Higher level statistics course may be taken with departmental approval

Machine Learning and Artificial Intelligence (3 credit hours)

Select one course from the following:

- CSCI-B 551 Elements of Artificial Intelligence
- CSCI-P 556 Applied Machine Learning
- ENGR-E 511 Machine Learning for Signal Processing
- ENGR-E 533 Deep Learning Systems (may be counted only once)

Data Science Domain (6 credit hours)

Students must select one of the following domains and complete two courses within that specific domain:

Data Analytics and Visualization

- DSCI-D 532 Applied Database Technologies
- DSCI-D 590 Topics in Data Science
  - Topic: Optimization and Simulation for Business Analytics
  - Topic: Data Visualization
- ENGR-E 534 Big Data Applications
- ENGR-E 583 Information Visualization
- ILS-Z 534 Search
- INFO-I 535 Management, Access, and Use of Big and Complex Data
- INFO-I 606 Network Science

Intelligent Systems Engineering

- ENGR-E 516 Engineering Cloud Computing
- ENGR-E 517 High Performance Computing
- ENGR-E 533 Deep Learning Systems (may be counted only once)

Cybersecurity

- INFO-I 520 Security in Networked Systems
- INFO-I 525 Organizational Informatics and Economics of Security
- INFO-I 533 Systems and Protocol Security and Information Assurance

Capstone Project (3 credit hours)
Students will be required to work on a project that applies the knowledge and skills learned to solve real-world problems for a company, organization, or individual. This may be fulfilled through a capstone course or an independent study project. The aim of this requirement is to demonstrate students' capabilities to prospective employers and inspire innovation.

- DSCI-D 590 Topics in Data Science
  - Topic: Faculty Assistance in Data Science
- DSCI-D 592 Data Science in Practice
- DSCI-D 699 Independent Study in Data Science

Electives (15 credit hours)

The remaining credit hours are selected from unselected courses listed above or additional data science-related course offerings listed below. Students may not earn credit for courses taken to fulfill core, domain, or capstone requirements.

- CSCI-B 505 Applied Algorithms
- CSCI-B 561 Advanced Database Concepts
- CSCI-B 657 Computer Vision
- DSCI-D 590 Topics in Data Science
  - Topic: Applied Data Science
  - Topic: Data Science On-Ramp **
  - Topic: Introduction to NLP for Data Science
  - Topic: Introduction to Python Programming
  - Topic: Time Series Analysis
- DSCI-D 591 Graduate Internship *
- INFO-I 513 Usable Artificial Intelligence

- INFO-I 529 Machine Learning in Bioinformatics
- ILS-Z 639 Social Media Mining
- SPCN-P 507 Data Analysis and Modeling for Public Affairs
- STAT-S 580 Introduction to Regression Models and Nonparametrics

(*) No more than 3 credit hours of DSCI-D 591 may be earned
(**) No more than three (3) credit hours of DSCI-D 590, Data Science On-Ramp, may be earned

4+1 MS Data Science-Online

Undergraduates with the B.S. Data Science Major, Minor, or Specialization will be able to complete a bachelor's degree and a M.S. in Data Science – Online. The students would take 120 credits for the bachelor's degree and 21 credits for the master's degree. The total credit hours will be 141 credits.

The program's overall course requirements add up to as much as 9 fewer credit hours than the sum total of the bachelor's and the master's degrees taken individually.

Admission and Status

- For admission to the 4+1 program, students must have earned a major and program GPA of at least 3.0 at the time of admission to the program.
- To apply to the 4+1 program, students must first talk with their undergraduate advisor, who will review their academic record to ensure that they meet the admission requirements. If a student meets the requirements, the advisor will notify the Luddy Graduate Office who will provide the student with an invitation code which will give the student access to the application. The Luddy Graduate Office will also provide the student with an application fee waiver code.
- Students in the program will be classified as undergraduates through the last semester in which they are enrolled in undergraduate requirements. Students in good standing, defined as a major and program GPA of at least 3.0, must submit the standard application to the University Graduate School by January 1 prior to the academic year they want to transition to graduate status.
- Those not in good standing at any time are dropped from the program and reclassified as undergraduate students. If the transition to graduate status is delayed for any reason, The 4+1 program status will revert to undergraduate status and the student will be encouraged to apply to the M.S. program.
- Students in the 4+1 program must complete at least 21 hours of coursework while registered in graduate status. Normally, this would encompass no fewer than two semesters.
- Students are advised to check on the effect that transition to graduate status may have on existing undergraduate funding; the possibility of graduate funding is conditional upon transition to graduate status.
- Once admitted to the program, if a student switches out of the 4+1 status, they may not switch back into the program after April 15th. These students will be encouraged to apply for the M.S. program.

Academic Requirements

- A minimum of 141 credit hours
- Major GPA of at least 3.0; Cumulative GPA for graduate courses of at least 3.0
- All undergraduate degree requirements
- All B.S. Data Science Specialization/Minor requirements
- Students in the 4+1 program are required to complete **6** credit hours of core coursework that covers **3** credit hours of **Statistical Methods** and **3** credit hours of **Machine Learning and Artificial Intelligence**. Students will specialize in **6** credit hours of a Data Science Domain. The remaining **9** credit hours are **3** credit hours of capstone project and **6** credit hours of electives, selected to best suit individual interests, needs, and overall career goals.

Statistical Methods (3 credit hours)

Select one course from the following:

- SPEA-V 506 Statistical Analysis for Effective Decision-Making
- STAT-S 519 A Gentle Introduction to Statistics in R
  - Higher level statistics course may be taken with departmental approval

Machine Learning and Artificial Intelligence (3 credit hours)

Select one course from the following:

- CSCI-B 551 Elements of Artificial Intelligence
- CSCI-P 556 Applied Machine Learning
- ENGR-E 511 Machine Learning for Signal Processing
- ENGR-E 533 Deep Learning Systems (may be counted only once)
- INFO-I 513 Usable Artificial Intelligence

Data Science Domain (6 credit hours)

Students must select one of the following domains and complete two courses within that specific domain:

Data Analytics and Visualization

- DSCI-D 590 Topics in Data Science
  - Topic: Optimization and Simulation for Business Analytics
  - Topic: Data Visualization
- ENGR-E 534 Big Data Applications
- ENGR-E 583 Information Visualization
- ILS-Z 534 Search
  - INFO-I 513 Usable Artificial Intelligence (may be counted only once)
- INFO-I 535 Management, Access, and Use of Big and Complex Data
- INFO-I 606 Network Science

Intelligent Systems Engineering

- ENGR-E 516 Engineering Cloud Computing
- ENGR-E 517 High Performance Computing
- ENGR-E 533 Deep Learning Systems (may be counted only once)

Cybersecurity

- INFO-I 520 Security in Networked Systems
- INFO-I 525 Organizational Informatics and Economics of Security
- INFO-I 533 Systems and Protocol Security and Information Assurance

Capstone Project (3 credit hours)

Students will be required to work on a project that applies the knowledge and skills learned to solve real-world problems for a company, organization, or individual. This may be fulfilled through a capstone course, an internship, or an independent study project. The aim of this requirement is to demonstrate students' capabilities to prospective employers and inspire innovation.

- DSCI-D 590 Topics in Data Science
  - Topic: Faculty Assistance in Data Science
- DSCI-D 592 Data Science in Practice
- DSCI-D 699 Independent Study in Data Science

Electives (6 credit hours)

The remaining credit hours are selected from additional data science-related course offerings within the Luddy School of Informatics, Computing, and Engineering. Students may not earn credit for courses taken to fulfill the core or capstone requirements.

- CSCI-B 505 Applied Algorithms
- CSCI-B 561 Advanced Database Concepts
- CSCI-B 657 Computer Vision
- DSCI-D 590 Topics in Data Science
  - Topic: Applied Data Science
  - Topic: Data Science On-Ramp **
  - Topic: Introduction to NLP for Data Science
  - Topic: Introduction to Python Programming
  - Topic: Time Series Analysis
- DSCI-D 591 Graduate Internship *
- INFO-I 529 Machine Learning in Bioinformatics
- ILS-Z 639 Social Media Mining
- SPCN-P 507 Data Analysis and Modeling for Public Affairs
- STAT-S 580 Introduction to Regression Models and Nonparametrics

(*) No more than three (3) credit hours of DSCI-D 591 may be earned
(**) No more than three (3) credit hours total of DSCI-D 590, Data Science On-Ramp, may be earned

Master of Science in Intelligent Systems Engineering

MS DEGREE REQUIREMENTS

The Master of Science in Intelligent Systems Engineering requires a total of 30 credits and a 3.0 GPA upon completion. Students must take 15 credits of 500+ level ISE courses (including any joint listed with other university programs).

Tracks

Upon admission to the program, students must choose a track to study: Bioengineering, Computer Engineering, Cyber-Physical Systems, Environmental Engineering, Intelligent Systems, Nanoscale and Molecular Engineering, or Neuroengineering.

Paradigms

Upon admission to the program, students must choose a paradigm for their studies: coursework, internship, project, and/or research.

Curriculum

Students are required to complete 30 credit hours of graduate level coursework for this degree. 15 credits must be ISE 500+ level classes. Individual program choices will vary.

ISE Compulsory Core (7 credits)

- ENGR-E 500 Introduction to the Intelligent Systems Engineering Program

Select two courses from the following (one from track focus and the other from track of choice)

- ENGR-E 501 Introduction to Computer Engineering
- ENGR-E 502 Introduction to Cyber Physical Systems
- ENGR-E 503 Introduction to Intelligent Systems
- ENGR-E 504 Introduction to Bioengineering
- ENGR-E 505 Introduction to Nano-Engineering
- ENGR-E 506 Introduction to Neuro-Engineering
- ENGR-E 507 Introduction to Environmental Engineering Intelligent Systems

Math Methods (6 credits)

Select two courses from the following or contact the GSO for a Math Methods waiver

- ENGR-E 503 Introduction to Intelligent Systems
- MATH-M 511 Real Variables I
- MATH-M 512 Real Variables II
- MATH-M 513 Complex Variables I
- MATH-M 514 Complex Variables II
- MATH-M 540 Partial Differential Equations I
- MATH-M 541 Partial Differential Equations II
- MATH-M 544 Ordinary Differential Equations I
- MATH-M 545 Ordinary Differential Equations II
- MATH-M 571 Analysis of Numerical Methods I
- MATH-M 572 Analysis of Numerical Methods II
- MATH-M 671 Numerical Treatment of Differential and Integral Equations I
- MATH-M 672 Numerical Treatment of Differential and Integral Equations II

Computing Tools Requirement (1 - 3 credits) optional

Select from the following

- ENGR-E 516 Engineering Cloud Computing
- INFO-I 590 Topics in Informatics
  - Topic: Data Science On-Ramp
- CSCI-B 673 Advanced Scientific Computing

Track Core (6 credits)

The core is different for each track and will be satisfied from courses listed below. Students select at least two classes based on their track: Bioengineering, Computer Engineering, Cyber-Physical Systems, Environmental Engineering, Intelligent Systems, Nanoscale and Molecular Engineering, or Neuroengineering.

Courses for each track

Bioengineering

- BIOL-L 585 Genetics
- BIOL-L 586 Cell Biology
- BIOT-T 540 Structure and Function of Biomolecules
- ENGR-E 535 Image Processing for Medical Applications
- ENGR-E 537 Rapid Prototyping for Engineers
- ENGR-E 540 Computational Methods for 3-D Biomaterials
- ENGR-E 541 Simulating Cancer as an Intelligent System
- ENGR-E 542 Introduction to Computational Bioengineering
- ENGR-E 543 Computational Modeling Methods for Virtual Tissues
- ENGR-E 545 Wearable Sensors
- ENGR-E 548 Computational Multicellular Systems Biology
- ENGR-E 570 Advanced Bioengineering
- ENGR-E 571 Microfluidic Devices and Systems
- ENGR-E 572 Biomedical Devices and Sensors
- ENGR-E 599 Topics in Intelligent Systems Engineering (topic related to Bioengineering)
- INFO-I 519 Introduction to Bioinformatics

Computer Engineering

- ENGR-E 510 Engineering Distributed Systems
- ENGR-E 512 Advanced Computer Architecture
- ENGR-E 513 Engineering Compilers
- ENGR-E 514 Embedded Systems
- ENGR-E 516 Engineering Cloud Computing
- ENGR-E 517 High Performance Computing
- ENGR-E 518 Engineering Networks
- ENGR-E 519 Engineering Operating Systems
- ENGR-E 533 Deep Learning Systems
- ENGR-E 534 Big Data Applications
- ENGR-E 536 High Performance Graph Analytics
- ENGR-E 599 Topics in Intelligence Systems Engineering (topic related to Computer Engineering)
- ENGR-E 621 Software Defined Systems

Cyber-Physcial Systems

- ENGR-E 512 Advanced Computer Architecture
- ENGR-E 513 Engineering Compilers
- ENGR-E 514 Embedded Systems
- ENGR-E 522 HPC and Cloud Computing for Large Scale Image Applications
- ENGR-E 523 Internet of Things
- ENGR-E 533 Deep Learning Systems
- ENGR-E 537 Rapid Prototyping for Engineers
- ENGR-E 545 Wearable Sensors
- ENGR-E 599 Topics in Intelligence Systems Engineering (topic related to Cyber-Physical Systems)
- ENGR-E 621 Software Defined Systems
- ENGR-E 623 Applied Streaming Data Systems

Environmental Engineering

- ENGR-E 504 Introduction to Bioengineering
- ENGR-E 571 Microfluidic Devices and Systems
- ENGR-E 572 Biodmedical Devices and Sensors
- ENGR-E 599 Topics in Intelligence Systems Engineering (topic related to Environmental Engineering)
- SPEA-E 515 Fundamentals of Air Pollution
- SPEA-E 520 Environmental Toxicology
- SPEA-E 536 Environmental Chemistry
- SPEA-E 537 Environmental Chemistry Laboratory
- SPEA-E 552 Environmental Engineering
- SPEA-E 555 Topics in Environmental Science
- SPEA-E 574 Energy Systems

Intelligent Systems

- ENGR-E 511 Machine Learning for Signal Processing
- ENGR-E 522 HPC and Cloud Computing for Large Scale Image Applications
- ENGR-E 523 Internet of Things
- ENGR-E 531 Physical Optimization
- ENGR-E 532 Systems Engineering
- ENGR-E 533 Deep Learning Systems
- ENGR-E 534 Big Data Applications
- ENGR-E 535 Image Processing for Medical Applications
- ENGR-E 536 High Performance Graph Analytics
- ENGR-E 583 Information Visualization
- ENGR-E 584 Scientific Visualization
- ENGR-E 599 Topics in Intelligence Systems Engineering (topic related to Intelligent Systems)

Nanoscale and Molecular Engineering

- CHEM-C 567 Chemical Statistical Mechanics
- CHEM-C 616 Surface Analysis and Surface Chemistry
- CHEM-M 501 Fundamentals of Materials I: Making, Measuring, and Modeling
- CHEM-M 502 Fundamentals of Materials II: Nanoscale and Molecular Materials
- ENGR-E 537 Rapid Prototyping for Engineers
- ENGR-E 545 Wearable Sensors
- ENGR-E 551 Simulating Nanoscale Systems
- ENGR-E 571 Microfludic Devices and Systems
- ENGR-E 572 Biomedical Devices and Sensors
- ENGR-E 599 Topics in Intelligence Systems Engineering (topic related to Nanoscale and Molecular Engineering)
- PHYS-P 575 Solid State Physics
- PHYS-P 609 Computational Physics II

Neuroengineering

- COGS-Q 551 The Brain and Cognition
- COGS-Q 570 Behavior-Based Robotics
- COGS-Q 610 Networks of the Brain

- ENGR-E 535 Image Processing for Medical Applications
- ENGR-E 599 Topics in Intelligence Systems Engineering (topic related to Neuroengineering)
- NEUS-N 500 Neural Science I
- NEUS-N 501 Neural Science II
- NEUS-N 550 Seminar on Sensorimotor Neuroplasticity
- NEUS-N 611 Neural Bases of Visual Sensation, Perception, and Cognition
- PHYS-P 582 Biological and Artificial Neural Networks
- PHYS-P 583 Signal Processing and Information Theory in Biology
- PSY-P 544 Introduction to MRI Measurement and Analysis
- PSY-P 546 Neurophysiological Techniques: Theory and Methods

Paradigms/Electives (8-17 credits)

The remaining credit hours can be selected from additional ISE 500+ level courses. In consultation with an ISE advisor, students may take 500+ level courses from other departments as long as they take at least 15 credits of 500+ level ISE courses. Students can take at most three DSCI-D 590 credits.

Upon admission to the program, students must choose a paradigm for their studies: coursework, internship, project, and/or research. In consultation with an ISE advisor, students may choose to pursue an independent study or relevant internship opportunity to complete their paradigm.

- **Coursework:** Students may choose to complete the 30 credit degree requirement with coursework
- **Internship:** May include 1-3 credit hours of ENGR-E 591 Graduate Internship. The number of credit hours approved for this requirement is dependent on time and length of internship
- **Thesis or Project:** May include a maximum of 6 credit hours of the following:
  - ENGR-E 687 Graduate Independent Studies in Intelligent Systems Engineering
  - ENGR-E 788 Master's Thesis
- **Transfer:** A maximum of 8 graduate level credits may be transferred from other universities and used to satisfy the 30 credit requirement with the permission of the advisor. These courses may not have been used to meet the requirements for another degree and must have been completed with a minimum grade of "B" (3.0).

Accelerated Master of Intelligent Systems Engineering

The accelereated program allows you to take 12 graduate level credits that may be used towards your undergraduate requirements. With this approach, once you complete your undergraduate degree, you will only need 18 credits to earn a master's degree, which can be completed in one year. Students apply for the program during their junior year and are eligbile for ISE graduate courses during their junior and senior years.

Application Requirements

Students in the program are classified as undergraduates until the end of the first semester in which 120 or more hours of credit toward graduation have been earned. Students need to begin graduate level courses while in undergraduate status; otherwise, the program may not be completed in five years. Students should consult with their advisor regarding appropriate graduate level courses. Permission to enroll in graduate level courses must be obtained from the course instructor or your advisor.

Academic Requirements

Students in the program must complete the same 30 credit hours and courses requirements as the ISE M.S. degree.

Intelligent Systems Engineering

- M.S. in Intelligent Systems Engineering
- Accelerated Master's Program in Intelligent Systems Engineering

Graduate Certificate in Cybersecurity

Eligibility

This certificate is open to all graduate students and undergraduates who have completed their undergraduate requirements, although formal graduation is not required.

Prerequisites

Appropriate technical background in computer science, informatics, or related field.

Admissions Requirements and Application Procedure

Prospective students should apply at least 90 days before the start of the semester in which they would like to enroll.

Items that are important in the evaluation process include:

- Complete online application
- Application fee (non-refundable). A fee waiver is provided for US active-duty military or those who have been active within the past 12 months. For consideration, submit most recent Leave and Earnings Statement (LES) and a copy of Military ID.
- Upload a copy of the official transcript(s) from each previous undergraduate or graduate institution via the online application under the "Additional Upload" section of the "Department Information" tab. All pages from one or more transcripts should be combined into a single .pdf document.
- Statement of Purpose essay explaining your interest in the program and academic/career goals should not exceed 400 words.
- One letter of recommendation. Register your recommenders email for online submission when you apply.
- Resume, listing any awards or publications.
- We require all students who are non-native English speakers to submit the Test of English as a Foreign Language (TOEFL) scores. TOEFL scores are good for two (2) years from the date you took the exam. We expect a minimum score of 100 or higher on the Internet-based test (iBT), 250 on the computer-based test, or 600 or higher on the paper-based

test. Submit TOEFL scores to institution 1324 and department code 78.
- GRE is not required

All items listed above must be submitted electronically with the online application. *Do not mail any supporting materials to the Computer Science Graduate Office.* Documents submitted to Indiana University will not be returned to the student.

Academic Requirements

Students are required to complete 12 credit hours with a grade of B- or higher

At least 6 credits from the following courses:

- INFO-I 520 Security for Networked Systems (3 cr.)
- INFO-I 521 Malware Epidemic: Threat and Defense (3 cr.)
- INFO-I 525 Organizational Informatics and Economics of Security (3 cr.)
- INFO-I 533 Systems and Protocol Security and Information Assurance (3 cr.)
- INFO-I 536 Foundational Mathematics of Cybersecurity (3 cr.)
- INFO-I 537 Legal and Social Informatics of Security (3 cr.)
- INFO-I 538 Introduction to Cryptography (3 cr.)
- INFO-I 539 Cryptographic Protocols (3 cr.)

At least 6 credits from the following courses:

- BUKD-T 560 IT Risk Management (3 cr.) (Online)
- BUKD-T 578 Cybersecurity Law and Policy (3 cr.) (Online)
- BUKD-T 579 Information Systems Security (3 cr.) (Online)
- BUS-S 538 Organizational Information Systems Security (3 cr.)
- LAW-B 536 Health Privacy Law (2 cr.)
- LAW-B 587 Information Security Law (3 cr.)
- LAW-B 708 Information Privacy Law I (3 cr.)
- LAW-B 728 Information Privacy Law II (3 cr.)
- LAW-B 738 Cybersecurity (3 cr.)

The certificate can be completed in residence in one semester and sufficient courses are offered so that students can complete the requirements in either the fall or spring semester. The certificate may also be pursued over multiple semesters. Not all courses are offered every semester, so interested students are advised to check in advance to see when the courses in which they may be particularly interested are offered. Generally, courses are not offered in the summer. Other cybersecurity certificates are available from the Kelley School of Business and the Maurer School of Law.

Graduate Certificate in Data Science - Online

The Graduate Certificate in Data Science (GCDS) is a fully online graduate program that encompasses a broad range of courses on topics such as cloud computing, visualization, high-performance computing, machine learning, and data analysis. This professional certificate allows students the opportunity to tailor their curriculum to suit their interests.

Upon successful completion of the Graduate Certificate in Data Science, students have the option of applying earned credits towards the Online Master of Science in Data Science. Those who apply by the established deadlines will receive Direct Admission to the MS program and credits earned will transfer automatically.

Curriculum

Students must complete 12 graduate credit hours with a grade of B or higher to earn the certificate; a cumulative GPA of 3.00 or higher must be achieved by program completion, with no outstanding grades (Incompletes). All coursework must be completed within two (2) years of entering the certificate program. No credits may be transferred from another graduate or undergraduate program to satisfy the requirements. The only exception to this policy is through the Indiana University Graduate School's Continuing Non-Degree (CND) Program. Students may apply no more than three (3) credit hours of approved graduate coursework in non-degree status; the course must be earned with a grade of B or higher.

Courses must be selected from the approved list of graduate courses below, unless otherwise approved by the Director of Data Science Graduate Studies; any four (4) courses may be taken for the certificate. Students are encouraged to consult with the Luddy Office of Online Education for course recommendations, availability, etc.

- CSCI-B 505 Applied Algorithms
- CSCI-B 551 Elements of Artificial Intelligence
- CSCI-B 561 Advanced Database Concepts
- CSCI-B 657 Computer Vision
- CSCI-P 556 Applied Machine Learning
- DSCI-D 532 Applied Database Technologies
- DSCI-D 590 Topics in Data Science
  - Topic: Applied Data Science
  - Topic: Data Science On-Ramp *
  - Topic: Data Visualization
  - Topic: Introduction to NLP for Data Science
  - Topic: Introduction to Python Programming
  - Topic: Optimization and Simulation for Business Analytics
  - Topic: Time Series Analysis
- ENGR-E 511 Machine Learning for Signal Processing
- ENGR-E 516 Engineering Cloud Computing
- ENGR-E 517 High Performance Computing
- ENGR-E 533 Deep Learning Systems
- ENGR-E 534 Big Data Applications
- ENGR-E 583 Information Visualization
- ILS-Z 534 Search
- ILS-Z 639 Social Media Mining
- INFO-I 513 Usable Artificial Intelligence
- INFO-I 520 Security for Networked Systems
- INFO-I 525 Organizational Informatics and Economics of Security
- INFO-I 529 Machine Learning in Bioinformatics
- INFO-I 533 Systems and Protocol Security and Information Assurance

- INFO-I 535 Management, Access, and Use of Big and Complex Data
- INFO-I 606 Network Science
- SPCN-P 507 Data Analysis and Modeling for Public Affairs
- SPCN-V 506 Statistical Analysis for Effective Decision-making
- STAT-S 519 A Gentle Introduction to Statistics in R
- STAT-S 520 Introduction to Statistics
- STAT-S 580 Introduction to Regression Models and Nonparametrics

(*) No more than three (3) credit hours of DSCI-D 590, Data Science On-Ramp, may be earned

Master of Science Informatics Animal Informatics

Our Master of Science in Informatics program provides multiple paths to advanced study on the technological, social, and scientific impact of information technology. We offer a wide range of multidisciplinary classes that will allow a student to forge their future while also building the skills they need to be successful in industry or academia.

Beyond the pursuit of a degree, our Masters of Informatics track is designed for students who are thinking about entering a specific Ph.D. track. Each M.S. in Informatics student is assigned a faculty advisor who will help the student decide if the Ph.D. in Informatics track is right for them. In certain circumstances, credits for the M.S. in Informatics may be transferred to the Ph.D. program. The courses taken must have a coherent focus within the general field of Informatics.

REQUIREMENTS

The student's advisor and the Informatics Director of Graduate Studies must approve all coursework prior to taking the course.

To receive the M.S. Informatics degree from Indiana University Luddy School of Informatics, Computing, and Engineering, the student must:

- Complete 36 credit hours - 27 credit hours of Informatics courses and nine (9) credit hours of electives of any graduate level coursework within or outside the Luddy School of Informatics, Computing, and Engineering with no individual course grade below a C (2.0)
- Maintain a minimum B (3.0) GPA
- Complete the course requirements as stated in the handbook for the term of matriculation
- Meet all of the above requirements within five (5) calendar years of initial matriculation

GRADES

The minimum overall GPA of a grade of B (3.0) for all graduate courses is required. A student whose semester GPA fall below a grade of B (3.0) will be put on probation. The student must raise their semester and cumulative GPA to B (3.0) or higher by the end of the following semester. Failure to do so may result in academic dismissal from the program. A student whose cumulative GPA falls below a grade of B (3.0) for two consecutive semesters (excluding summer) may result in academic dismissal from the program.

Animal Informatics Track

Students following the Animal Informatics Track are required to complete **36** credit hours of coursework - that covers **18** credit hours in the core Animal Informatics area and **18** credit hours of electives.

Core Classes (18 credit hours)

- INFO-I 511 Animal-Computer Interaction Methods
- INFO-I 512 Direct Observation and Design
- INFO-I 513 Usable Artificial Intelligence
- INFO-I 514 Seminar in Animal-Computer Interaction
- INFO-I 590 Topics in Informatics
  - Topic: Prototyping with Arduino Tools
- INFO-I 699 Independent Study in Informatics

Technology Electives (9 credit hours)

Select three courses from the following:

Animal Behavior, Cognition, and Conservation Management

- BIOL-L 553 Sensory Ecology
- GEOG-G 548 Capitalism and Nature
- INFO-I 590 Topics in Informatics
  - Topic: Technological Nature
- SPEA-E 563 Wildlife Management

Artificial Intelligence and Data Analytics

- CSCI-B 551 Elements of Artificial Intelligence
- CSCI-B 555 Machine Learning
- CSCI-B 565 Data Mining
- CSCI-B 657 Computer Vision
- CSCI-P 556 Applied Machine Learning
- ENGR-E 511 Machine Learning for Signal Processing
- ENGR-E 533 Deep Learning Systems
- ENGR-E 534 Big Data Applications
- ENGR-E 583 Information Visualization
- ENGR-E 584 Scientific Visualization
- ILS-Z 534 Search
- INFO-I 590 Topics in Informatics
  - Topic: Data Visualization
- INFO-I 606 Network Science

Augmented and Virtual Reality

- INFO-I 590 Topics in Informatics
  - Topic: Artificial Life in Virtual Reality
  - Topic: Building Virtual Worlds
  - Topic: Creating Virtual Assets
  - Topic: Introduction to Virtual Reality

Geospatial Information System

- GEOG-G 535 Environmental Remote Sensing
- GEOG-G 536 Advanced Remote Sensing
- GEOG-G 538 Geographic Information Systems
- GEOG-G 539 Advanced Geographic Information Systems

- GEGO-G 578 Global Change, Food and Farming Systems
- GEOG-G 588 Applied Spatial Statistics
- GEOG-G 639 GIS and Environmental Analysis

IoT Systems and Physical Fabrication

- CSCI-P 535 Pervasive Computing OR INFO-I 527 Mobile and Pervasive Design
- ENGR-E 514 Embedded Systems
- ENGR-E 537 Rapid Prototyping for Engineers
- INFO-I 540 Human Robot Interaction
- INFO-I 549 Advanced Prototyping
- INFO-I 590 Topics in Informatics
  - Topic: Makerspace: Design & Fabrication

Mobile App Development

- CSCI-P 535 Pervasive Computing OR INFO-I 527 Mobile and Pervasive Design
- INFO-I 590 Topics in Informatics
  - Topic: Cross-platform Mobile Programming

Qualitative Methods and Design

- CSCI-P 535 Pervasive Computing OR INFO-I 527 Mobile and Pervasive Design
- INFO-I 516 Informatics in Disasters and Emergency Response
- INFO-I 530 Field Deployments
- INFO-I 543 Interaction Design Methods
- INFO-I 544 Experience Design
- INFO-I 590 Topics in Informatics
  - Topic: Environmental Policy and Health Design
- INFO-I 604 Human-Computer Interaction Design Theory

Technology Entrepreneurship

- INFO-I 566 Technology Innovation
- INFO-I 567 Design Strategy
- INFO-I 568 Technology Entrepreneurship

Web and Database Design

- CSCI-B 561 Advanced Database Concepts
- DSCI-D 532 Applied Database Technologies
- ENGR-E 516 Engineering Cloud Computing
- ILS-Z 511 Database Design
- ILS-Z 512 Information Systems Design
- ILS-Z 513 Organizational Informatics
- ILS-Z 514 Social Aspects of Information Technology
- ILS-Z 515 Information Analytics
- ILS-Z 517 Web Programming
- ILS-Z 519 Information Analytics
- ILS-Z 532 Information Architecture for the Web
- ILS-Z 556 Systems Analysis and Design
- INFO-I 535 Management, Access, and Use of Big and Complex Data

Additional Electives (9 credit hours)

The remaining 9 credit hours are selected from unselected courses above or additional animal informatics-related course offerings at Indiana University Bloomington.

4+1 MS in Informatics, Animal Informatics Track

Undergraduates with a Minor or Cognate in Animal Computer Interaction will be able to complete a bachelor's degree and a M.S. in Informatics, Animal Informatics Track. The students would take 120 credits for the bachelor's degree and 21 credits for the master's degree. The total credit hours will be 141 credits.

The program's overall course requirements add up to as much as 15 fewer credit hours than the sum total of the bachelor's and master's degrees taken individually.

Admission and Status

- For admission to the 4+1 program, students must have earned a major and program GPA of at least 3.0 at the time of admission to the program.
- To apply to the **4+1 program** students pursuing the Informatics B. S. degree must first talk with their undergraduate advisor, who will review their academic record to ensure that they meet the admission requirements. If a student meets the requirements, the advisor will notify the Luddy Graduate Office who will provide the student with an invitation code which will give the student access to the application. The Luddy Graduate Office will also provide the student with an application fee waiver code.
- Students in the program will be classified as undergraduates through the last semester in which they are enrolled in undergraduate requirements.Students in good standing, defined as a major and program GPA of at least 3.0, must submit the standard application to the University Graduate School by January 1 prior to the academic year they want to transition to graduate status.
- Those not in good standing at any time are dropped from the program and reclassified as undergraduate students. If the transition to graduate status is delayed for any reason, The 4+1 program status will revert to undergraduate status and the student will be encouraged to apply to the M.S. program.
- Students in the 4+1 program must complete at least 21 hours of coursework while registered in graduate status. Normally, this would encompass no fewer than two semesters.
- Students are advised to check on the effect that transition to graduate status may have on existing undergraduate funding; the possibility of graduate funding is conditional upon transition to graduate status.
- Once admitted to the program, if a student switches out of the 4+1 status, they may not switch back into the program after April 15th. These students will be encouraged to apply for the M.S. program.

Academic Requirements

- A minimum of 141 credit hours
- Major GPA of at least 3.0; Cumulative GPA for graduate courses of at least 3.0
- All undergraduate degree requirements
- At least 21 Animal Informatics credit hours beyond the requirements for the B.S. degree at 500 level or above
- Students in the 4+1 program are required to complete 9 credit hours of core courework. The

remaining are 12 credit hours of electives, selected to best suit individual interests, needs, and overall career goals.

Core Classes (9 credit hours)

- INFO-I 512 Direct Observation and Design
- INFO-I 513 Usable Artificial Intelligence
- INFO-I 590 Topics in Informatics
  - Topic: Prototyping with Arduino Tools

Electives (12 credit hours)

The remaining 12 credit hours are selected from additional animal informatics-related course offerings at Indiana University Bloomington. Students may not earn credit for courses taken to fulfill the core requirements.

Degree Programs

- Graduate Certificate in Data Science - Online
- Graduate Certificate in Cybersecurity
- Graduate Certificate in Information Architecture
- M.S. and Accelerated Master's Program in Computer Science
- M.S. in Bioinformatics
- M.S. in Data Science and 4+1 MS Data Science
- M.S. in Data Science - Online and 4+1 MS Data Science-Online
- M.S. in Human-Computer Interaction Design
- M.S. in Informatics (MSI) and 4+1 MSI
- M.S. and Accelerated Master's Program in Intelligent Systems Engineering
- M.S. and Accelerated Master's Program in Secure Computing
- Master of Information Science (MIS) and 4+1 MIS
- Master of Library Science (MLS) and 4+1 MLS
- Master of Information Science (MIS) and Master of Library Science (MLS) Dual Degree
- ILS Specializations
- ILS Dual Degrees
- Ph.D. in Computer Science (offered through the University Graduate School)
- Ph.D. in Informatics (offered through the University Graduate School)
- Ph.D. in Information Science (offered through the University Graduate School)
- Ph.D in Intelligent Systems Engineering (offered through the University Graduate School)

Accelerated Master's Program in Computer Science

The Accelerated Master’s Program combines the Computer Science B.S. and M.S. degrees to enable highly focused and motivated students to organize their studies so as to earn the two degrees in five years from the time of matriculation to the university.

The program's overall course requirements add up to as much as nine fewer credit hours than the sum total of the B.S. and M.S. degrees taken individually.

Admission and Status

- For admission to the Accelerated Master’s Program, students must have earned a major and program GPA of at least 3.0 and an average grade of B or higher on Computer Science core courses (C200 or C211, C212, C241 and C343).
- To apply to the B.S. M.S. Accelerated program, students must first talk with their undergraduate advisor, who will review their academic record to ensure that they meet the admission requirements. If a student meet the requirements, the advisor will notify the Luddy Graduate Office who will provide the student with an invitation code which will give the student access to the application. The Luddy Graduate Office will also provide the student with an application fee waiver code.
- Students are eligible to apply to the Accelerated Master's Program when they achieve junior academic standing. The application deadlines are September 1 (for Spring admissions) and January 1 (for Fall admission).
- Those not in good standing at any time are dropped from the program and reclassified as undergraduate B.S. students. If the transition to graduate status is delayed for any reason, Accelerated Master's status will revert to undergraduate B.S. status and the student will be encouraged to apply to the Computer Science M.S. program.
- Students in the Accelerated Master’s Program must complete at least 15 hours of coursework while registered in graduate status. Normally, this would encompass no fewer than two semesters.
- Students are advised to check on the effect that transition to graduate status may have on existing undergraduate funding; the possibility of graduate funding is conditional upon transition to graduate status.
- Students will need to take at least one graduate level course in their senior year, while in undergraduate status, to ensure the program completion within five years. Students should consult with the undergraduate advisor regarding appropriate graduate level courses. Permission to enroll in graduate level courses must be obtained from the course instructor or your advisor.
- The B.S. and M.S. degrees must be pursued simultaneously. The student must graduate with both degrees at the same time and apply to graduate for both degrees with the undergraduate recorder.
- Once admitted to the program, if a student switches out of Accelerated MS status, they may not switch back into the program after April 15th. These students will be encouraged to apply for the Computer Science M.S. program.

Academic Requirements

- A minimum of 141 credit hours
- Major GPA of at least 3.0; Cumulative GPA for graduate courses of at least 3.0
- All Computer Science B.S. degree requirements
- At least 21 Computer Science credit hours beyond the requirements for the B.S. degree at 500 level or above. This may not include CSCI-Y 890. At least 15 credit hours need to be CSCI courses for majors, and the remaining 6 credit hours may be any CSCI, DSCI, ENGR, ILS, INFO, STAT, or MATH courses at 500 level or above. At most 6 combined credit hours may be CSCI-Y 790, Y 791, Y 792, Y 793 or Y 798.

Computer Science

- M.S. in Computer Science
- Accelerated Master's Program in Computer Science

About the Program

What imagination makes possible, computer science makes real.

Robots were once science fiction. Today, they build cars, take photos on Mars, disarm bombs, and vacuum our living rooms. While there may be no limit to what technology can accomplish—from space travel to curing cancer—none of it is possible without key breakthroughs in computing theory, programming, artificial intelligence, data analysis, and systems and application design.

As a graduate student in computer science, you'll develop a deep understanding of computing theory and applications that will serve as a springboard to new discoveries. Our cross-disciplinary approach to computer science exposes you not only to the latest research in high-performance computing, data and search, artificial intelligence, and computer security—but also gives you the opportunity to apply those insights to real-world problems such as controlling pandemic disease and tracking the effects of climate change on polar ice.

Major research concentrations on campus include:

- Artificial intelligence and cognitive science
- Bioinformatics
- Computer networks and security
- Cybersecurity
- Database and information systems
- Data mining
- Distributed and parallel systems
- Formal methods for system design, hardware, and robotics
- Foundations: Theory of computing, algorithms, and applied logic
- Graphics and visualization
- High-performance computing
- Machine learning
- Programming languages and compilers
- Vision and audio perception

Degrees

M.S. in Computer Science

- A two-year, multidisciplinary program that provides broad insights in computing theory, data and search, networks, systems, applications and programming, and their practical applications in solving problems

Accelerated Master's Program in Computer Science

- A five-year combined B.S. and M.S. in computer science for highly focused students who want a head start on their careers

Ph.D. in Computer Science

(See University Graduate School Bulletin)

M.S. in Computer Science

M.S. Requirements

The Master of Science in Computer Science program includes a minimum of 30 credit hours in the following four categories.

Foundations (3 cr.)

Complete one course from the following:

- CSCI-B 501 Theory of Computing
- CSCI-B 503 Algorithms Design and Analysis
- CSCI-B 505 Applied Algorithms

Systems (3 cr.)

Complete:

- CSCI-P 536 Advanced Operating Systems
- CSCI-P 538 Computer Networks

Computer Science Courses (15 cr.)

Complete any CSCI 500+ level course

- Excludes DSCI, ENGR, INFO, ILS, STATS, etc. courses
- May include a maximum of 3 credit hours of independent study (CSCI-Y 790, Y 791, Y 792, or Y 793)
- Excludes CSCI-A 500 - A 599 courses
- Excludes CSCI-Y 798 Professional Practicum Internship

Creativity Requirement (9 cr.)

Complete any CSCI, DSCI, ENGR, INFO, ILS, or STATS 500+ level course

- May include a maximum of 3 credit hours of CSCI-Y 798 Professional Practicum Internship
  - One (1) credit is awarded for each 160 hours of internship work, up to a maximum of two (2) credits per internship
  - Internship must be academically related to the program of study
  - Internships in the fall or spring are limited to remote or local offers only
  - Internships are not permitted in the final term
- May include a maximum of 6 credit hours of the following:
  - Independent study (CSCI-Y 790 or Y 791)
  - Master's thesis (CSCI-Y 792)
    - Students who opt to complete a master's thesis must seek approval from the Director of Graduate Studies
    - Enroll in 6 credit hours of CSCI-Y 792
    - Complete and submit master's thesis as directed by the Computer Science Graduate Studies Office

M.S. in Bioinformatics

M.S. Requirements

The M.S. in Bioinformatics is a two-year professional program that emphasizes computation and informatics but also integrates knowledge from biology, statistics,

and related areas. It prepares students to pursue a bioinformatics career or admission to a Ph.D. program.

Prerequisites

Our M.S. students are expected—but not required—to have at least introductory knowledge of both informatics and biology, including:

- Approximately 6 credit hours of undergraduate course work in biology, covering molecular biology, genetics, and evolution
- Approximately 6 credit hours of undergraduate course work in computer science or informatics, covering programming, discrete structures, and data structures

If you have not completed these prerequisites, you will be required to take one or two appropriate 500-level background classes suggested by the program directorate.

Courses
Students are required to complete 30 credit hours of graduate-level course work, including the following courses:

- INFO-I 519 Introduction to Bioinformatics (3 cr.)
- INFO-I 529 Machine Learning in Bioinformatics (3 cr.)

Other courses can be selected from a wide range of bioinformatics-related course offerings in computer science, informatics, biology, statistics, mathematics, or chemistry. Students will be advised on their individual study plans by the program directorate.

Students must also complete a yearlong, 6 credit hour capstone research project in their second year, including an oral presentation to the public and submission of a written report. These projects are typically supervised by one of the core bioinformatics faculty members, but we encourage students to work with a supervisor in a related discipline—such as biology, computer science, chemistry, or medical sciences—and choose a co-supervisor among the bioinformatics core faculty.

All other courses can be selected from topics and seminars in bioinformatics and courses in related disciplines.

Master of Data Science and 4+1 Master of Data Science

Master of Data Science

The M.S. in Data Science (MSDS) is a two-year residential program offering multidisciplinary coursework in computer science, information science, informatics, statistics, engineering, and other disciplines. It prepares students to pursue a data science related career or admission to a Ph.D. program. As an MSDS student, you have the option of our distinct tracks: **Applied Data Science, Big Data Systems, Computational and Analytical, and Managerial Data Science**. Students are required to complete **30** credit hours of graduate-level coursework for this degree.

Applied Data Science Track

The Applied Data Science track offers the training in both the data science methods and their application in different domains. This track is suitable for students with an interdisciplinary background who want to specialize in application areas of data science.

Student following the Applied Data Science track are required to complete **12** credit hours of core coursework that covers **3** credit hours of Statistical Methods, **3** credit hours of Data Mining and Search, **3** credit hours of Data Management and Engineering, and **3** credit hours of Data Visualization and Storytelling. Students will specialize in **6** credit hours of a Data Science domain. The remaining **12** credit hours are **3** credit hours of capstone project and **9** credit hours of electives, selected to best suit individual interests, needs, and overall career goals.

Statistical Methods (3 credit hours)

- STAT-S 520 Introduction to Statistics
  - Higher level statistics course may be taken with departmental approval

Data Mining and Search (3 credit hours)

Select one course from the following:

- CSCI-B 551 Elements of Artificial Intelligence
- CSCI-B 555 Machine Learning
- CSCI-B 565 Data Mining
- CSCI-P 556 Applied Machine Learning
- ENGR-E 511 Machine Learning for Signal Processing
- ILS-Z 534 Search
- INFO-I 606 Network Science (may be counted only once)

Data Management and Engineering (3 credit hours)

Select one course from the following:

- CSCI-B 561 Advanced Database Concepts
- DSCI-D 532 Applied Databased Technologies
- ENGR-E 516 Engineering Cloud Computing
- INFO-I 535 Management, Access, and Use of Big and Complex Data

Data Visualization and Storytelling (3 credit hours)

Select one course from the following:

- ENGR-E 583 Information Visualization (may be counted only once)
- ENGR-E 584 Scientific Visualization
- INFO-I 590 Topics in Informatics
  - Topic: Data Visualization (may be counted only once)
- STAT-S 670 Exploratory Data Analysis

Data Science Domain (6 credit hours)
Select one of the following domains and complete two courses within that specific domain:

Augmented and Virtual Reality

- INFO-I 590 Topic in Informatics
  - Topic: Artificial Life in Virtual Reality
  - Topic: Building Virtual Worlds

- Topic: Creating Virtual Assets
- Topic: Introduction to Virtual Reality

Data Security and Privacy

- INFO-I 520 Security for Networked Systems
- INFO-I 525 Organizational Informatics and Economics of Security
- INFO-I 533 Systems and Protocol Security and Information Assurance
- INFO-I 538 Introduction to Cryptography

Economic Data Analytics

- ECON-M 504 Econometrics I
- ECON-M 511 Microeconomic Theory II
- ECON-M 514 Econometrics II
- ECON-M 518 Econometrics: Big Data
- ECON-M 524 Financial Econometrics

Health and Biomedical Data Science

- INFO-I 507 Introduction to Health Informatics
- INFO-I 519 Introduction to Bioinformatics
- INFO-I 529 Machine Learning in Bioinformatics

Human Robotic Interaction

- CSCI-B 657 Computer Vision
- ENGR-E 599 Topics in Intelligent Systems Engineering
  - Topic: Autonomous Robotics
- INFO-I 513 Usable Artificial Intelligence
- INFO-I 527 Mobile and Pervasive Design
- INFO-I 540 Human Robot Interaction
- INFO-I 542 Foundations of HCI

Social Data Science

- ENGR-E 583 Information Visualization (may be counted only once)
- ILS-Z 604 Topics in Library and Information Science
  - Topic: Music Data Mining
- ILS-Z 639 Social Media Mining
- INFO-I 513 Usable Artificial Intelligence
- INFO-I 590 Topics in Informatics
  - Topic: Data Visualization (may be counted only once)
- INFO-I 606 Network Science (may be counted only once)

Capstone Project (3 credit hours)

Students will be required to work on a project that applies the knowledge and skills learned to solve real-world problems for a company, organization, or individual. This may be fulfilled through a capstone course, an internship, or an independent study project. The aim of this requirement is to demonstrate students' capabilities to prospective employers and inspire innovation.

- DSCI-D 590 Topics in Data Science
  - Topic: Faculty Assistance in Data Science
- DSCI-D 591 Graduate Internship
- DSCI-D 592 Data Science in Practice
- DSCI-D 699 Independent Study in Data Science
- ILS-Z 690 Capstone in Information Architecture

Electives (9 credit hours)

The remaining **9** credit hours are selected from unselected courses above or additional data science-related course offerings within the Luddy School of Informatics, Computing, and Engineering. Students may not earn credit for courses taken to fulfill the core, domain, or capstone requirements.

- No more than three (3) credit hours of DSCI-D 591 may be earned
- No more than three (3) credit hours of DSCI-D 590, Data Science On-Ramp, may be earned

Big Data Systems Track

The Big Data Systems track focuses on the development and engineering of software systems for collecting, managing, and mining massive data. This is most suitable for students with a background in computer science or engineering who prefer hands-on and project-based learning.

Students following the Big Data Systems track are required to complete **21** credit hours of core coursework that covers **3** credit hours of Statistical Methods, **6** credit hours of AI and Machine Learning, **9** credit hours of Big Data, Cloud Computing, and Visualization, and **3** credit hours of Core Engineering. The remaining **9** credit hours are electives selected to best suit individual interests, needs, and overall career goals.

Pre-requisites: Students in this program need to have a solid foundation in STEM course work, specifically the following:

- Proficient level of programming experience in C, Java or Python
- Familiarity with R and MATLAB is useful
- Calculus I and II and basic understanding or probability and elements of discrete math

Statistical Methods (3 credit hours)

Select one course from the following:

- SPEA-V 506 Statistical Analysis for Effective Decision-making
- STAT-S 520 Introduction to Statistics
  - Student who have completed equivalent prior coursework in statistics can opt to take an additional elective in lieu of one of the Statistical Methods courses

AI and Machine Learning for Engineering (6 credit hours)

Select two courses from the following:

- CSCI-B 555 Machine Learning
- CSCI-B 565 Data Mining
- CSCI-P 556 Applied Machine Learning
- ENGR-E 511 Machine Learning for Signal Processing
- ENGR-E 533 Deep Learning Systems
- ENGR-E 536 High Performance Graph Analytics

Big Data, Cloud Computing, and Visualization (9 credit hours)

Select three courses from the following:

- CSCI-B 561 Advanced Database Concepts
- ENGR-E 516 Engineering Cloud Computing
- ENGR-E 522 HPC and Cloud Computing for Large Scale Image Applications
- ENGR-E 534 Big Data Applications
- ENGR-E 583 Information Visualization
- ENGR-E 584 Scientific Visualization

Core Engineering (3 credit hours)

Select one course from the following:

- ENGR-E 503 Introduction to Intelligent Systems
- ENGR-E 517 High Performance Computing
- ENGR-E 535 Image Processing for Medical Applications
- ENGR-E 551 Simulating Nanoscale Systems

Electives (9 credit hours)

The remaining **9** credit hours can be selected from unselected courses above or additional data science-related course offerings within the Luddy School of Informatics, Computing, and Engineering. Students may not earn extra credit for courses taken to fulfill core requirements.

- No more than three (3) credit hours of DSCI-D 591 may be earned
- No more than three (3) credit hours of DSCI-D 590, Data Science On-Ramp, may be earned

Computational and Analytical Track

The Computational and Analytical track focuses on the foundational data science methods. This track is most suitable for students with a background in computer science, statistics, or mathematics who wish to dive deeper into the mechanics of data science methodologies.

Students following the Computational and Analytical track are required to complete **15** credit hours of core coursework that covers **3** credit hours of Data Systems Foundation, **3** credit hours of Algorithmic Foundation, **6** credit hours of Data Analytics Foundation, and **3** credit hours of Big Data Infrastructures. The remaining **15** credit hours are electives selected to best suit individual interests, needs, and overall career goals.

Data Systems Foundation (3 credit hours)

- CSCI-B 561 Advanced Database Concepts

Algorithmic Foundation (3 credit hours)

Select one course from the following:

- CSCI-B 503 Algorithms Design and Analysis
- CSCI-B 505 Applied Algorithms

Data Analytics Foundation (6 credit hours)

- STAT-S 520 Introduction to Statistics
  - Higher level statistics course may be taken with departmental approval

Select one additional course from the following:

- CSCI-B 555 Machine Learning
- CSCI-B 565 Data Mining

Big Data Infrastructure (3 credit hours)

Select one course from the following:

- DSCI-D 532 Applied Database Technologies
- ENGR-E 516 Engineering Cloud Computing
- INFO-I 535 Management, Access and Use of Big and Complex Data

The remaining **15** credit hours are selected from unselected courses above or additional data science-related offerings within the Luddy School of Informatics, Computing, and Engineering. Students may not earn credit for courses taken to fulfill core requirements.

- No more than three (3) credit hours of DSCI-D 591 may be earned
- No more than three (3) credit hours of DSCI-D 590, Data Science On-Ramp, may be earned

Managerial Data Science Track

The managerial data science track combines advanced knowledge in database systems and programming languages with strong interpersonal and project management skills. This track is most suitable for students with prior work experience who wish to develop organizational and project management skills.

Students following the Managerial Data Science track are required to complete **21** credit hours of core coursework that covers **3** credit hours of Statistical Methods, **3** credit hours of Machine Learning, Data Mining, and Text Mining, **3** credit hours of Data Visualization and Storytelling, **6** credit hours of Management in Theory, and **6** credit hours of Management in Practice. The remaining **9** credit hours are **3** credit hours of capstone project, and **6** credit hours of electives, selected to best suit individual interests, needs, and overall career goals.

Statistical Methods (3 credit hours)

Select one course from the following:

- SPEA-V 506 Statistical Analysis for Effective Decision-Making
- STAT-S 520 Introduction to Statistics
  - Higher level statistics course may be taken with departmental approval

Machine Learning, Data Mining, and Text Mining (3 credit hours)

Select one course from the following:

- CSCI-B 505 Applied Algorithms
- CSCI-B 551 Elements of Artificial Intelligence
- CSCI-B 555 Machine Learning
- CSCI-B 561 Advanced Database Concepts
- CSCI-B 565 Data Mining
- CSCI-B 657 Computer Vision
- CSCI-P 556 Applied Machine Learning
- ENGR-E 511 Machine Learning for Signal Processing
- ILS-Z 534 Search

- INFO-I 513 Usable Artificial Intelligence
- INFO-I 606 Network Science

Data Visualization and Storytelling (3 credit hours)

Select one course from the following:

- ENGR-E 583 Information Visualization
- ENGR-E 584 Scientific Visualization
- INFO-I 590 Topics in Informatics
    - Topic: Data Visualization

Management in Theory (6 credit hours)

Select two courses from the following:

- ILS-Z 513 Organizational Informatics
- ILS-Z 604 Topics in Library and Information Science
    - Topic: Social and Ethical Impacts of Big Data
- ILS-Z 645 Social and Organizational Informatics of Big Data

Management in Practice (6 credit hours)

Select two courses from the following:

- ILS-Z 512 Information Systems Design
- ILS-Z 556 Systems Analysis and Design
- ILS-Z 586 Digital Curation

Capstone Project (3 credit hours)

Students will be required to work on a project that applies the knowledge and skills learned to solve real-world problems for a company, organization, or individual. This may be fulfilled through a capstone course, an internship, or an independent study project. The aim of this requirement is to demonstrate students' capabilities to prospective employers and inspire innovation.

- DSCI-D 590 Topics in Data Science
    - Topic: Faculty Assistance in Data Science
- DSCI-D 591 Graduate Internship
- DSCI-D 592 Data Science in Practice
- DSCI-D 699 Independent Study in Data Science
- ILS-Z 690 Capstone in Information Architecture

Electives (6 credit hours)

The remaining **6** credit hours are selected from unselected courses above or additional data science-related course offerings within the Luddy School of Informatics, Computing, and Engineering. Students may not earn credit for courses taken to fulfill the core, domain, or capstone requirements.

- No more than three (3) credit hours of DSCI-D 591 may be earned
- No more than three (3) credit hours of DSCI-D 590, Data Science On-Ramp, may be earned

4+1 MS Data Science

Undergraduates with the B.S. Data Science Major, Minor, or Specialization will be able to complete a bachelor's degree and a M.S. in Data Science. The students would take 120 credits for the bachelor's degree and 21 credits for the master's degree. The total credit hours will be 141 credits.

The program's overall course requirements add up to as much as 9 fewer credit hours than the sum total of the bachelor's and the master's degrees taken individually.

Admission and Status

- For admission to the 4+1 program, students must have earned a major and program GPA of at least 3.0 at the time of admission to the program.
- To apply to the 4+1 program, students must first talk with their undergraduate advisor, who will review their academic record to ensure that they meet the admission requirements. If a student meets the requirements, the advisor will notify the Luddy Graduate Office who will provide the student with an invitation code which will give the student access to the application. The Luddy Graduate Office will also provide the student with an application fee waiver code.
- Students in the program will be classified as undergraduates through the last semester in which they are enrolled in undergraduate requirements. Students in good standing, defined as a major and program GPA of at least 3.0, must submit the standard application to the University Graduate School by January 1 prior to the academic year they want to transition to graduate status.
- Those not in good standing at any time are dropped from the program and reclassified as undergraduate students. If the transition to graduate status is delayed for any reason, The 4+1 program status will revert to undergraduate status and the student will be encouraged to apply to the M.S. program.
- Students in the 4+1 program must complete at least 21 hours of coursework while registered in graduate status. Normally, this would encompass no fewer than two semesters.
- Students are advised to check on the effect that transition to graduate status may have on existing undergraduate funding; the possibility of graduate funding is conditional upon transition to graduate status.
- Once admitted to the program, if a student switches out of the 4+1 status, they may not switch back into the program after April 15th. These students will be encouraged to apply for the M.S. program.

Academic Requirements

- A minimum of 141 credit hours
- Major GPA of at least 3.0; Cumulative GPA for graduate courses of at least 3.0
- All undergraduate degree requirements
- All B.S. Data Science Specialization/Minor requirements
- Students in the 4+1 program are required to complete **9** credit hours of core coursework that covers **3** credit hours of **Statistical Methods**, **3** credit hours of **Data Management and Engineering**, and **3** credit hours of **Machine Learning, Data Mining, and Text Mining**. The remaining **12** credit hours are **3** credit hours of capstone project and **9** credit hours of electives, selected to best suit individual interests, needs, and overall career goals.

Statistical Methods (3 credit hours)

Select one course from the following:

- SPEA-V 506 Statistical Analysis for Effective Decision-Making
- STAT-S 520 Introduction to Statistics
    - Higher level statistics course may be taken with departmental approval

Data Management and Engineering (3 credit hours)

Select one course from the following:

- CSCI-B 561 Advanced Database Concepts
- DSCI-D 532 Applied Database Technologies
- ENGR-E 516 Engineering Cloud Computing
- INFO-I 535 Management, Access, and Use of Big and Complex Data

Machine Learning, Data Mining, and Text Mining (3 credit hours)

Select one course from the following:

- CSCI-B 551 Elements of Artificial Intelligence
- CSCI-B 555 Machine Learning
- CSCI-B 565 Data Mining
- CSCI-B 657 Computer Vision
- CSCI-P 556 Applied Machine Learning
- ENGR-E 511 Machine Learning for Signal Processing
- ILS-Z 534 Search
- INFO-I 513 Usable Artificial Intelligence
- INFO-I 606 Network Science

Capstone Project (3 credit hours)

Students will be required to work on a project that applies the knowledge and skills learned to solve real-world problems for a company, organization, or individual. This may be fulfilled through a capstone course, an internship, or an independent study project. The aim of this requirement is to demonstrate students' capabilities to prospective employers and inspire innovation.

- DSCI-D 590 Topics in Data Science
    - Topic: Faculty Assistance in Data Science
- DSCI-D 591 Graduate Internship
- DSCI-D 592 Data Science in Practice
- DSCI-D 699 Independent Study in Data Science
- ILS-Z 690 Capstone in Information Architecture

Electives (9 credit hours)

The remaining 9 credit hours are selected from additional data science-related course offerings within the Luddy School of Informatics, Computing, and Engineering. Students may not earn credit for courses taken to fulfill the core or capstone requirements.

- No more than three (3) credit hours of DSCI-D 591 may be earned
- No more than three (3) credit hours of DSCI-D 590, Data Science On-Ramp, may be earned

M.S. in Human-Computer Interaction (design emphasis)

Our Human-Computer Interaction (HCI/d) program offers a unique graduate experience that creates design professionals who will shape the future of design. Our graduates make an impact immediately and quickly grow into the design leaders of the next generation. IU's HCI/d program was the first in the United States to emphasize design as an equal partner to HCI. The original vision, updated to reflect today's technologies and trends, has been crafted to lay the groundwork for students to grow rapidly into sought after design leaders.

Traditionally, HCI has been the domain of engineering and psychology. Here, we approach it from the perspective of design. Our focus goes beyond simply using technology to solve a problem. It is about creating a technology experience that will be functional, intuitive, and even delightful for the people who use it. Students from a variety of backgrounds, from computer science to the liberal arts, come together to study and practice the design of computer technology creating a close-knit, high collaborative and imaginative group. Our students build relationships and skills that continue long after they graduate.

M.S. Requirements

The Master of Science in HCI/d (design emphasis) is an intensive, two-year program that teaches students to shape new media, interactive tools, artifacts, and systems in ways that enhance usability, augment learning, facilitate communication, and enrich the lives of the people using them. The Master of Science degree program in HCI/d consists of 36 credit hours of studies, normally taken over two (2) consecutive years, evenly distributed as three (3) classes or nine (9) credit hours per semester.

Please refer to the Human-Computer Interaction Design Handbook.

To receive the M.S. HCI/d degree, a student must

- Complete 36 credit hours of graduate work with no individual course grade below a C (2.0)
- Maintain a B (3.0) or better GPA
- Meet all the course requirements as stated in the handbook for the term of matriculation
- Meet all of the above requirements within five (5) calendar years of initial matriculation

GRADES

The minimum overall GPA of a grade of B (3.0) for all graduate Informatics courses is required. A student whose semester GPA falls below a grade of B (3.0) will be put on probation. The student must raise their semester and cumulative grade point average to B (3.0) or higher by the end of the following semester. Failure to do so may result in academic dismissal from the program. A student whose cumulative GPA falls below a B (3.0) for two consecutive semesters (excluding summer) may result in academic dismissal from the program.

CURRICULUM

Year 1 Fall

- INFO-I 541 Interaction Design Practice (3 cr.)
- INFO-I 542 Foundations of HCI (3 cr.)

- Elective (3 cr.)

Year 1 Spring

- INFO-I 543 Interaction Design Methods (3 cr.)
- INFO-I 561 Meaning and Form in HCI (3 cr.)
- Elective (3 cr.)

Year 2 Fall

- INFO-I 694 Thesis/Project in Human-Computer Interaction I (3 cr.)
- Elective (3 cr.)
- Elective (3 cr.)

Year 2 Spring

- INFO-I 694 Thesis/Project in Human-Computer Interaction II (3 cr.)
- Elective (3 cr.)
- Elective (3 cr.)

* **Electives and Recommended Electives**

- INFO-I 528 Participatory Design (3 cr.)
- INFO-I 567 Design Strategy (3 cr.)
- INFO-I 568 Technology Entrepreneurship (3 cr.)
- INFO-I 590 Topics in Informatics (Topic: Interaction Culture) (3 cr.)
- INFO-I 590 Topics in Informatics (Topic: Social Computing) (3 cr.)
- INFO-I 590 Topics in Informatics (Topic: Sustainability in HCI & Design((3 cr.)
- INFO-I 590 Topics in Informatics (Topic: Visual Literacy in HCI/D) (3 cr.)
- INFO-I 604 Human Computer Interaction Design Theory (3 cr.)
- SOAD-S 552 Graphic Design for Graduate Non-Majors (3 cr.)

The recommended electives detailed above are the elective classes that students most typically select and the classes which they can select without additional approval from the program director. It is possible for students to tailor their particular program by selecting, with approval of the director, alternative graduate classes from within the University. Independent Study or Internship credits are sometimes possible as an additonal alternative, as described in the HCI/d MS Handbook. Electives can be from any school at Indiana University with courses related to the student's area of concentration, including other areas in Informatics, Computer Science, and Information and Library Science.

Accelerated Master's Program in Secure Computing

The Accelerated Master's in Secure Computing is designed to allow Computer Science undergraduates, who specialize in Security, to complete the M.S. in Secure Computing with one additional year of study. The program is a specialized offering of the Accelerated M.S. in Computer Science degree program, and it meets all of the requirements of the Accelerated M.S. in Computer Science.

To satisfy the degree requirements for the M.S. in Secure Computing, students are required to complete 36 hours as specified below.

- **Computing and Networking Foundations (9 hours)**Students must satisfy a networking and operating system requirement, either by taking one of (CSCI-P 436/P536) for operating systems and one of (CSCI-P 438/P 538) for networking.
- **Security Core (12 hours)**Students must take I 520/ B 544 and I 533/B547 for 6 of these core credits. As specified by previously defined requirements, students will receive credit for either B 430 or B 544, but not both and B 433 or B 547, but not both.
- **Applied Security and Professional Practice (6 hours)**The goal of these credits is to ensure that students have the opportunity to practice skills in an applied or professional setting. Students are required to obtain 6 credits through internship credits.
- **Electives (9 hours)**Unless students have the program director's permission for a specific course beforehand, *all elective credits must be at the 500 level or higher.* Students may use these credits to enhance their mathematical or computing skills, or to concentrate on areas that complement their cybersecurity skills. If the student is missing certain courses in programming, data structures, and algorithms, these courses must be taken as electives.
- **Graduate credit**A total of 24 credits of graduate courses need to be completed in addition to requirements for the undergraduate degree, of which at least 15 credits must be taken with graduate enrollment status. This may not include CSCI-Y 890.

Admission and Status

- For admission to the Accelerated M.S. in Secure Computing program, students must have earned a major and program GPA of at least 3.0 at the time of admission to the program.
- Students must complete the program contract with their advisor prior to submitting the application to the University Graduate School. This contract and major change cannot be completed until 12 CSCI credits have been earned.
- Students in the program will be classified as undergraduates through the last semester in which they are enrolled in undergraduate requirements. Students in good standing, defined as a major and program GPA of at least 3.0, must submit the standard application to the University Graduate School by January 1 prior to the academic year they want to transition to graduate status.
- Those not in good standing at any time are dropped from the program and reclassified as undergraduate B.S. students. If the transition to graduate status is delayed for any reason, Accelerated Master's status will revert to undergraduate B.S. status and the student will be encouraged to apply to the M.S. in Secure Computing program.
- Students in the Accelerated M.S. in Secure Computing program must complete at least 15 hours of coursework while registered in graduate status. Normally, this would encompass no fewer than two semesters.
- Students are advised to check on the effect that transition to graduate status may have on existing undergraduate funding; the possibility of graduate

funding is conditional upon transition to graduate status.
- To avoid an overload of credits in their fifth year, students are advised to take at least two graduate level courses in their senior year, while in undergraduate status, to ensure program completion within five years (i.e., taking the remainder of six graduate courses in their fifth year). Students should consult with the undergraduate advisor regarding appropriate graduate level courses. Permission to enroll in graduate level courses must be obtained from the course instructor or advisor.
- The B.S. and M.S. degrees must be pursued consecutively. The student must apply for graduation through the undergraduate recorder and graduate with the B.S. in Computer Science before transitioning to graduate status. The student must apply to graduate with the M.S. in Secure Computing through the graduate recorder and the degree will be awarded upon completion of the graduate requirements.
- Once admitted to the program, if a student switches out of the Accelerated M.S. in Secure Computing program status, they may not switch back into the program after April 15th. These students will be encouraged to apply for the M.S. in Secure Computing program.
- Student must complete the program within five years (unless an extension is approved by the School). Students who exceed five years will be encouraged to apply for the M.S. Secure Computing program.

Academic Requirements

- A minimum of 144 credit hours
- Major GPA of at least 3.0; Cumulative GPA for graduate courses of at least 3.0
- All Computer Science B.S. degree requirements
- A total of 24 credits of graduate courses need to be completed in addition to requirements for the undergraduate degree, of which at least 15 credits must be taken with graduate enrollment status. At most 6 combined credit hours may CSCI-Y 790, Y 791, Y 792, Y 793, or Y 798. This may not include CSCI-Y 890.

Per the requirements for the Accelerated M.S. in Secure Computing, students must take at least 24 Computer Science credit hours beyond the requirements for the B.S. degree at 500 level or above. Students may meet this additional 24 hour requirement and the requirements for the M.S. in Secure Computing as outlined in the table below.

Students will be required to complete at least 15 credit hours in their 5th year. Please note that students may elect to take CSCI-P 536, P 538, INFO-I 520/CSCI-B 544, or INFO-I 533/CSCI-B 547 instead of their undergraduate versions. While taking these graduate level courses will reduce the credit hours that a student takes, these courses will not count towards the 24 hours of graduate credit because they are required by the undergraduate specialization in security.

To satisfy the degree requirements for the M.S. in Secure Computing, students are required to complete 36 hours as specified below.

Core Area

Computing and Network Foundations (9 cr.)

- CSCI-P 436 Introduction to Operating Systems
- CSCI-P 438 Introduction to Computer Networks
- 1 Approved CSCI 500 level course

Security Core (12 cr.)

- CSCI-B 430 Security for Networked Systems
- CSCI-B 433 Systems & Protocol Security & Information Assurance
- 2 Approved CSCI 500 level courses related to security

Applied (6 cr.)

- CSCI-Y 790 Graduate Independent Study
- CSCI-Y 798 Professional Practicum/Internship

Elective (9 cr.)

- 3 - 3 credit hour 500 level or above CSCI courses

The following subsections describe exactly which courses can be used to attain credit for each of the areas mentioned. Courses may not be double-counted across categories; that is, a course that appears in multiple categories may only be used to fulfill credit requirements for one of those categories.

Computing and Network Foundations

Students must satisfy a networking and operating system requirement, either by taking one of (CSCI-P 436/P 536) for operating systems and one of (CSCI-P 438/P 538) for networking. Students who have previously taken such courses in prior studies can ask to be exempted from taking these specific courses, but must still take 9 credit hours in the area.

- CSCI-P 436 Introduction to Operating Systems
- CSCI-P 438 Introduction to Computer Networks
- CSCI-B 534 Distributed Systems
- CSCI-B 541 Hardware System Design I
- CSCI-B 543 Computer Architecture
- CSCI-B 561 Advanced Database Concepts
- CSCI-B 649 Topics in Systems
  - Internet Services and Protocols
- CSCI-P 535 Pervasive Computing
- CSCI-P 536 Advanced Operating Systems
- CSCI-P 538 Computer Networks
- CSCI-P 542 Hardware System Design II
- CSCI-P 545 Embedded and Real-Time Systems

Secure Computing Core

Students need to take 12 credit hours from the following list of courses. *Students must take INFO-I 520/CSCI-B 430/CSCI-B 544 and INFO-I 533/CSCI-B 433/CSCI-B 547 for 6 of these core credits.* This ensures that student get a well-rounded background in Secure Computing.

- INFO-I 520/CSCI-B 430/CSCI-B 544 Security for Networked Systems (**required)**
- INFO-I 521/CSCI-B 546 Malware: Threat and Defense
- INFO-I 525 Organizational Informatics and Economics of Security

- INFO-I 533/CSCI-B 433/CSCI-B 547 Systems and Protocol Security for Information Assurance **(required)**
- INFO-I 536 Foundational Mathematics of Cybersecurity
- INFO-I 537 Legal and Social Informatics of Security
- INFO-I 538/CSCI-B 504 Introduction to Cryptography
- INFO-I 539 Cryptographic Protocols
- INFO-I 590/CSCI-B 649 Topics in Informatics/Topics in Systems
  - Usable Privacy and Security
  - Data-DrivenSecurity and Privacy
- INFO-I 590/CSCI-B 548 Topics in Informatics/ Privacy in Pervasive Computing
  - Privacy in Pervasive Computing
- ENGR-E 599 Topics in Intelligent Systems Engineering
  - Reverse Engineering Embedded Systems
- Note: INFO-I 590/CSCI-B 649/ENGR-E 599 are "topics" courses which means many different courses are offered under this course listing. This course may be taken multiple times to satisfy credit hours in this area so long as the courses are taught by core security program faculty or approval of the Secure Computing program director. If you have any concerns, please check with the graduate office.

Applied Security and Professional Practice

The goal of these credits is to ensure that student have the opportunity to practice skills in an applied or professional setting. Students are required to obtain 6 credits through courses or internship credits.

Internship credit must be obtained from organizations where students are exposed to some practical aspect of cybersecurity. Each 10-hour per week internship over a semester/summer provides 1 credit hour. **A student may take a maximum of two internships, for a maximum of 6 credit hours. Further, a student may work no more than 40 hours per week for credit.** The school's Career Services group is an excellent resource that is useful in helping students find internships, and students are recommended to start this process early. Pease see the section on Career Services later in the document for contact and other useful information.

Students may also engage in internships with security faculty at academic institutions.

- CSCI-Y 798 Graduate Internship

The remaining 9 credit hours are electives. Unless you have the program director's permission for a specific course beforehand, *all elective credits must be at the 500 level or higher.* Students may use these credits to enhance their mathematical or computing skills, or to concentrate on areas that complement their cybersecurity skill.

If the student has not taken the following relevant equivalent courses in a prior program (e.g., at the undergraduate level), the following courses must be taken as graduate level electives"

- Programming - CSCI-A 591 Introduction to Computer Science
- Data Structures - CSCI-A 594 Data Structures
- Algorithms - CSCI-B 505 Applied Algorithms

Master of Science in Secure Computing

M.S. Requirements

Program-Level Learning Outcomes

- Appraise relationships among a variety of computing practices and technologies to create integrated solutions to cybersecurity problems
- Formulate and defend realistic and detailed designs for solutions of cybersecurity problems of enterprise scope
- Evaluate and apply common cybersecurity standards for technology and technology management
- Communicate cybersecurity problems and suggested solutions to other professionals and with business clients

The Masters of Science Degree in Secure Computing is structured as follows. A student must complete **36 credit hours** of courses with the requirement that the following number of credit hours be achieved in each of the four areas as described below:

Areas:

- Computing Foundations (9 cr.)
- Secure Computing Core (12 cr.)
- Applied Security and Professional Practice (6 cr.)
- Electives (9 cr.)

Computing Foundations

These courses ensure that students have a firm grasp of computing systems. Students need to take **9 credit hours** from the following list of courses.

Required (unless exempted):

- CSCI-P 536 Advanced Operating Systems
- CSCI-P 538 Computer Networks

Must complete at least one course from the following (total of 9 credit hours including required courses):

- CSCI-B 534 Distributed Systems
- CSCI-B 541 Hardware System Design I
- CSCI-B 543 Computer Architecture
- CSCI-B 561 Advanced Database Concepts
- CSCI-P 535 Pervasive Computing
- CSCI-P 542 Hardware System Design II
- CSCI-P 545 Embedded and Real-Time Systems

Secure Computing Core

These courses ensure that students have a firm grasp of the fundamental ideas, skills, models and tools of cybersecurity. Students need to take **12 credit hours** from the following list of courses.

Required (unless exempted):

- CSCI-B 544 Security for Networked Systems
- CSCI-B 547 Systems and Protocol Security and Information Assurance

Must complete at least 2 courses (total of 12 credit hours including required courses):

- CSCI-B 504 Introduction to Cryptography

- CSCI-B 546 Malware Epidemic: Threat and Defense
- CSCI-B 590 Topics in Computer Science
  - Topic: Programming/Cyber Competitions
- CSCI-B 649 Topics in Systems
  - The course section you enroll in should be for a security or privacy topic
  - Examples: Data Driven Security & Privacy OR Security and Applied Crypto OR Usable Security and Privacy
- ENGR-E 599 Topics in Intelligent Systems Engineering
  - Topic: Reverse Engineering Embedded Systems
- INFO-I 525 Organizational Informatics and Economics of Security
- INFO-I 537 Legal and Social Informatics of Security

Applied Security and Professional Practice

Internship credit must be obtained from organizations where students are exposed to some practical aspect of cybersecurity. Each 10-hour per week internship over a semester/summer provides 1 credit hour. Students may also engage in internships with security faculty at academic institutions.
A student may take a maximum of two internships, for a maximum of 6 credit hours. Further, a student may work no more than 40 hours per week for credit.

Students may also satisfy their Applied Security and Professional credit requirements through specific course:

- CSCI-Y 798 Graduate Internship

Electives

The remaining 9 credit hours are electives. All elective credits must be 500 level or higher, unless you have permission from the Secure Computing program director.

Electives must be used to take the following courses unless these topics have already been covered at the undergraduate level (with approval from the Secure Computing program director).

- Programming - CSCI-A 591 Introduction to Computer Science
- Data Structures - CSCI-A 594 Data Structures
- Algorithms - CSCI-B 505 Applied Algorithms

Secure Computing

Accelerated Master's Program in Secure Computing

M.S. in Secure Computing

Master of Information Science (MIS)

Goals and Objectives of the Master of Information Science Program The Master of Information Science (MIS) program is an interdisciplinary professional program designed to prepare students for lifelong careers in designing, managing, and consulting about information and communication technologies (ICT) and services in public, corporate, and nonprofit settings. The program couples best-practices training in the management and use of ICT with exposure to current information management and systems research; there is a strong emphasis on essential career development skills including written and oral communication, team building, analysis, and critical thinking that are necessary for assuming management positions in business, nonprofit, academic, and government organizations.

ILS has identified the following primary goals and objectives for the MIS program. Upon completion of this program, graduates will be prepared to:

Demonstrate understanding of research necessary for careers as information professionals

- Apply appropriate strategies, tools and technologies to represent, organize, and manage data and information
- Apply appropriate theories and empirical evidence for effective leadership, management, and collaboration
- Use critical thinking to evaluate information, technology, and services problems and challenges
- Synthesize and interpret relevant research findings for use in ICT project management

Adopt socio-technical and user-centered approaches to studying and working with information and communication technologies (ICT)

- Understand the management and organizational structures of information organizations
- Utilize effectively the theoretical and practical bases of information organization, architecture, storage, retrieval, and delivery systems
- Apply techniques from human-computer interaction, systems analysis, programming and database design, to analyze user needs and information systems in social and organizational settings
- Develop innovative solutions to address information, technology, and services problems and challenges

Work effectively within and across a variety of information settings and contexts

- Communicate effectively, orally and in writing, with a variety of audiences
- Identify information and technical resources that will support an organization's activities
- Analyze, evaluate, and manage ICT to support organizational activities and work practices
- Demonstrate knowledge of relevant concepts and theories of organizational behavior for managing people, information, and technology in public and private sector organizations

Participate successfully and responsibility in the information professions

- Explain socio-economic, cultural, policy, and ethical issues involved in the design, development, management, and use of ICT
- Engage in life-long learning, making effective use of the range of information resources (research and popular writings, professional organizations) that support information work

MIS DEGREE REQUIREMENTS

The MIS program helps to educate a distinctive information professional, one whose expertise includes

understanding the human side of information and information technologies and applying this understanding to practical problems. The curriculum has been designed to provide a sound conceptual foundation for developing leadership-oriented careers and enabling students to develop expertise in one or more specific areas. A candidate for the Master of Information Science degree must complete 36 credit hours of graduate course work; at least 30 credit hours must be taken in the IU Department of Information and Library Science.

A maximum of 6 graduate credit hours from outside the IU Department of Information and Library Science may, in certain circumstances and with approval (using the "Outside Course Approval Form"), be applied to the MIS degree. These 6 credit hours may be taken at Indiana University, or at another university. Outside courses are warranted only when they are relevant to the student's career objectives and will contribute more to the enrichment of their programs than would additional ILS courses. Permission for such outside course work must be obtained before enrolling in the course. The course must be completed with a grade of B or higher, must not be applied to another degree (except in the case of a recognized dual-degree program), and must be taken within the five-year time frame allowed for completion of the degree.

MIS Requirements: (36 cr.)

Foundation Courses (18 cr.)

- ILS-Z 510 Introduction to Information Studies
  * Must be fulfilled before you complete 18 credit hours
- ILS-Z 511 Database Design
- ILS-Z 515 Information Architecture
- ILS-Z 516 Human-Computer Interaction
- Programming Requirement e.g. ILS-Z 517, Z639, Z 656, approved Z 603)

Complete one course from the following:

- ILS-Z 513 Organizational Informatics
- ILS-Z 556 Systems Analysis and Design

Electives (18 cr.)

Choose from:

- Any 500/600 level ILS course
- ILS-Z 601 Directed Readings
- ILS-Z 602 Directed Research
- ILS-Z 603 Workshop in Library and Information Science
  - These workshops focus on practical, professional skills. You can count up to 6 credits of Z 603 toward your degree.
- ILS-Z 604 Topics in Library and Information Science (professional issue topic)

4+1 Master of Information Science

The 4+1 Master's Program is intended for highly motivated undergraduate students looking to further their education with a master's degree. Students apply for the program during their junior year and begin taking ILS courses during their senior year.

Students admitted into the program will take 12 ILS credit hours during their senior year and an additional 6 credit hours during the summer after graduation. Summer work can either be graduate coursework or an internship. Students will complete the 4+1 Master's degree by taking 9 credit hours of coursework during each of the following two semesters.

The requirements for the degree are the same as the regular MIS degree, and no courses taken at the undergraduate or graduate level are allowed to count towards both an undergraduate and a graduate degree.

For more information: please see website

Master of Library Science

Goals and Objectives for the Master of Library Science Program The Master of Library Science (MLS) is a 36 credit hour program accredited by the American Library Association. The program is designed to meet the new challenges of our profession. Students in the program are introduced to the roles and functions of libraries, information centers, and cultural heritage institutions in contemporary society. They become familiar with key policy issues and technological trends, and with how these issues and trends affect libraries and information centers of all kinds. Students learn to manage and evaluate collections, respond to the information needs of patrons, and to use technology to improve access to information.
Students who complete the program are prepared for careers in library administration, public services, technical services, reference services, and collection development at public, school, academic, special libraries, and other information organizations.

ILS has identified the following primary goals and objectives for the MLS program. Upon completion of the MLS program, graduates will be prepared to:

Approach Professional Issues with Understanding

- Understand the social, political, ethical, and legal aspects of information creation, access, ownership, service, and communication
- Anticipate emerging trends and respond proactively

Assist and Educate Users

- Analyze and identify the information needs of diverse communities of users
- Educate users and potential users to locate, use, and evaluate information resources and tools
- Analyze and evaluate information systems and services in a variety of settings

Develop and Manage Collections of Information Resources

- Design and apply policies and procedures that support the selection and acquisition of information resources for particular communities of users
- Manage, evaluate, and preserve physical and virtual collections of information resources

- Uphold ethical and legal standards in acquiring, leasing, preserving, and providing access to information resources

Represent and Organize Information Resources

- Understand and apply principles of representation and organization

Manage and Lead libraries and Other Information Organizations

- Perform basic managerial functions, including planning, budgeting, and performance evaluation
- Communicate effectively to a variety of audiences
- Apply theories of organizational behavior and structure

Use Research Effectively

- Design, conduct, interpret, and take action based upon research and evaluation

Deploy Information Technologies in Effective and Innovative Ways

- Implement and evaluate information and communication technologies for efficiency, usability and value to users

MLS DEGREE REQUIREMENTS

The Master of Library Science degree requires 36 credit hours of graduate course work in Information and Library Science and a digital literacy requirement (see below).

A maximum of 6 graduate credit hours from outside the IU Department of Information and Library Science may, in certain circumstances and with approval (using the "Outside Course Approval Form"), be applied to the MLS degree. These 6 credit hours may be taken at Indiana University, or at another university. Outside courses are warranted only when they are relevant to the student's career objectives and will contribute more to the enrichment of their programs than would additional ILS courses. Permission for such outside course work must be obtained before enrolling in the course. The course must be completed with a grade of B or higher, must not be applied to another degree (except in the case of a recognized dual-degree program), and must be taken within the five-year time frame allowed for completion of the degree.

MLS Foundation Requirements: (12 cr.)

- ILS-Z 501 User Services and Tools
- ILS-Z 503 Representation and Organization
- ILS-Z 550 Information Institutions and their Management

Complete one technical course from the following:

- ILS-Z 511 Database Design
- ILS-Z 516 Human-Computer Interaction
- ILS-Z 517 Web Programming
- ILS-Z 519 Information Analytics
- ILS-Z 532 Information Architecture for the Web
- ILS-Z 534 Search
- ILS-Z 556 Systems Analysis and Design
- ILS-Z 634 Metadata
- ILS-Z 637 Information Visualization
- ILS-Z 639 Social Media Mining
- ILS-Z 652 Digital Libraries
- ILS-Z 656 Digital Publishing Standards and Systems
- ILS-Z 657 Digital Humanities

Electives (21 cr.)

Choose from the following:

- Any 500/600 level ILS course
- ILS-Z 601 Directed Readings
- ILS-Z 602 Directed Research
- ILS-Z 603 Workshop in Library and Information Science
    - These workshops focus on practical, professional skills. You can count up to 6 credits of Z 603 toward your degree.

- ILS-Z 604 Topics in Library and Information Science (professional issue topic)
- ILS-Z 629 Topics in Information Sources and Services (professional issue topic)

4+1 Master of Library Science

The 4+1 Master's Program is intended for highly motivated undergraduate students looking to further their education with a master's degree. Students apply for the program during their junior year and begin taking ILS courses during their senior year.

Students admitted into the program will take 12 ILS credit hours during their senior year and an additional 6 credit hours during the summer after graduation. Summer work can either be graduate coursework or an internship. Students will complete the 4+1 Master's degree by taking 9 credit hours of coursework during each of the following two semesters.

The requirements for the degree are the same as the regular MLS degree, and no courses taken at the undergraduate or graduate level are allowed to count towards both an undergraduate and a graduate degree.

For more information: please see website

MIS and MLS Dual Degree

CURRICULUM

A total of 54 credit hours is required for this degree.

If a course fulfills requirements for both the MIS foundation and the MLS foundation, the course is allowed to fulfill both requirements, but students must take additional electives to fulfill the required number of credit hours.

MIS Foundation Requirements (18 cr.)

- ILS-Z 510 Introduction to Information Studies
  * Must be fulfilled before you complete 18 credit hours
- ILS-Z 511 Database Design
- ILS-Z 515 Information Architecture
- ILS-Z 516 Human-Computer Interaction
- Programming Requirement (e.g. ILS-Z 517, Z639, Z 656, approved Z 603)

Complete one course from the following:

- ILS-Z 513 Organizational Informatics
- ILS-Z 556 Systems Analysis and Design

MLS Foundation Requirements (12 cr.)

- ILS-Z 501 User Services and Tools
- ILS-Z 503 Representation and Organization
- ILS-Z 550 Perspectives on Librarianship

Complete one technical course from the following:

- ILS-Z 511 Database Design
- ILS-Z 516 Human-Computer Interaction
- ILS-Z 517 Web Programming
- ILS-Z 519 Information Analytics
- ILS-Z 532 Information Architecture for the Web
- ILS-Z 534 Search
- ILS-Z 556 Systems Analysis and Design
- ILS-Z 634 Metadata
- ILS-Z 637 Information Visualization
- ILS-Z 639 Social Media Mining
- ILS-Z 652 Digital Libraries
- ILS-Z 656 Digital Publishing Standards and Systems
- ILS-Z 657 Digital Humanities

Electives (24 cr.)

MLS electives must be ILS courses. Choose from:

- Any 500/600 level ILS course
- ILS-Z 601 Directed Readings
- ILS-Z 602 Directed Research
- ILS-Z 603 Workshop in Library and Information Science
  - These workshops focus on practical, professional skills. You can count up to 6 credits of Z 603 toward your degree.
- ILS-Z 604 Topics in Library and Information Science (professional issue topic)
- ILS-Z 629 Topics in Information Sources and Services (professional issue topic)

ILS Specializations

Specializations In addition to the MIS/MLS, ILS offers two kinds of joint program options. Specializations within a master's program are reflected on the student's transcript; 9 specializations are available in the MLS, MIS or both.

All specializations with the MIS must complete the MIS Foundation requirements (18 cr.) and all specializations with the MLS must complete the MLS Foundation requirements (15 cr.) plus the specialization requirements in order to earn a degree.

If a course fulfills requirements for both the MLS or MIS foundation and a specialization or dual degree, the course is allowed to fulfill both requirements, but students must take additional electives to fulfill the required number of credit hours towards the dual degree or specialization.

Students are required to declare specializations before they complete 18 credits of work in ILS.

MIS with Data Science Specialization

Specialization Requirements (18 cr.)
Required:

- ILS-Z 605 Internship in Library and Information Science

Choose 9 credits from the following:

- CSCI-B 555 Machine Learning
- CSCI-B 649 Topics in Systems
  - Topic: Cloud Computing OR ENGR-E 516 Cloud Computing
- CSCI-B 669 Topics in Database and Information Systems
  - Topic: Scientific Data Management
- INFO-I 573 Programming for Science Informatics
- STAT-S 520 Intro to Statistics
- STAT-S 670 Exploratory Data Analysis

Specialization Electives
Choose 6 credits from the following:

- ILS-Z 503 Representation and Organization
- ILS-Z 532 Information Architecture for the Web
- ILS-Z 534 Search
- ILS-Z 603 Workshop in Library and Information Science - approved by your specialization advisor
- ILS-Z 634 Metadata
- ILS-Z 635 Ontologies
- ILS-Z 637 Information Visualization
- ILS-Z 639 Social Media Mining

MIS with Digital Content, Curation, and Collection

Specialization Requirements (18 cr.)
Required:

- ILS-Z 586 Digital Curation
- ILS-Z 634 Metadata
- ILS-Z 652 Digital Libraries
- ILS-Z 690 Capstone in Information and Library Science

Specialization Electives
Digital Media

Choose one course from the following:

- ILS-Z 587 Introduction to Moving Image Preservation
- ILS-Z 604 Topics in Library and Information Science
  - Topic: Audio Preservation

Analysis/Methods

Choose one course from the following:

- ILS-Z 637 Social Media Mining
- ILS-Z 656 Digital Publishing Standards and Systems
- ILS-Z 657 Digital Humanities

MIS with Digital Humanities Specialization

Specialization requirements (18 cr.)
Required:

- ILS-Z 657 Digital Humanities
- Capstone Project
  - ILS-Z 601 Directed Readings (Capstone Project) - Semester 1

- ILS-Z 690 Capstone in Information and Library Science - Semester 2

Specialization Electives (9 cr.)
Choose 9 credits from the following or approved by the specialization advisor. Classes taken outside ILS must be approved by completing the Outside Course Approval Form. A maximum of 6 credits outside of ILS may be approved.

- ILS-Z 543 Computer-Mediated Communication
- ILS-Z 544 Gender and Computerization
- ILS-Z 584 Manuscripts
- ILS-Z 603 Workshop in Library and Information Science - approved by your specialization advisor
- ILS-Z 604 Topics in Library and Information Science
  - Topic: Information Ethics
- ILS-Z 634 Metadata
- ILS-Z 635 Ontologies
- ILS-Z 637 Information Visualization
- ILS-Z 640 Seminar in Intellectual Freedom
- ILS-Z 642 Content Analysis for the Web
- ILS-Z 652 Digital Libraries
- ILS-Z 656 Digital Publishing Standards and Systems
- ILS-Z 680 The Book to 1800
- ILS-Z 681 The Book 1800 to the Present
- ILS-Z 684 Descriptive Bibliography

Outside course example

- INFO-I 587 Introduction to Virtual Heritage
- INFO-I 588 Advanced Topics in Virtual Heritage

MIS with Information Architecture Specialization

Specialization Requirements (18 cr.)
Required:

- ILS-Z 690 Capstone in Information and Library Science

Choose 15 credits from the following:

- ILS-Z 503 Representation and Organization
- ILS-Z 519 Information Analytics
- ILS-Z 532 Information Architecture for the Web
- ILS-Z 534 Search
- ILS-Z 603 Workshop in Library and Information Science - approved by your specialization advisor
- ILS-Z 604 Topics in Library and Information Science
  - Topic: Information Architecture in Practice
- ILS-Z 633 Indexing
- ILS-Z 634 Metadata
- ILS-Z 635 Ontologies
- ILS-Z 637 Information Visualization
- Other LUDDY courses: up to 9 cr. approved by your specialization advisor

MIS with Information Technology Leadership Specialization

Specialization Requirements (18 cr.)
Required:

- ILS-Z 514 Social Aspects of Information Technology
- ILS-Z 555 Strategic Intelligence
- ILS-Z 556 Systems Analysis and Design OR ILS-Z 513 Organizational Informatics - whichever not taken with the M.I.S. Foundation requirements
- ILS-Z 605 Internship in Library and Information Science OR ILS-Z 690 Capstone in Information and Library Science

Choose 6 credits from the following:

- ILS-Z 518 Communication in Electronic Environments
- ILS-Z 534 Search
- ILS-Z 542 International Information Issues
- ILS-Z 550 Information Institutions and their Management
- ILS-Z 604 Topics in Library and Information Science
  - Topic: Information Ethics
- ILS-Z 640 Seminar in Intellectual Freedom

MLS with Archives and Records Management Specialization

Specialization Requirements (15 cr.)
Required:

- ILS-Z 581 Archives and Records Management
- ILS-Z 586 Digital Curation

Choose 9 credits from the following:

- ILS-Z 511 Database Design
- ILS-Z 513 Organizational Informatics
- ILS-Z 519 Information Analytics
- ILS-Z 556 Systems Analysis and Design
- ILS-Z 582 Preservation
- ILS-Z 584 Manuscripts
- ILS-Z 585 Records Management
- ILS-Z 587 Introduction to Moving Image Preservation
- ILS-Z 603 Workshop in Library and Information Science;
  - Choose a workshop in Encoded Archival Description (EAD), Metadata Object Description Schema (MODS), Digital Publishing Standards and Systems, Processing Manuscript Collections, XML, or another topic approved by the specialization advisor
- ILS-Z 604 Topics in Library and Information Science
  - Choose a course in Advanced Archival Appraisal, Audio Preservation: Principles and Practices, Clarification and Business Processes, Evaluation and Audit, Introduction to Moving Image Preservation, Oral History, or another topic approved by the specialization advisor
- ILS-Z 634 Metadata
- ILS-Z 652 Digital Libraries
- ILS-Z 685 Electronic Records Management
- Other courses approved by the specialization advisor

This leaves 9 credits of elective coursework outside of the specialization.

MLS with Art Librarianship Specialization

Specialization Requirements (18 cr.)
Required:

- ILS-Z 651 Art Librarianship
- ILS-Z 657 Digital Humanities
- ILS-Z 680 The Book to 1800
- ILS-Z 681 The Book 1800 to Present

Specialization Electives (9 cr.)

- Choose from information and library science courses. Consult your specialization advisor for recommended electives

This leaves 3 credits of elective coursework outside of the specialization.

MLS with Children's and Young Adult Services Specialization

Specialization Requirements (18 cr.)
Required:

- ILS-Z 571 Materials for Youth
- ILS-Z 572 Youth Services
- ILS-Z640 Seminar in Intellectual Freedom
- ILS-Z 672 Seminar on Literature for Youth

Choose 9 credits from the following:

- ILS-Z 532 Information Architecture for the Web
- ILS-Z 603 Workshop in Library and Information Science;
    - Choose a workshop in Electronic Materials for Children, Emergent Literacy, Public Library Programming, Storytelling, or another topic approved by your specialization advisor
- ILS-Z 604 Topics in Library and Information Science
    - Choose Storytelling or another topic approved by your specialization advisor
- ILS-Z 621 Audio and Video Sources
- Other courses approved by your specialization advisor

This leaves 3 credits of elective coursework outside of the specialization.

MLS with Data Science Specialization

Specialization Requirements (21 cr.)
Required:

- ILS-Z 517 Web Programming OR ILS-Z 639 Social Media Mining
- ILS-Z 605 Internship in Library and Information Science OR ILS-Z 690 Capstone in Information and Library Science

Choose 9 credits from the following:

- CSCI-B 555 Machine Learning
- CSCI-B 649 Topics in Systems
    - Topic: Cloud Computing OR ENGR-E 516 Cloud Computing
- CSCI-B 669 Topics in Artificial Intelligence
    - Topic: Scientific Data Management and Preservation
- INFO-I 573 Programming for Science Informatics
- STAT-S 520 Intro to Statistics
- STAT-S 670 Exploratory Data Analysis

Specialization Electives (6 cr.)
Choose 2 from the following:

- ILS-Z 511 Database Design
- ILS-Z 515 Information Architecture
- ILS-Z 532 Information Architecture for the Web
- ILS-Z 534 Search
- ILS-Z 603 Workshop in Library and Information Science - approved by your specialization advisor
- ILS-Z 634 Metadata
- ILS-Z 635 Ontologies
- ILS-Z 637 Information Visualization
- ILS-Z 645 Social and Organizational Informatics of Big Data

This leaves 3 credits of elective coursework outside of the specialization

MLS with Digital Content, Curation, and Collections

Specialization Requirements (21 cr.)
Required:

- ILS-Z 586 Digital Curation
- ILS-Z 634 Metadata
- ILS-Z 652 Digital Libraries
- ILS-Z 690 Capstone in Information and Library Science

*Students who have taken one of these courses as part of their MLS Foundation technology requirement, will be advised to select an appropriate elective in consultation with the Specialization directors

Specialization Electives
Digital Media

Choose one course from the following:

- ILS-Z 587 Introduction to Moving Image Preservation
- ILS-Z 604 Topics in Information and Library Science
    - Topic: Audio Preservation

Analysis/Methods

Choose one course from the following:

- ILS-Z 637 Information Visualization
- ILS-Z 657 Digital Humanities

Programming

Choose one course from the following:

- ILS-Z 639 Social Media Mining
- ILS-Z 656 Digital Publishing Standards and Systems
- A graduate level programming course approved by the specialization director

This leaves 3 credits of elective coursework outside of the specialization

MLS with Digital Humanities Specialization

Specialization Requirements (18 cr.)
Required:

Choose 6 - 9 credits from the following:

- ILS-Z 657 Digital Humanities
- Capstone Project
  - ILS-Z 601 Directed Readings (Capstone Project) - Semester 1
  - ILS-Z 690 Capstone in Information and Library Science - Semester 2

Choose 9 - 12 credits from the following or approved by your specialization advisor; maximum of 6 credits outside of ILS courses

- ILS-532 information Architecture for the Web
- ILS-Z 543 Computer-Mediated Communication
- ILS-Z 544 Gender and Computerization
- ILS-Z 584 Manuscripts
- ILS-Z 603 Workshop in Library and Information Science - approved by your specialization advisor
- ILS-Z 604 Topics in Library and Information Science
  - Topic: Information Ethics
- ILS-Z 634 Medadata
- ILS-Z 635 Ontologies
- ILS-Z 637 Information Visualization
- ILS-Z 640 Seminar in Intellectual Freedom
- ILS-Z 642 Content Analysis for the Web
- ILS-Z 652 Digital Libraries
- ILS-Z 656 Digital Publishing Standards and Systems
- ILS-Z 680 The Book to 1800
- ILS-Z 681 The Book 1800 to the Present
- ILS-Z 684 Descriptive Bibliography

Outside course example:

- INFO-I 587 Introduction to Virtual Heritage
- INFO-I 588 Advanced Topics in Virtual Heritage

This leaves 6 credits of elective coursework outside of the specialization

MLS with Information Architecture Specialization

Specialization Requirement (21 cr.)
Required:

- ILS-Z 690 Capstone in Information and Library Science

Choose 18 credits from the following:

- ILS-Z 515 Information Architecture
- ILS-Z 516 Human-Computer Interaction
- ILS-Z 519 Information Analytics
- ILS-Z 532 Information Architecture for the Web
- ILS-Z 534 Search
- ILS-Z 603 Workshop in Library and Information Science - approved by your specialization advisor
- ILS-Z 604 Topics in Information and Library Science
  - Topic: Information Architecture in Practice
- ILS-Z 633 Indexing
- ILS-Z 634 Metadata
- ILS-Z 635 Ontologies
- ILS-Z 637 Information Visualization
- Other LUDDY courses approved by your specialization advisor

This leaves 3 credits of elective coursework outside of the specialization.

MLS with Music Librarianship Specialization

Specialization Requirements (15 cr.)
Required:

- MUS-M 539 Introduction to Music Bibliography
- ILS-Z 504 Cataloging
- ILS-Z 605 Internship in Library and Information Science
  - One of two areas related to music librarianship, such as music cataloging, music collection development, music reference, or music technology. Internships must be approved by your specialization advisor.
- ILS-Z 655 Music Librarianship

Specialization Electives (3 cr.)

- Choose from Information and Library Science courses approved by the Specialization Director

This leaves 9 credits of elective coursework outside of the specialization.

MLS with Rare Books and Manuscripts Specialization

Specialization Requirement (15 cr.)
Required:

- ILS-Z 583 Rare Book Librarianship

Choose 12 credits from the following:

- ILS-Z 580 History of Libraries
- ILS-Z 582 Preservation
- ILS-Z 584 Manuscripts
- ILS-Z 629 Topics in Information Sources and Services
- ILS-Z 652 Digital Libraries
- ILS-Z 680 The Book to 1800
- ILS-Z 681 The Book 1800 to the Present
- ILS-Z 683 Reference Sources for Rare Books
- ILS-Z 684 Descriptive Bibliography
- Other courses approved by your specialization advisor

This leaves 9 credits of elective coursework outside of the specialization.

ILS Dual Degree and Certificates

Dual Degrees

Dual master's degree programs are available with other units on campus; 14 options are offered with the MLS, MIS or both programs. Admission to a dual degree program requires separate admission to both ILS and to the department or school responsible for the other degree. Both degrees must be awarded simultaneously.

All dual degrees with the MIS must complete the MIS Foundation Requirement (18 cr.), and all dual degrees with the MLS must complete the MLS Foundation Requirement (12 cr.) plus the dual degree requirements in order to earn a degree. Please see the University Graduate School bulletin (all MA degrees), the School

of Public and Environmental Affairs (MPA), or the Maurer School of Law (JD) for the dual departments' requirements.

If a course fulfills requirements for both the MLS core and a specialization or dual degree, the course is allowed to fulfill both requirements, but students must take additional electives to fulfill the required number of credit hours towards the dual degree or specialization.

MIS and Central Eurasian Studies (MA)

- MIS Electives (12 cr.)
  - Choose from information and library science courses
  - MA Requirements (24 cr.)
    - The Department of Central Eurasian Studies provides information about the M.A. requirements

MIS and Folklore and Ethnomusicololgy (MA)

- MIS Electives (12 cr.)
  - Choose from information and library science courses
- MA Requirements (21 cr.)
  - The Department of Folklore and Ethnomusicology provides information about the M.A. requirements

MIS and Latin American and Caribbean Studies (MA)

- MIS Additional Requirements (9 cr.)
  - ILS-Z 534 Search
  - ILS-Z 605 Internship in Library and Information Science (under the supervision of the Latin American bibliographer) or an equivalent experience
  - ILS-Z 629 Topics in Information Sources and Services
    - Topic: Latin American bibliography

Alternatively, you may elect to take an ILS advanced reference course (Z 525) and do a course project involving Latin American materials.

- MIS Electives (3 cr.)
  - Choose from information and library science courses
- MA Requirements (24 cr.)
  - The Center for Latin American and Caribbean Studies provides information about the M.A. requirements

MIS and Public Affairs (MPA)

- MIS Electives (12 cr.)
  - Choose from information and library science courses
- MPA Requirements (36 cr.)
  - Contact SPEA for information about the M.P.A. requirements

MIS and Russian and East European Studies (MA)

- MIS Electives (12 cr.)
  - Choose from information and library science courses
- MA Requirements (24 cr.)
  - The Russian and East European Institute provides information about the M.A. requirements

MLS and African American and African Diaspora Studies (MA)

- MLS Additional Requirements (3 cr.)
  - ILS-Z 525 Government Information OR ILS-Z 542 International Information Issues
- MLS Electives (15 cr.)
  - Choose from information and library science courses
- MA Requirements (28 cr.)
  - The Department of African American and African Diaspora Studies provides information about the M.A. requirements

MLS and African Studies (MA)

- MLS Additional Requirements (3 cr.)
  - ILS-Z 525 Government Information OR ILS-Z 542 International Information Issues
- MLS Electives (15 cr.)
  - Choose from information and library science courses
- MA Requirements (26 cr.)
  - The African Studies Program provides information about the M.A. requirements

MLS and Central Eurasian Studies (MA)

- MLS Electives (18 cr.)
  - Choose from information and library science courses
- MA Requirements (24 cr.)
  - The Department of Central Eurasian Studies provides information about the M.A. requirements

MLS and Comparative Literature (MA)

- MLS Electives (18 cr.)
  - Choose from information and library science courses
- MA Requirements (20 cr.)
  - The Department of Comparative Literature provides information about the M.A. requirements

MLS and English (MA)

- MLS Electives (18 cr.)
  - Choose from information and library science courses
- MA Requirements (24 cr.)

- Learn about the M.A. in English requirements in the University Graduate School Bulletin

MLS and Folklore and Ethnomusicology (MA)

- MLS Electives (18 cr.)
  - Choose from information and library science courses
- MA Requirements (21 cr.)
  - The Department of Folklore and Ethnomusicology provides information about the M.A. requirements

MLS and History (MA)

- MLS Additional Requirements (6 cr.)
  - ILS-Z 525 Government Information OR ILS-Z 542 International Information Issues
  - ILS-Z 581 Archives and Records Management OR ILS-Z 584 Manuscripts
- MLS Electives (12 cr.)
  - Choose from information and library science courses
- MA Requirements (26 cr.)
  - The Department of History provides information about the M.A. requirements

MLS and History of Art (MA)

- MLS Additional Requirements (3 cr.)
  - ILS-Z 651 Art Librarianship
- MLS Electives (15 cr.)
  - Choose one of these courses:
    - ILS-Z 532 Information Architecture for the Web
    - ILS-Z 581 Archives and Records Management
    - ILS-Z 586 Digital Curation
    - ILS-Z 633 Indexing
    - ILS-Z 652 Digital Libraries
- MA Requirements (30 cr.)
  - The Department of Art History provides information about the M.A. requirements

MLS and History and Philosophy of Science (MA)

- MLS Additional Requirements (6 cr.)
  - ILS-Z 523 Science and Technology Information
  - ILS-Z 581 Archives and Records Management OR ILS-Z 584 Manuscripts
- MLS Electives (12 cr.)
  - Choose from information and library science courses.
- MA Requirements (21 cr.)
  - The Department of History and Philosophy of Science provides the information about the M.A. requirements

MLS and Latin American and Caribbean Studies (MA)

- MLS Additional Requirements (6 cr.)
  - ILS-Z 533 Online Searching
  - ILS-Z 629 Topics in Information Sources and Services
    - Topic: Latin American Bibliography

Alternatively, you may elect to take an ILS advanced course (Z 525) and do a course project involving Latin American materials.

- MLS Electives (12 cr.)
  - Choose from information and library science courses
- MA Requirements (24 cr.)
  - The Center for Latin American and Caribbean Studies provides information about the M.A. requirements

MLS and Law (JD)

- MLS Additional Requirements (6 cr.)
  - ILS-Z 525 Government Information
  - ILS-Z 654 Law Librarianship
- MLS Electives (12 cr.)
  - Choose from information and library science courses. ILS-Z 533 Online Searching and ILS-Z 640 Seminar in Intellectual Freedom are particularly appropriate
- JD Requirements (79 cr.)
  - The IU Maurer School of Law provides information about the J.D. requirements

MLS and Musicology (MA)

- MLS Additional Requirements (9 cr.)
  - ILS-Z 504 Cataloging
  - ILS-Z 605 Internship in Library and Information Science
  - ILS-Z 655 Music Librarianship: you must take MUS-M 539 and ILS-Z 504 before or with this course
- MLS Electives (9 cr.)
  - Choose from information and library science courses
- MA Requirements (30 cr.)
  - The Jacobs School of Music provides information about the M.A. requirements

MLS and Public Affairs (MPA)

- MLS Electives (18 cr.)
  - Choose from information and library science courses
- MPA Requirements (36 cr.)
  - Contact SPEA for information about the M.P.A. requirements

MLS and Russian and East European Studies (MA)

- MLS Electives (18 cr.)
  - Choose from information and library science courses. The Russian and East European

Institute counts ILS-Z 605 and ILS-Z 629 toward the M.A., allowing an additional 6 cr. of ILS courses in your program

- MA Requirement (24 cr.)
  - The Russian and East European Institute provides information about the M.A. requirements

Requirements for dual degrees do sometimes change. Please visit the ILS website for the most recent requirements.

State Certification The state of Indiana certifies librarians for positions in public libraries and school media centers. Each of these certifications can be completed within the MLS program. The ILS website has details on certification requirements.

Specialist in Library and Information Science (30 cr.) The Specialist degree [is a post-master's degree] requires 30 cr. of graduate coursework, of which at least 15 cr. must be taken in ILS. The additional 15 cr. may be taken in another school or department of Indiana University. The program should be planned in consultation with the ILS advisor to meet the student's academic and professional goals.

Student Organizations & Services

The following student groups are available for students to participate in:

- CS - Computer Science Club
- Cyber Security Club
- Data Science Club
- INgineering Club
- National Society of Black Engineers - IU Chapter
- Product Management Club
- Programmatik
- Luddy Consulting
- Luddy Student Alumni Council
- Sociotechnical Ethics Society
- uWIC - Undergraduate Women in Informatics and Computing

Other information on Student Groups may be found on the website.

Academic Integrity

Academic integrity requires that students take credit only for their own ideas and efforts. Misconduct, including cheating, fabrication, plagiarism, interference, or facilitating academic dishonesty, is prohibited because it undermines the bonds of trust and cooperation among members of this community and between us and those who may depend on our knowledge and integrity. Complete details are contained in the Indiana University

Academic Misconduct

Cheating

Cheating is dishonesty of any kind with respect to course assignments, alteration of records, or examinations. It is the student's responsibility not only to abstain from cheating, but also to avoid the appearance of cheating and to guard against making it possible for others to cheat. Any student who helps another student cheat is as guilty of cheating as the student assisted. The student also should do everything possible to induce respect for the examining process and for honesty in the performance of assigned tasks in or out of class.

Plagiarism

Plagiarism is assuming credit for someone else's work, words, or ideas—whether or not the ideas are expressed in the borrower's own words. Honesty requires that any ideas or materials taken from another source for either written or oral use must be fully acknowledged. Plagiarism includes language or ideas taken from isolated formulas, sentences, or paragraphs; entire articles copied from books, periodicals, or speeches; the writings or created works of other students; and materials assembled or collected by others in projects or collections without acknowledgment.

A faculty member who has evidence that a student is guilty of cheating or plagiarism will initiate the process of determining the student's guilt or innocence. No penalty will be imposed until the student has been informed of the charge and of the evidence on which it is based, and has been given an opportunity to present a defense. If the faculty member finds the student guilty, the faculty member assesses a penalty within the course and promptly reports the case in writing to the dean of the school or comparable head of the academic unit. The report should include the names of any other students who may be involved in the incident and recommendations for further action. The dean, in consultation with the faculty member if the latter so desires, will initiate any further disciplinary proceedings and inform the faculty member of any action taken. In every case, a record of the offenses remains on file.
For further regulations, please refer to the *IU Code of Student Rights, Responsibilities, and Conduct*.

Academic Standing

Students are considered to be in good standing during any semester in which their academic grade point average is at least 3.0 (B) for both their last semester's course work and for the cumulative average of all course work completed. Only courses with grades of C (2.0) or above may be counted toward degree requirements. However, grades below C are used in computing the cumulative grade point average, even if a course is repeated and a higher grade is earned.

Academic Probation

Students are placed on probation following a semester in which their graduate cumulative or semester grade point average falls below 3.0. Students on probation are required to attain an average of at least 3.0 for all graduate course work completed by the end of the next semester of full-time enrollment or its equivalent (9 credit hours). Failure to do so is cause for dismissal.

Course Waivers

Requests for waiver of specific courses or requirements on the basis of previous course work are to be submitted in writing to the dean.

Credit Earned in Non-Degree Status

Not more than 9 hours of graduate credit completed as a non-degree student may be credited toward Luddy School of Informatics, Computing, and Engineering graduate degree. Deficiency courses do not apply to the 9 credit hours.

Degree Conferral

For all students seeking a master's degree, an application for the degree must be filed with Luddy School of Informatics, Computing, and Engineering at least 60 days before the date anticipated for degree conferral. All degree requirements must be completed at least 30 days prior to the date of expected degree conferral, including submission of the bound copies of the master's thesis (if required for degree).

Grading System

The official grading system is as follows:

Grade	Quality of Achieveme	Points Per Credit Hour	Grade	Quality of Achieveme	Points Per Credit Hour
A+	Highest passing grade	4.0	D-	Lowest passing grade	0.7
A		4.0	P	Passing	-
A-		3.7	S	Satisfactory	-
B+		3.3	F	Failure	0.0
B		3.0	W	Withdrawn	-
B-		2.7	I	Incomplete	-
C+		2.3	R	Deferred Grade	-
C		2.0	NC	No Credit	-
C-		1.7	NR	No grade received	-
D+		1.3	NY	Signifies enrollment in a special program for which credit earned will be recorded when completed.	

A minimum of a B (3.0) average in graduate work is required for continuance in graduate study. Courses completed with grades below C (2.0) are not counted toward degree requirements, but such grades will be counted in calculating a student's grade point average. Note that no work may be transferred from another institution unless the grade is B (3.0) or higher.

Incomplete Grades

A grade of Incomplete may be given only if the completed portion of a student's work is of passing quality. It is the responsibility of the student to satisfy the requirements of that course within one calendar year from the date on which the Incomplete is recorded. The student is expected to finish all necessary work in time for the instructor to assign a regular grade before the expiration of this time period. If the student is unable to do so, it is the student's responsibility to notify the instructor of the course and the graduate advisor within the year to request an extension of time. Every overdue Incomplete will be changed to a grade of F after one calendar year.

A student who has received a grade of Incomplete (I) should not register for the course a second time, but should arrange with the instructor to have the Incomplete (I) changed to a letter grade upon completion of all requirements.

Withdrawals

Because deadlines for withdrawal from courses may vary by campus and/or school, students should check with the current campus *Schedule of Classes* to verify deadlines and procedures.

Graduate

For forms, please visit the Luddy School of Informatics, Computing, and Engineering website.

Please note, this is for the Master's degree(s) only. The Ph.D. degrees are offered through the University Graduate School.

- Academic Integrity
- Academic Standing
- Course Waivers
- Credit Earned in Non-Degree Status
- Degree Conferral
- Grading System
- Intercampus Transfer
- Student Grievance
- Time Requirements and Revalidation of Courses
- Transfer of Credit

Intercampus Transfer

Students enrolled as majors in Informatics, Computer Science, Data Science, Engineering (ISE), or Library of Information and Science at any campus of Indiana University may transfer provided they are in good standing.

Student Grievance

All academic personnel (faculty, part-time instructors, and advisors) are expected to conform to the Code of Student Rights, Responsibilities and Conduct. Students who feel that they have been treated unfairly by a faculty member may lodge a complaint by following these steps:

1. Discuss the matter with the faculty member or instructor.
2. If step 1 fails to resolve the situation, discuss the matter with the chairperson of the department or the coordinator of the program in which the faculty member is employed. The departmental chairperson will discuss it with the faculty member and seek some resolution.
3. If step 2 fails, the student may discuss the matter or file a written, signed complaint with the dean. Anonymous complaints will not be entertained. A copy of any written complaint will be forwarded to the faculty member, who may respond in writing.
4. When warranted, the dean may refer a written complaint and the faculty member's response to the

Faculty Affairs Committee for further investigation and review.

5. The Faculty Affairs Committee will evaluate the complaint on the basis of university policy and may recommend to the dean that the instructor be sanctioned. If the committee finds the complaint to be unfounded, a letter to that effect may be placed in the student's file.

Time Requirements

All requirements for the M.S. degrees must be met within five consecutive calendar years from the date of completion of the first credited (i.e., nondeficiency) course.

Revalidation of Courses

Normally, a course may not be counted toward degree requirements if it has been completed more than five years prior to the awarding of the degree for master's students. The advisor may recommend to the dean that course work taken prior to the deadline be revalidated if it can be demonstrated that the knowledge contained in the course(s) remains current. Currency of knowledge may be demonstrated by (a) passing an examination specifically on the material covered by the course; (b) passing a more advanced course in the same subject area; (c) passing a comprehensive examination in which the student demonstrates substantial knowledge of the content of the course; or (d) publishing scholarly research demonstrating knowledge of the content of the course.

Courses taken while an undergraduate and counted toward the requirements of a baccalaureate degree may not also be counted toward a graduate degree.

Transfer of Credit

A maximum of 9 credit hours of graduate course work with grades of B (3.0) or higher may be transferred from other accredited colleges and universities and applied to Luddy School of Informatics, Computing, and Engineering degree programs. The transfer must be approved by the dean and is not an automatic occurrence. (See Revalidation of Courses for more information.)

Undergraduate

Absences

From Final Examinations: Students are required to adhere to the policies regarding final examinations, as published in the Enrollment and Student Academic Information Bulletin or the Registration Guide and Academic Information.

From Scheduled Classes: Illness is usually the only acceptable excuse for absence from class. Other absences must be explained to the satisfaction of the instructor, who will decide whether omitted work may be made up.

Dean's List

Luddy School of Informatics, Computing, and Engineering recognizes exceptional academic performance in baccalaureate degree programs. The Dean's List contains the names of students who have achieved a semester grade point average of 3.7 or higher during any semester in which the student completes 12 or more graded credit hours.

Degree Application

Candidates for graduation must file an application through SAMS by September 15 for Fall graduation and by February 15 for Spring or Summer graduation to be included in the graduation ceremony program. Students who apply for Summer graduation, walk in the Spring ceremony, there is no Summer ceremony. **To receive your diploma, you must apply to graduate**.

Dismissal

Students will be dismissed if their semester grade point average is below 2.0, their cumulative Luddy grade point average is below 2.0 and they have had a previous probation while in Luddy School of Informatics, Computing, and Engineering. Students will be notified in writing that they have been dismissed and will be administratively withdrawn from all classes for which they have registered.

Degrees Awarded with Distinction

Luddy School of Informatics, Computing, and Engineering awards bachelor's degrees with three levels of distinction with the following cumlative Luddy grade point average: Distinction (3.7); High Distinction (3.8); and Highest Distinction (3.9). Students must have taken 60 graded credit hours at Indiana University.

The level of distinction is printed on both the final transcript and the diploma.

Academic Regulations

- Absences
- Academic Probation
- Academic Standing
- Dean's List
- Degree Application
- Degrees Awarded with Distinction
- Dismissal
- Readmission
- Semester Load
- Statute of Limitations

Academic Probation

Students will be placed on academic probation if their semester grade point average is below 2.0. Students will be instructed to complete an academic self-assessment, schedule an appointment at the Student Academic Center and to meet with their Luddy School of Informatics, Computing, and Engineering advisor. Students, that have had one previous semester of probation and this probation results in the cumulative Luddy grade point average to be below 2.0, will be dismissed.

Readmission

Dismissed students must petition the dean of Luddy School of Informatics, Computing, and Engineering for readmission. A Petition for Readmission must be filed by July 15 for fall, November 15 for spring, and April 15 for summer readmission. A student who has been dismissed is eligible to return to school after being out of school for one regular semester (summer sessions do not count) and having petitioned successfully. A third dismissal is final.

Dismissed students whose petitions are denied will not be allowed to register.

Semester Load
A typical full-time academic load is 12 to 18 credit hours per semester, with the average load being approximately 15 credit hours. Students who expect to carry more than 19 credit hours a semester should have a cumulative grade point average of at least 3.0 (B) and have approval from an academic advisor or dean.

Academic Standing
A student is in good academic standing for an Indiana University bachelor's degree when his or her semester grade point average is a minimum of 2.0 (C) for the last semester's course work and when his or her cumulative grade point average is at least 2.0 (C).

Class Standing
Class standing is based on the number of credit hours completed:

- Freshman, fewer than 30 credits
- Sophomore, 30 to 59 credits
- Junior, 60 to 89 credits
- Senior, 90 or more credits

Statute of Limitations
Candidates for the bachelor's degree in Luddy School of Informatics, Computing, and Engineering have the right to complete the degree requirements specified by the bulletin in effect at the time they entered Indiana University, provided that the required courses are available and that no more than eight calendar years have elapsed since the date of entry.

Change of Grade
A student desiring a change of grade should discuss the situation with the instructor. A change of grade must be justified. If the instructor agrees, the faculty member will submit a grade change. If the instructor and student do not agree on a changed grade, or if the instructor cannot be located, the student should discuss the matter with the chairperson or director of the department offering the course. Appeals unresolved at this level may be referred to the academic deans. Appeals of grades or requests for other actions will not be considered after one calendar year from the end of the semester in which the course in question was taken.

Extended-X Option
Any undergraduate student may retake a course for which he/she received a grade below an A. A student may exercise this option for no more than three courses, totaling no more than 10 credits. A student may use this option only once for a given course. The following grades cannot be replaced under the Extended-X policy: S, P, W, I, R, NC.

NOTE: The form should be submitted after auto "W" of the semester the student is enrolled in the 2nd course. The FINAL deadline is the last day of classes of the semester the student has applied to graduate.

For transcript purposes:

The student's official transcript shall record both grades. For the course retaken, only the second grade shall be counted in the determination of the student's grade-point average (GPA). Any GPA calculated in accord with this policy shall be marked with an asterisk denoting that a lower grade has been replaced by a second grade in the course.

Grade Point Average
The cumulative grade point average is computed by dividing the total number of grade points earned by the total number of credit hours completed in which grades of A through F are assigned. Credits earned at other IU campuses are included in this average. Credit earned at another institution may be applied toward degree requirements, but the grades earned at other non-IU institutions will not be calculated in the Indiana University cumulative grade point average.

Incomplete Courses
A temporary grade of Incomplete (I) on the transcript indicates that the course work is mostly completed, generally 75 to 80 percent, and of passing quality.

It is the student's responsibility to contact the instructor to have a grade of Incomplete assigned. The instructor specifies the work to be done to remove the grade of Incomplete and the period of time allowed for completion. If the student fails to remove the Incomplete within one calendar year, the Office of the Registrar will change the grade to an F. The dean (or instructor) authorizes adjustments of this period in exceptional circumstances. A student who has received a grade of Incomplete should not register for the course a second time but should arrange with the instructor to have the grade changed to a letter grade upon completion of requirements, provided that it is done within the year.

Grading Policies
The Luddy School of Informatics, Computing, and Engineering follows the official grading system of Indiana University, which is as follows:

A+	= 4.00	C+	= 2.30
A	= 4.00	C	= 2.00
A-	= 3.70	C-	= 1.70
B+	= 3.30	D+	= 1.30
B	= 3.00	D	= 1.00
B-	= 2.70	D-	= 0.70
		F	= 0.00

The following grades carry no grade points: I (Incomplete), NC (No Credit), NR (No Report Filed by Instructor), P (Passing), R (Deferred), S (Satisfactory), W (Withdrawal).

- Change of Grade
- Extended-X Option
- Grade Point Average
- Incomplete Courses
- Pass/Fail Option
- R Grade
- Withdrawals

Pass/Fail Option
Students in the Luddy School of Informatics, Computing, and Engineering may elect to take a maximum of 12 credit hours total under the Pass/Fail option. The procedure for declaring this option can be found in the Enrollment and Student Academic Information Bulletin. Special regulations

affecting the Pass/Fail option for School of Informatics, Computing, and Engineering students are as follows:

- Two courses per academic year can be taken under the Pass/Fail option.
- The Luddy School of Informatics, Computing, and Engineering students may take only university elective courses or general elective courses on a Pass/Fail basis. The Pass/Fail option may not be used for any course that satisfies the requirements for a major, minor, or certificate.
- A grade of P is not counted in the grade point average; a grade of F is included. Grades of P cannot be changed to any other letter grade.
- Pass/Fail forms are available from your advisor.

R Grade

The R grade (Deferred) on the final report indicates that the nature of the course is such that the work of the student can be evaluated only after two or more terms. Courses in which an R grade is assigned will be announced as deferred grade courses in the online enrollment system.

Withdrawals

A grade of W (Withdrawal) is given automatically to the student who withdraws from courses during the automatic withdrawal period as specified in the Enrollment and Student Academic Information Bulletin. After the automatic withdrawal period, a student may withdraw only with the permission of the dean. This approval is given only for urgent reasons related to extended illness or equivalent distress. The desire to avoid a low grade is not an acceptable reason for withdrawal from a course.

A grade of W does not affect the overall grade point average. A grade of F will be recorded on the official transcript if a student stops attending but does not officially withdraw from class. Students who alter their schedules, whether at their own initiative or by departmental directive, must follow withdrawal procedures. Students who do not assume this responsibility are jeopardizing their records because they will incur a failing grade in a course not properly dropped and will not receive credit for work done in a course not properly added.

Students who wish to cancel their Bloomington campus registrations for a future semester must notify the Office of the Registrar in writing prior to the first day of classes.

Students who are forced to discontinue all studies during the semester (even if enrolled in only one course) and withdraw from the university must contact the Student Advocates Office in Eigenmann Hall West 225 to complete the withdrawal process.

At IUB, if a student withdraws after the first week of classes, the courses in which the student was enrolled will be retained on the student's record with a grade of W or F (as appropriate) and a notation of the date of withdrawal. To qualify for a grade of W after the deadline, a student must be passing the course(s) on the date of withdrawal. If the student is failing, the grade on the date of withdrawal will be F.

Academic Misconduct

Cheating

Cheating is dishonesty of any kind with respect to course assignments, alteration of records, or examinations. It is the student's responsibility not only to abstain from cheating, but also to avoid the appearance of cheating and to guard against making it possible for others to cheat. Any student who helps another student cheat is as guilty of cheating as the student assisted. The student also should do everything possible to induce respect for the examining process and for honesty in the performance of assigned tasks in or out of class.

Plagiarism

Plagiarism is assuming credit for someone else's work, words, or ideas—whether or not the ideas are expressed in the borrower's own words. Honesty requires that any ideas or materials taken from another source for either written or oral use must be fully acknowledged. Plagiarism includes language or ideas taken from isolated formulas, sentences, or paragraphs; entire articles copied from books, periodicals, or speeches; the writings or created works of other students; and materials assembled or collected by others in projects or collections without acknowledgment.

A faculty member who has evidence that a student is guilty of cheating or plagiarism will initiate the process of determining the student's guilt or innocence. No penalty will be imposed until the student has been informed of the charge and of the evidence on which it is based, and has been given an opportunity to present a defense. If the faculty member finds the student guilty, the faculty member assesses a penalty within the course and promptly reports the case in writing to the dean of the school or comparable head of the academic unit. The report should include the names of any other students who may be involved in the incident and recommendations for further action. The dean, in consultation with the faculty member if the latter so desires, will initiate any further disciplinary proceedings and inform the faculty member of any action taken. In every case, a record of the offenses remains on file.
For further regulations, please refer to the *IU Code of Student Rights, Responsibilities, and Conduct*.

Student Grievance Procedures

All academic personnel (faculty, part-time instructors, and advisors) are expected to conform to the Code of Student Rights, Responsibilities and Conduct. Students who feel that they have been treated unfairly by a faculty member may lodge a complaint by following these steps:

1. Discuss the matter with the faculty member or instructor.
2. If step 1 fails to resolve the situation, discuss the matter with the chairperson of the department or the coordinator of the program in which the faculty member is employed. The departmental chairperson will discuss it with the faculty member and seek some resolution.
3. If step 2 fails, the student may discuss the matter or file a written, signed complaint with the dean. Anonymous complaints will not be entertained. A copy of any written complaint will be forwarded to the faculty member, who may respond in writing.

4. When warranted, the dean may refer a written complaint and the faculty member's response to the Faculty Affairs Committee for further investigation and review.
5. The Faculty Affairs Committee will evaluate the complaint on the basis of university policy and may recommend to the dean that the instructor be sanctioned. If the committee finds the complaint to be unfounded, a letter to that effect may be placed in the student's file.

Academic Policies and Procedures

Academic policies and procedures have been developed and approved by faculty to govern and facilitate student academic progress. These policies and procedures exist for undergraduate and graduate students.

Core Faculty

- Ahn, Yong-Yeol, Ph.D. *(KAIST, 2008)*, *Professor of Informatics and Computing*
- An, Jisun, Ph.D. (University of Cambridge, 2014) *Assistant Professor of Informatics*
- Anguili, Carlo, Ph.D. (Carnegie Mellon University, 2019) *Assistant Professor of Computer Science*
- Azad, Ariful, Ph.D. *(Purdue University, 2014), Director of Engineering Graduate Studies; Assistant Professor of Intelligent Systems Engineering*
- Beer, Randall, Ph.D. *(Case Western Reserve University, 1989), Professor of Cognitive Science, Computer Science, and Informatics*
- Blanco Rodriguez, Saul, Ph.D. *(Cornell University, 2011), Assistant Professor of Computer Science*
- Blevis, Eli, Ph.D. *(Queen's University at Kingston, 1990), Director of HCI/d PhD Program; Professor of Informatics and Cognitive Science*
- Bollen, Johan, Ph.D. (University of Brussels, 2001), *Chair of Informatics*, *Professor of Informatics*
- Bondesson Bolin, Maria, Ph.D. *(Karolinska Institute [Sweden], 1995), Associate Professor of Intelligent Systems Engineering*
- Börner, Katy, Ph.D. *(University of Kaiserslautern [Germany], 1997), Director of Cyberinfrastructure for Network Science (CNS) Center; Victor H. Yngve Distinguished Professor of Information Science; Distinguished Professor of Intelligent Systems Engineering; Adjunct Professor of Statistics*
- Brendel, Volker, Ph.D. *(Weizmann Institute of Science [Israel], 1986), Director of Bioinformatics; Professor of Biology and Computer Science*
- Brown, Geoffrey, Ph.D. *(University of Texas at Austin, 1987), Professor of Computer Science*
- Camp, L. Jean, Ph.D. *(Carnegie Mellon University, 1996), Associate Director, Center for Applied Cybersecurity Research; Co-Director of the Center for Security and Privacy in Informatics, Computing, and Engineering; Professor of Informatics and Computer Science; Adjunct Professor of Telecommunications*
- Choi, Kahyun, Ph.D. *(University of Illinois at Urbana-Champaign, 2018), Assistant Professor of Information and Library Science*
- Chung, Christina, Ph.D. *(University of Washington, 2018), Assistant Professor of Informatics*
- Clawson, James, Ph.D. *(Georgia Institute of Technology, 2012), Assistant Professor of Informatics*
- Crandall, David, Ph.D. *(Cornell University, 2008), Director of Computer Science Graduate Studies; Director of the Artificial Intelligence Center; Professor of Informatics and Computing*
- Dalkilic, Mehmet, Ph.D. *(Indiana University, 2000), Director of Data Science Undergraduate Studies; Professor of Computer Science; Adjunct Professor of Statistics*
- Day, Ronald E., Ph.D. *(State University of New York– Binghamton, 1990), Professor of Information and Library Science*
- Donaldson, Devan, Ph.D. *(University of Michigan, 2015), Director MLS Program; Associate Professor of Information Science*
- Ekbia, Hamid, Ph.D. *(Indiana University, 2003), Director of Center for Research on Mediated Interaction; Professor of Informatics, Cognitive Science, and International Studies*
- Ensmenger, Nathan, Ph.D. *(University of Pennsylvania, 2001), Director of Informatics Graduate Studies; Associate Professor of Informatics*
- Ergun, Funda, Ph.D. *(Cornell University, 1998), Professor of Computer Science*
- Ferradal, Silvina, Ph.D. *(Washington University in St. Louis, 2014), Assistant Professor of Intelligent Systems Engineering*
- Fichman, Pnina, Ph.D. *(University of North Carolina at Chapel Hill, 2003), Director of ILS PhD Program; Director of Rob Kling Center for Social Informatics (RKCSI); Professor of Information Science*
- Flammini, Alessandro, Ph.D. *(International School for Advanced Studies, 1996), Professor of Informatics; Adjunct Professor of Physics; Affiliated Researcher in the Biocomplexity Institute*
- Fortunato, Santo, Ph.D. *(University of Bielefeld [Germany], 2000), Co-Director of Informatics Complex Systems; Co-Director of Network Science Institute; Professor of Informatics*
- Friedman, Daniel P., Ph.D. *(The University of Texas at Austin, 1973), Professor of Computer Science*
- Frischer, Bernard, Ph.D. *(University of Heidelberg, Germany, 1975), Professor of Informatics*
- Garyfallidis, Eleftherios, Ph. D. *(University of Cambridge, 2012), Associate Professor of Intelligent Systems Engineering*
- Glazier, James, Ph.D. *(University of Chicago, 1989), Director of Biocomplexity Institute Biophysics; Professor of Intelligent Systems Engineering*
- Gray, Mary, Ph.D. *(University of California-San Diego, 2004), Associate Professor of Informatics*
- Groth, Dennis, Ph.D. *(Indiana University, 2002), Professor of Informatics, Computer Science, and Cognitive Science*
- Guidi, Gabriele, Ph.D. *(University of Bologna, 1992), Professor of Informatics*
- Gumennik, Alexander, Ph.D. *(Hebrew University of Jerusalem, 2010), Assistant Professor of Intelligent Systems Engineering*

- Guo, Feng, Ph.D. *(Pennsylvania State University, 2015), Associate Professor of Intelligent Systems Engineering*
- Habeeb, Dana, Ph.D. *(Georgia Institute of Technology, 2017), Assistant Professor of Informatics*
- Haghverdi, Esfandiar, Ph.D. *(University of Ottawa, 2000), Professor of Computer Science and Informatics; Adjunct Professor of Mathematics*
- Hahn, Matthew, Ph.D. *(Duke University, 2003), Director of Center for Genomics and Bioinformatics; Professor of Informatics and Biology*
- Hara, Noriko, Ph.D. *(Indiana University, 2000), Chair of Information and Library Science; Professor of Information Science*
- Herring, Susan C., Ph.D. *(University of California, Berkeley, 1991), Professor of Information Science; Adjunct Professor of Linguistics*
- Hofstadter, Douglas, Ph.D. *(University of Oregon, 1975), Director, Center for Research on Concepts and Cognition; Distinguished Professor; College Professor of Cognitive Science and Computer Science; Adjunct Professor of Comparative Literature*
- Huang, Yan, Ph.D. *(University of Virginia, 2012), Director of Computer Science Graduate Studies; Associate Professor of Computer Science*
- Jadhao, Vikram, Ph.D. *(University of Illinois at Urbana-Champaign, 2010), Associate Professor of Intelligent Systems Engineering*
- Jiang, Lei, Ph.D. *(University of Pittsburgh, 2014), Associate Professor of Intelligent Systems Engineering*
- Kapadia, Apu, Ph.D. *(University of Illinois at Urbana-Champaign, 2005), Associate Dean for Graduate Programs; Professor of Computer Science and Informatics*
- Kaziunas, Elizabeth, Ph.D. *(University of Michigan, 2018), Assistant Professor of Informatics*
- Keidari, Mohen, Ph.D. *(University of Michigan, Ann Arbor, 2018), Assistant Professor of Computer Science*
- Kim, Minje, Ph.D. *(University of Illinois at Urbana-Champaign, 2016), Associate Professor of Intelligent Systems Engineering*
- Khardon, Roni, Ph.D. *(Harvard University, 1996), Professor of Computer Science*
- Khoozani Heidari, Mohen, Ph.D. *(University of Michigan, Ann Arbor, 2018), Assistant Professor of Computer Science*
- Kwak, Haewoon, Ph.D. (Korea Institute of Science and Technology, 2011) Associate Professor of Informatics
- LaRacuente, Nicholas, Ph.D. (University of Illinois at Urbana-Champaign 2929) Assistant Professor of Computer Science
- Leake, David, Ph.D. *(Yale University, 1990), Professor of Computer Science*
- Leivant, Daniel, Ph.D. *(University of Amsterdam [Netherlands], 1975), Professor of Computer Science; Adjunct Professor of Philosophy and Mathematics*
- Lewis, Greg, Ph.D. *(University of Illinois at Chicago, 2011), Director of Engineering Undergraduate Studies; Assistant Professor of Intelligent Systems Engineering*
- Liao, Xiaojing, Ph.D. *(Georgia Tech, 2017), Assistant Professor of Computer Science*
- Liu, Lantao, Ph.D. *(Texas A&M, 2013), Associate Professor of Intelligent Systems Engineering*
- Lukefahr, Andrew, Ph.D. *(University of Michigan-Ann Arbor, 2016), Assistant Professor of Intelligent Systems Engineering*
- Ma, Rongqian, Ph.D. *(University of Pittsburgh, 2022), Assistant Professor of Information and Library Science*
- Macklin, Paul, Ph.D. *(University of California-Irvine, 2007), Associate Dean for Undergraduate Programs, Professor of Intelligent Systems Engineering*
- Malbasa, Veljko, Ph.D. *(University of Novi Sad [Yugoslavia], 1985), Clinical Professor of Computer Science*
- Martell, Allan, Ph.D. *(University of Michigan, 2020), Assistant Professor of Information and Library Science*
- Menczer, Filippo, Ph.D. *(University of California at San Diego, 1998), Professor of Informatics, Computer Science, and Cognitive Science; Adjunct Professor of Physics*
- Milojevi#, Staša, Ph.D. *(University of California, Los Angeles, 2009), Director of CNeTS; Professor of Informatics*
- Millunchick, Joanna, Ph.D. *(Northwestern University, 1995), Dean; Professor of Engineering*
- Nippert-Eng, Christena, Ph.D. *(State University of New York at Stony Brook, 1994), Director of Social Informatics; Professor of Informatics*
- Paolillo, John, Ph.D. *(Stanford University, 1992), Associate Professor of Informatics and Information Science; Adjunct Associate Professor of Linguistics*
- Plale, Beth, Ph.D. *(State University of New York at Binghamton, 1998), Chair of ISE, Director of Data to Insight; Michael A and Laura Burns McRobbie Bicentennial Professor of Intelligent Systems Engineering*
- Radicchi, Filippo, Ph.D. *(Jacobs University [Germany], 2007), Director of Data Science Admissions; Professor of Informatics*
- Raphael, Christopher, Ph.D. *(Brown University, 1991), Professor of Informatics and Cognitive Science; Adjunct Professor of Music Theory*
- Riddell, Allen, Ph.D. *(Duke University, 2013), Associate Professor of Information Science*
- Rosenbaum, Howard S., Ph.D. *(Syracuse University, 1996), Director of Graduate Programs; Director of Master of Information Science Program; Professor of Information Science*
- Sabanovic, Selma, Ph.D. *(Rensselaer Polytechnic Institute, 2007), Associate Dean for Faculty Affairs; Professor of Informatics*
- Sabry, Amr, Ph.D. *(Rice University, 1994), Professor of Computer Science*
- Sahinalp, S. Cenk, Ph.D. *(University of Maryland at College Park, 1997), Professor of Computer Science*
- Shan, Chung-Chein (Ken), Ph.D. *(Harvard University, 2005), Associate Professor of Computer Science*

- Sharma, Prateek, Ph.D. *(University of Massachusetts-Amherst, 2018), Assistant Professor of Intelligent Systems Engineering*
- Shih, Patrick C., Ph.D. *(University of California-Irvine, 2011), Director of Data Science Graduate Studies; Associate Professor of Informatics*
- Siek, Jeremy, Ph.D. *(Indiana University, 2005), Professor of Computer Science*
- Siek, Katie, Ph.D. *(Indiana University, 2006), Director o f Proactive Health; Professor of Informatics*
- Sterling, Thomas, Ph.D. (*Massachusetts Institute of Technology,* 1984), *Professor of Intelligent Systems Engineering*
- Stolterman, Erik, Ph.D. *(Umea University [Sweden], 1991), Professor of Informatics*
- Swany, Martin, Ph.D. *(University of California, Santa Barbara, 2003), Chair of Intelligent Systems Engineering; Professor of Intelligent Systems Engineering*
- Tang, Haixu, Ph.D. *(Shanghai Institute of Biochemistry [China], 1998), Director of Data Science Program; Professor of Informatics and Computer Science; Affiliated Researcher in the Center for Genomics and Bioinformatics*
- Tiganj, Zoran, Ph.D. *(French Institute for Research in Computer Science and Control (INRIA) and University of Science and Technology, Lille, France, 2011), Assistant Professor of Computer Science*
- Tobin-Hochstadt, Sam, Ph.D. *(Northeastern University, 2010), Director of Computer Science Undergraduate Education; Associate Professor of Computer Science*
- Todd, Peter M., Ph.D. *(Stanford University, 1992), Professor of Informatics, Cognitive Science, and Psychological and Brain Sciences*
- Van Gucht, Dirk, Ph.D. *(Vanderbilt University, 1985), Professor of Computer Science*
- Walsh, John A., Ph.D. *(Indiana University, 2000), Associate Professor of Information and Library Science; Adjunct Associate Professor of English*
- *Wang, Chenghong, Ph.D. (Duke3 University, 2023) ****Acting***** Assistant Professor of Computer Science*
- Wang, XiaoFeng, Ph.D. *(Carnegie Mellon University, 2004), Co-Director of Center for Security and Privacy Informatics; James H Rudy Professor of Computer Science, Engineering, and Informatics; Affiliated Researcher in the Center for Applied Cybersecurity Research*
- Wang, Yijie, Ph.D. *(Texas A&M University, 2015), Assistant Professor of Computer Science*
- Wild, David, Ph.D. *(Sheffield University [United Kingdom], 1994), Director of Cheminformatics; Professor of Informatics*
- Wood, Justin, Ph.D. *(University of Toronto, 2012), Director of HCI/d MS program; Assistant Professor of Informatics*
- Wood, Samantha, Ph.D. *(University of Southern California, 2017), Assistant Professor of Informatics*
- Xing, Luyi, Ph.D. *(Indiana University, 2017), Assistant Professor of Computer Science*
- Yan, Da, Ph.D. (Hong Kong University of Science and Technology, 2014) Assistant Professor of Computer Science.
- Ye, Yuzhen, Ph.D. *(Shanghai Institute of Biochemistry [China], 2001), Chair of Computer Science; Director of Center for Bioinformatics Research; Professor of Informatics and Computer Science*
- Zeavin Musser, Hannah, Ph.D. *(New York University, 2018), Assistant Professor of Informatics*
- Zhang, Hang, Ph.D. (University of California, Riverside, 2020) Assistant Professor of Computer Science
- Zhang, Qin, Ph.D. *(Hong Kong University of Science and Technology [China], 2010), Director of Computer Science Admissions; Professor of Computer Science*
- Zhang, Xuhong, Ph.D. *(University of California, Irvine, 2017), Assistant Professor of Computer Science*
- *Zhou, Dongruo, Ph.D. (University of California, Los Angeles, 2023) Assistant Professor of Computer Science*

Emeriti Faculty

- Abrera, Josefa B., Ph.D. *(Indiana University, 1970), Associate Professor Emerita of Information and Library Science*
- Bramley, Randall, Ph.D. *(University of Illinois at Urbana-Champaign, 1989), Professor of Computer Science*
- Callison, Daniel, Ed.D. *(Indiana University, 1982), Professor Emeritus of Information and Library Science*
- Cronin, Blaise, Ph.D. *(The Queen's University of Belfast, 1983), D.S.Sc. (The Queen's University of Belfast, 1998), D.Litt. (h.c.), Queen Margaret University College, Edinburgh, 1997, Emeritus Rudy Professor of Information and Library Science*
- Dunn, J. Michael, Ph.D. *(University of Pittsburgh, 1966), Former Dean, School of Informatics; Emeritus Oscar R. Ewing Professor of Philosophy; Emeritus Professor of Informatics and Computer Science; Founding Member, Cognitive Science Program*
- Dybvig, R. Kent, Ph.D *(Universtiy of North Carolina at Chapel Hill, 1987), Professor Emeritus of Computer Science*
- Fitzgibbons, Shirley A., Ph.D. *(Rutgers University, 1976), Associate Professor Emeritus of Information and Library Science*
- Gannon, Dennis, Ph.D. *(University of California, Davis, 1974; University of Illinois, 1980), Professor Emeritus of Computer Science*
- Gasser, Michael E., Ph.D. *(University of California at Los Angeles, 1988), Associate Professor Emeritus of Computer Science and Cognitive Science; Adjunct Associate Professor Emeritus of Linguistics*
- Hagstrom, Stanley A., Ph.D. *(Iowa State University, 1957), Professor Emeritus of Physics and Computer Science*
- Hanson, Andrew J., Ph.D. *(Massachusetts Institute of Technology, 1971), Professor Emeritus of Computer Science*
- Harter, Stephen P., Ph.D. *(University of Chicago, 1974), Professor Emeritus of Information and Library Science*

- Haynes, Christopher T., Ph.D. *(University of Iowa, 1982), Associate Professor Emeritus of Computer Science and Informatics*
- Jacob, Elin K., Ph.D. *(University of North Carolina at Chapel Hill, 1994), Associate Professor of Library and Information Science*
- Johnson, Steven D., Ph.D. *(Indiana University, 1983), Professor Emeritus of Computer Science*
- McRobbie, Michael A., Ph.D. *(Australian National University, 1979), President Emeritus of Indiana University; Professor of Computer Science; Adjunct Professor of Information and Library Science*
- Menzel, Suzanne, M.S. *(Rutgers University, 1983), Senior Lecturer in Computer Science*
- Nisonger, Thomas E., Ph.D. *(Columbia University, 1976), Professor Emeritus of Information and Library Science*
- Ogan, Christine, Ph.D. *(University of North Carolina, 1976), Professor Emeritus of Informatics and Journalism*
- Preer, Jean, Ph.D. *(George Washington University, 1980), Professor Emeritus*
- Prosser, Franklin, Ph.D. *(Pennsylvania State University, 1961), Professor Emeritus of Computer Science*
- Purdom, Paul W., Ph.D. *(California Institute of Technology, 1966), Professor Emeritus of Computer Science*
- Rawlins, Gregory J.E., Ph.D. *(University of Waterloo [Canada], 1987), Associate Professor of Computer Science and Informatics*
- Robbin, Alice R., Ph.D. *(University of Wisconsin—Madison, 1984), Associate Professor of Library and Information Science*
- Robertson, Edward L., Ph.D. *(University of Wisconsin - Madison, 1970), Professor Emeritus of Computer Science and Informatics*
- Schnabel, Robert, Ph.D. *(Cornell University, 1977), Former Dean, School of Informatics and Computing; Professor of Computer Science and Informatics*
- Shaw, Debora, Ph.D. *(Indiana University, 1983), Professor Emeritus of Library and Information Science*
- Siegel, Martin A., Ph.D. *(University of Illinois, 1973), Professor of Informatics, Cognitive Science, and Instructional Systems Technology*
- Van Gucht, Dirk, Ph.D. *(Vanderbilt University, 1985), Professor of Computer Science*
- White, Herbert S., M.S.L.S. *(Syracuse University,1950), Distinguished Professor Emeritus of Information and Library Science*
- Wiggins, Gary D., Ph.D. *(Indiana University, 1985), Director of Chemical Informatics Program; Interim Director of Bioinformatics Program; Professor Emeritus of Informatics*
- Wise, David S., Ph.D. *(University of Wisconsin—Madison, 1971), Professor Emeritus of Computer Science*

Faculty

Lecturers and Non-Tenure Track Appointments

- Ashraf, Nazim, Ph.D. *(University of Central Florida, 2012), Senior Lecturer of Computer Science*
- Blevis, Shunying, M.S. *(Indiana University, 2007), Lecturer of Informatics*
- Brodowicz, Maciej, Ph.D. *(University of Houston, 1998), Assistant Research Scientist in Intelligent Systems Engineering*
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- Bueckle, Andreas, Ph.D. (*Indiana University, 2021*), *Assistant Research Scientist in Intelligent Systems Engineering*
- Choksy, Carol E.B., Ph.D. *(University of Chicago, 1987), Senior Lecturer of Information and Library Science*
- D'Alessandro, Luke, Ph.D. (*University of Rochester, 2012*), *Senior Research Scientist in Intelligent Systems Engineering*
- Duncan, John, Ph.D. *(Indiana University, 2011), Associate Chair of Informatis; Teaching Professor of Informatics*
- El-Shamy, Jehan "Jenny", M.F.A. *(Indiana University, 1999), Senior Lecturer of Informatics*
- Francisco, Matthew, Ph.D. *(Rensselaer Polytechnic Institute, 2010), Senior Lecturer of Informatics*
- German, Dan-Adrian, M.S. *(Indiana University, 1994), Senior Lecturer of Computer Science*
- Ghazinejad, Ali, Ph.D. *(Indiana University, 2019), Lecturer of Information and Library Science*
- Himebaugh, Bryce, B.S. *(University of Evansville, 1993), Clinical Associate Professor of Intelligent Systems Engineering*
- Hmeljak, Mitja, Ph.D. *(Indiana University, 2010), Senior Lecturer of Computer Science*
- Hottell, Mathew, M.S. *(Indiana University, 2003), Senior Lecturer of Informatics*
- Jordan, Philipp, Ph.D. *(University of Hawaii, Manoa, 2019), Lecturer of Informatics*
- Kavousian, Shabnam, Ph.D. *(Simon Fraser University, 2008), Teaching Professor of Informatics*
- Kouper, Inna, Ph.D. *Associate Research Scientist in Informatics*
- Lasassmeh, Suha, Ph.D. *(University of Wisconsin, Milwaukee, 2017), Lecturer of Engineering*
- Lee, Erika, M.A. *(Indiana University, 2004), Senior Lecturer of Informatics*
- Li, Sujun, Ph.D. (*Shanghai Institutes for Biological Sciences, 2007*), *Assistant Research Scientist in Computer Science*
- Malbasa, Velijko, Ph.D. *(University of Novi Sad, 1985), Clinical Professor of Computer Science*
- McCoy, Chase, MLS *(Indiana Univeristy, 2019), Lecturer of Informatics*
- Nascimento Silva, Filipi, Ph.D. (*Universidade de S#o Paulo, 2015*), *Assistant Research Scientist in Informatics*
- Paul, Logan, M.S. *(Indiana University, 2015), Senior Lecturer of Informatics*
- Pierce Caudell, Alexis, Ph.D. *(Indiana University, 2020), Lecturer of Informatics*
- Pierz, Dan, M.A. *(Indiana University, 2009), Senior Lecturer of Informatics*

- Pope, Charles E., B.S. *(Ambassador University, 1993), CSCI A110 Course Coordinator; Assoicate Chair of Computer Science; Senior Lecturer of Computer Science*
- Seiffert, Kurt, B.S. *(Indiana University, 1996), Lecturer of Computer Science*
- Siddiqui, Muazzam, Ph.D. *(University of Central Florida, 2008), Senior Lecturer of Computer Science*
- Sluka, James P., Ph.D. *(California Institute of Technology), Research Scientist at the Biocomplexity Institute; Senior Scientist in Intelligent Systems Engineering*
- Soe, Younei, Ph.D. *(Indiana University, 2012), Lecturer of Information and Library Science*
- Stark, Roderick, M.S. *(Indiana University, 1986), Lecturer of Informatics*
- Tang, Wei, Ph.D. (*Florida Atlantic University, 2011*), *Assistant Research Scientist in Computer Science*
- Terrell, Jennifer, Ph.D. *(Indiana University, 2015), Director of Informatics Undergraduate Studies; Senior Lecturer of Informatics*
- Wennstrom, Erik, Ph.D. *(Indiana University, 2012), Senior Lecturer of Computer Science*
- Whitmer, Jeffrey M., M.A. *(Indiana University, 1986), Senior Lecturer of Computer Science*
- Wood, Brian, B.A. (*University of Virginia, 2002*), *Lecturer of Informatics*

Special Faculty

- Acharya, Raj, Ph.D. *(University of Minnesota/Mayo Medical School, 1984), Associate Vice President for Research and AI Innovation; Rudy Professor of Engineering, Computer Science, and Informatics*
- Andrews, Barbara, Ph.D. *(Brown University), Adjunct Professor of Informatics*
- Anousheh, Nasim, Ph.D. *(University of Sherbrooke, Canada, 2017), Assistant Research Scientist in Engineering*
- Arave, Gary, M.L.S. *(Indiana University, 2011), Research and Instruction Librarian; Assistant Librarian; Adjunct Assistant Professor of Information and Library Science*
- Asher, Andrew, Ph.D. *(University of Illinois at Urbana-Champaign, 2008), Information and Library Science; Adjunct Associate Professor*
- Backs, Steven, M.L.S. *(Indiana University), Software Project Consultant at Envisage Technologies LLC; Adjunct Lecturer of Information and Library Science*
- Ballard, Joshua, Ph.D. *(University of Colorado, 2003), Director of Research Operations, Intelligent Systems Engineering*
- Bantin,Philip C., M.L.S. *(University of Wisconsin-Madison, 1976), Adjunct Instructor of Information and Library Science*
- Baumann, Rebecca, *Head of Lilly Library Public Services; Assistant Librarian; Adjunct Assistant Professor in Information and Library Science*
- Beggs, John, Ph.D. *(Yale University, 1998), Adjunct Associate Professor of Informatics*
- Bonk, Curtis, Ph.D. *(University of Wisconsin-Madison, 1989), Professor of Education; Adjunct Professor of Informatics*
- Bruecks, Melissa, M.L.S. *(Indiana University, 2006), Reference Librarian at City of Rancho Mirage Public Library; Adjunct Lecturer of Information and Library Science*
- Callas, Jon, B.S. *(University of Maryland at College Park, 1980), Chief Technical Officer and Co-founder, Silent Circle; Adjunct Professor of Computer Science*
- Carter, Sarah, M.A./M.L.S. *(Indiana University, 2007), Art, Architecture and Design Librarian; Adjunct Assistant Professor of Information and Library Science*
- Casey, Michael, *Media Preservation Leader VPIT; Adjunct Faculty of Library and Information Science*
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