College of Engineering

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Codirectors, Iowa Institute for Biomedical Imaging
• Colin P. Derdeyn, Milan Sonka

Director, IIHR—Hydroscience and Engineering
• Gabriele Villarini

Undergraduate degree: B.S.E.
Undergraduate certificates: naval hydrodynamics; technological entrepreneurship
Graduate degrees: M.S.; Ph.D.
Graduate certificate: sustainable water development
Website: https://www.engineering.uiowa.edu/

Engineers play an important role in modern society. They design and develop new and improved materials, products, and processes ranging from nanoparticles to antibiotics to major bridges and dams. Engineers are in demand across a broad spectrum of industry, spanning traditional fields such as mechanical and electrical engineering to the emerging fields of artificial intelligence and medicine. Engineers not only satisfy society's demand for improved performance, reliability, and safety of products, they also supply solutions for unforeseen societal consequences that may arise as the result of new technologies.

The College of Engineering has six academic departments: the Roy J. Carver Department of Biomedical Engineering and the Departments of Chemical and Biochemical Engineering, Civil and Environmental Engineering, Electrical and Computer Engineering, Industrial and Systems Engineering, and Mechanical Engineering.

Moreover, research and educational activities of the college are supported by four research centers and institutes: the Center for Bioinformatics and Computational Biology, the Center for Computer-Aided Design, the Iowa Institute for Biomedical Imaging, and IIHR—Hydroscience & Engineering.

Programs

Undergraduate Programs of Study

The College of Engineering offers the Bachelor of Science in Engineering (B.S.E.) with majors in biomedical, chemical, civil, electrical, computer science and engineering, environmental, industrial, and mechanical engineering. For information about each B.S.E. major, see the Catalog's College of Engineering department sections.

The college also offers combined undergraduate degree programs with the College of Liberal Arts and Sciences and the Tippie College of Business; a dual degree with the University of Northern Iowa; a combined bachelor's/master's degree program in each engineering discipline; and a combined bachelor's/master's degree with the School of Urban and Regional Planning (also see the graduate Certificate in Transportation Studies in the Graduate College). For additional information, see “Combined and Dual Degrees” in the Bachelor of Science in Engineering section of the Catalog.

In addition, the College of Engineering offers an undergraduate Certificate in Naval Hydrodynamics, and partners with the Tippie College of Business to offer a Certificate in Technological Entrepreneurship for undergraduate engineering students.

Graduate Programs of Study

The College of Engineering offers graduate degree programs, the Master of Science (M.S.) and Doctor of Philosophy (Ph.D.) in biomedical engineering, chemical and biochemical engineering, civil and environmental engineering, electrical and computer engineering, industrial and systems engineering, and mechanical engineering. See the College of Engineering Graduate Studies web page for an overview, and the departmental sections in the Catalog for information about specific areas of research and study, admission and degree requirements, and financial support for the graduate programs. The College of Engineering also offers the graduate Certificate in Sustainable Water Development.

In addition, the college administers the M.S. in engineering and information technology.

High School Program of Study

FIRST: FTC

For Inspiration and Recognition of Science and Technology (FIRST) gives students the opportunity for real-world application of science, technology, engineering, and math (STEM) concepts. Students participate in an atmosphere that encourages team building, entrepreneurship, and sportsmanship. FIRST Tech Challenge (FTC) allows teams of students to be responsible for designing, building, and programming robots based on sound engineering principles. Students learn about working in a team environment, effective communication skills, the ability to fail and succeed at the same time, and competing fairly while being supportive of their competition.
Facilities and Resources

Seamans Center for the Engineering Arts and Sciences
The Seamans Center for the Engineering Arts and Sciences is home to the College of Engineering. In addition to faculty offices, classrooms, conference rooms, instructional laboratories, and faculty offices, the Seamans Center houses the Lichtenberger Engineering Library, the Hanson Center for Technical Communication, a machine shop, electronic shop, student work spaces, computational facilities, and research laboratories. A number of classrooms and open spaces located throughout the building were designed to readily accommodate collaborative work.

Engineering Student Services
The professional staff of Engineering Student Services administer student services for the College of Engineering, including advising, tutoring, student records, and global engineering. It also is the administrative home of Engineering Professional Development and the Hanson Center for Technical Communication.

Engineering Professional Development
Engineering Professional Development (EPD) develops and promotes experiential education and professional opportunities for students in the College of Engineering. Professional staff coordinate the college’s co-op and internship program, engage in employer outreach, and provide opportunities for students to network with employers, including an engineering career fair each semester and other programming related to career development. EPD offers individual advising and class presentations on résumé and cover letter preparation, job and internship search strategies, interviewing skills, and job offer evaluation. EPD partners with the Pomerantz Career Center to facilitate on-campus interviewing and administration of the University’s online recruiting system, Handshake.

Hanson Center for Technical Communication
The Hanson Center for Technical Communication (HCTC) assists undergraduate engineering students in developing and polishing their communication skills. The center’s director and assistant director supervise a staff of professional writing consultants and peer tutors.

HCTC writing tutors are professional instructors who work in teams to help engineering faculty members present and evaluate writing-intensive assignments. They also provide individual feedback and assessment of students’ work throughout the writing process.

HCTC peer consultants are engineering students who have strong communication skills. Peer tutors conduct one-on-one tutoring sessions at the center to help their fellow students develop skills for organization and audience analysis, and to create precise technical descriptions and persuasive, logical narratives.

Global Engineering
In today’s global society, engineering graduates in all disciplines are expected to have a level of global competence in order to successfully interact with colleagues and customers around the world. Successful engineers are able to communicate across cultures, work on diverse teams, and effectively deal with issues and conflicts arising from differences. Many top employers look for these global competencies in new graduates.

University of Iowa engineering students have a variety of opportunities to study abroad. Students can experience a new culture while completing required engineering courses in English for a winter, summer, semester, or full academic year. Students also can explore opportunities abroad to fulfill their minor or elective focus area requirements.

In addition to completing course work abroad, engineering students can pursue additional opportunities abroad, such as global internships, conducting research in other countries, and volunteering. The College of Engineering and the University support these endeavors by offering a variety of scholarships and financial aid.

Lichtenberger Engineering Library
The Lichtenberger Engineering Library is a branch of the University of Iowa Main Library and is a center of engineering college activity. Its collections include more than 140,000 volumes and electronic full-text access to over 5,000 engineering and scientific journals. It offers electronic access to primary engineering and scientific indexes and abstracts, and full-text access to standards and U.S. patents. The library also maintains a substantial collection of publications from major engineering societies and a collection of national and international standards.

Tools also are available for check out to students and faculty in order to allow for more hands-on projects and use in class assignments. Example tools include screwdrivers, scales, and light meters. The library provides 35 computer workstations with specialized software packages and a significant amount of study space for students. Study spaces allow for individual as well as group study. The library features individual study carrels, group tables, lounge chairs, a collaborative work station, and movable whiteboards. Library personnel are available to assist with specialized engineering-related reference and informational questions. Personnel also provide course- and topic-specific instructional programs to further critical thinking and lifelong learning skills.

Engineering Computer Services
Engineering Computer Services (ECS) provides information technology administration for curricular, administrative, and research computing at the College of Engineering. The college has three drop-in computer labs with 180 high-end Linux and Windows computer workstations, 24-seat and a 45-seat computer classrooms and labs, and a 400-seat virtual computer lab with graphics support that students can access from the internet. Numerous public domain applications and commercial engineering applications support the full range of engineering classes. Software is upgraded annually, and hardware is upgraded every four years. The college’s computer labs are open 24 hours a day, every day of the year.
Engineering Electronics Shop
The Engineering Electronics Shop (EES) is a full-service electronics facility that supports sales and service for the College of Engineering and the University. EES provides design, construction, repair, calibration, and preventive maintenance services for teaching and research laboratories. EES maintains more than 20,000 parts in stock, including electronic components, computer and office supplies. The shop has laser cutting and etching equipment, and 3-D printers. EES also maintains a large set of rental lockers for students.

Engineering Machine Shop
The Engineering Machine Shop (EMS) is a full-service, light manufacturing facility that supports curricular, research, and operational needs of the College of Engineering and the University. EMS provides professional design and fabrication services and gives students, staff, and faculty controlled access to a variety of manufacturing equipment. The shop has a high resolution 3-D scanner, commercial 3-D printers, a waterjet, a full wood shop, welding, and multi-axis CNC machines. EMS also supports College of Engineering clubs with its projects support facility.

College of Engineering Research Centers

Center for Bioinformatics and Computational Biology
The Center for Bioinformatics and Computational Biology (CBCB) is a multidisciplinary research center dedicated to applying high performance networking and computing to basic life science and applied biomedical research. With faculty and students representing more than 20 traditional disciplines, the CBCB has contributed to the understanding of inherited human diseases, including blinding eye disease, cancer, deafness, diabetes, autism, schizophrenia, hypertension, obesity, and heart disease. For almost 20 years, the CBCB has been at the cutting edge of high throughput molecular discovery and interpretation in transcriptomics, genomics, and proteomics. At the confluence of these efforts lies the current wavefront of personalized genomic medicine, to which the CBCB plays a central role in partnership with labs, centers, and institutes across the University’s Carver College of Medicine and basic science programs across campus. The CBCB also has been a nexus for industry start-ups and partnerships with numerous commercial enterprises. The center is jointly sponsored by the College of Engineering and the Carver College of Medicine.

Center for Computer-Aided Design
The Center for Computer-Aided Design (CCAD) focuses on modeling and simulation, and conducts basic and applied research in the following areas: flight testing and human performance (the Operator Performance Laboratory); human modeling and simulation (the Virtual Soldier Research Program); driving and transportation (the National Advanced Driving Simulator); advanced manufacturing technology and robotics; biomedical and biochemical research; and multidisciplinary research in the fields of machine learning, smart sensors, remote sensing, renewable energy, and modeling of environmental change.

Iowa Institute for Biomedical Imaging
The Iowa Institute for Biomedical Imaging (IIBI) conducts research in the following areas: medical imaging (CT, MR, OCT, PET, SPECT, ultrasound, multimodality imaging), medical image analysis and computer-aided diagnosis; cardiovascular image analysis (angiography-intravascular ultrasound data fusion, MR image analysis of congenital heart disease, coronary CT image analysis, early detection of cardiovascular disease); pulmonary image analysis (CT and MR image analysis of the lung); cell image analysis (cell tracking, shape analysis); virtual surgery planning (augmented reality for surgical planning), cancer-related assessment of tumor progression/regression, staging, general machine learning; and disease/treatment outcome prediction. The institute is sponsored by the College of Engineering and the Carver College of Medicine.

IIHR—Hydroscience & Engineering
IIHR—Hydroscience & Engineering is a world-renowned center with almost 100 years of education, research, and public service focusing on hydraulic engineering and fluid mechanics. Based in the C. Maxwell Stanley Hydraulics Laboratory, a five-story red brick building on the banks of the Iowa River, IIHR is a unit of the College of Engineering. IIHR students, faculty members, research engineers and scientists, and staff work together to understand and manage one of the world’s greatest resources—water. Students from around the world benefit from IIHR’s comprehensive multidisciplinary approach, which includes basic fluid mechanics, laboratory experimentation, and computational approaches.

IIHR activities include fluid dynamics (turbulent flows, vortex dynamics, ship hydrodynamics, biological fluid flow, atmospheric boundary layer, experimental and computational fluid dynamics); environmental hydraulics (hydraulics structures, river mechanics, hydraulic structures, fish passage, sediment management, heat disposal in water bodies and power productions, bioremediation of groundwater, computational hydraulics, water-quality monitoring); water and air resources (air pollution, hydroclimatology, hydrogeology, hydrology, hydrometeorology, remote sensing, water resources and basin-scale processes); environmental engineering and science (PCBs in the air and water, innovative ways of removing contaminants from the soil and water, ultra-fine particles of pollutants in the atmosphere, bioremediation strategies for persistent groundwater contaminants); and water sustainability (development of sound strategies and technological solutions to meet the challenges facing society’s growing need for water resources). In 2009, the Iowa Flood Center was founded at IIHR as the only academic center devoted solely to flood-related research and education.

The University of Iowa’s Water Sustainability Initiative (WSI) brought new interdisciplinary expertise to the institute in 2013 when the WSI faculty members (based in the Colleges of Liberal Arts and Sciences, Engineering, and Public Health) affiliated with IIHR. The Iowa Geological Survey joined IIHR in 2014, bringing new expertise in Iowa’s subsurface resources, groundwater modeling, innovative geophysical skills, and more.

Students gain hands-on experience through close cooperation with faculty and staff on research projects funded by industry, government, and other organizations.
The engineering course requirements for engineering majors are outlined in the respective Catalog sections. Each undergraduate program builds upon a core program (see the Bachelor of Science in Engineering in the Catalog). Not all engineering core courses listed below are required for each engineering major. Core program courses are intended for College of Engineering students. Undergraduate students in other disciplines who wish to register for core engineering courses should contact Engineering Student Services.

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### Core Engineering Courses

**ENGR:0000 Engineering Internship/Co-op** 0 s.h.
For engineering majors participating in the Cooperative Education and Internship Program and averaging 35-40 hours per week on assignment.

**ENGR:0002 Engineering Half-Time Internship** 0 s.h.
For engineering majors participating in the Cooperative Education and Internship Program and averaging 15-20 hours per week on assignment.

**ENGR:0004 Engineering Academic Internship** arr. Academic credit for engineering majors participating in the Cooperative Education and Internship Program. Requirements: for international students—F-1 or J-1 visa, engineering undergraduate standing, full-time internship offer letter in hand (at least 40 hours/week and one semester in length), internship approved by International Student and Scholar Services for F-1 Curricular Practical Training (CPT) or J-1 Academic Training (AT), concurrent registration in approved 3 s.h. distance education or evening course, and preapproval of internship by Engineering Professional Development; non-international students may be eligible on case-by-case basis.

**ENGR:0006 Engineering Global Internship/Co-op** 0 s.h.
For engineering majors participating in the Cooperative Education and Internship Program working on a global assignment.

**ENGR:1000 Engineering Success for First-Year Students** 1 s.h.
Introduction to engineering student life; electronic resources; keys to and skills for success; coping with adversity; selecting a major; advising; curriculum choices and career objectives; ethics; communication; internships and co-ops; job search skills.

**ENGR:1029 First-Year Seminar** arr.
Introduction to engineering fields of study; work closely with a faculty member or senior administrator; participation that eases the transition to college-level learning; cutting-edge research taking place in the College of Engineering.

**ENGR:1100 Introduction to Engineering Problem Solving** 3 s.h.
Development and demonstration of specific problem solving skills; directed project or case study involving actual engineering problems and their solutions.

**ENGR:1300 Introduction to Engineering Computing** 3 s.h.
Engineering problem solving using computers; introduction to digital computations; problem formulation using a procedural high-level language; structured, top-down program design methodology; debugging and testing; introduction to use of software libraries; examples from numerical analysis and contemporary applications in engineering. Corequisites: MATH:1550.

**ENGR:1550 FIRST Tech Challenge - Introduction to Engineering Problem Solving** 3 s.h.
Introduction to engineering problem solving and design; projects introduce students to common elements of engineering problem solving and design (e.g., application of organizing principles to describe engineered systems, economic analysis upon which to base decisions, technical presentation and analysis of data), and provides an opportunity for students to apply common elements of problem solving in the solution of engineering problems in context of a structured problem solving and design process. Taught in high schools by state certified teachers.

**ENGR:2110 Engineering Fundamentals I: Statics** 2-3 s.h.
Vector algebra, forces, couples, moments, resultants of force couple systems; friction, equilibrium analysis of particles and finite bodies, centroids; applications. Prerequisites: MATH:1550. Corequisites: MATH:1560 and PHYS:1611.

**ENGR:2120 Engineering Fundamentals II: Electrical Circuits** 3 s.h.
Kirchhoff’s laws and network theorems; analysis of DC circuits; first order transient response; sinusoidal steady-state analysis; elementary principles of circuit design; SPICE analysis of DC, AC, and transient circuits. Corequisites: MATH:2560.

**ENGR:2130 Engineering Fundamentals III: Thermodynamics** 3 s.h.
Basic elements of classical thermodynamics, including first and second laws, properties of pure materials, ideal gas law, reversibility and irreversibility, and Carnot cycle; control volume analysis of closed simple systems and open systems at steady state; engineering applications, including cycles; psychrometrics. Prerequisites: PHYS:1611 and CHEM:1110. Corequisites: MATH:1560.

**ENGR:2510 Fluid Mechanics** 4 s.h.
Fluid properties; hydrostatics; transfer of mass, momentum, and energy in control-volume and differential forms; dimensional analysis and similitude; laminar and turbulent flow in conduits; flow past bluff bodies and airfoils; engineering applications; experimental laboratories, computer simulation projects. Prerequisites: MATH:2560 and ENGR:2710. Corequisites: ENGR:2130.

**ENGR:2710 Dynamics** 3 s.h.
Vector calculus, Newton’s laws, 3-D motion of particles and multiparticle systems, 2-D motion of rigid bodies applications. Prerequisites: ENGR:2110 and MATH:1550.

**ENGR:2720 Materials Science** 3 s.h.
Concepts and examples of selection and applications of materials used by engineers; mechanical, electrical, and thermal properties that govern a material’s suitability for particular applications; lectures supplemented by laboratory experiments. Prerequisites: CHEM:1110. Corequisites: MATH:1550.
ENGR:2730 Computers in Engineering 2-3 s.h.
Advanced programming; good software engineering techniques including pseudocode and documentation; dynamic data structures, recursive programming, procedural and object-oriented computing, inheritance, and standard template library; C++. Prerequisites: ENGR:1300.

ENGR:2750 Mechanics of Deformable Bodies 3 s.h.
Elementary theory of deformable bodies, stress, strain; axial, transverse, bending, torsion, combined and buckling loads; deflection of beam. Prerequisites: ENGR:2110. Corequisites: MATH:2560.

ENGR:2760 Design for Manufacturing 3 s.h.
Fundamentals of design, engineering graphics, and manufacturing processing; computer graphics using Pro/ENGINEER for CAD and CAM; typical industrial processes, including casting, welding, machining, forming; laboratory exercises and projects. Corequisites: ENGR:2720.

ENGR:4000 Engineering Honors Seminar 1 s.h.
Completion of an approved project under the supervision of a faculty member. Requirements: engineering honors and junior or higher standing.

ENGR:4001 Leadership Seminar: Mediocrity is Not an Option 1 s.h.
Skills needed to gain competitive edge in professional world with understanding that mediocrity is not an option; importance of developing a career plan, power of networking, significance of soft skills, value of mentoring; participation in series of discussions and activities; deeper insight of strengths and weaknesses, how to enhance skills that employers desire, and become effective leaders in workplace; presentation by retired chief operating officer of a leading aerospace company.

ENGR:4003 Women in Science and Engineering Leadership Seminar 1 s.h.
WISE peer mentors develop practical mentoring and leadership skills while participating in a one-on-one relationship with a first-year UI student in a STEM major; peer mentors meet monthly with mentees, submit meeting reflection/evaluations, and attend three educational or social events hosted by WISE or another University entity during the semester.

ENGR:4005 Developing Cultural Intelligence for STEM Leadership 1 s.h.
How cultural values impact technological innovation; knowledge and strategies to develop skills for leadership in the global marketplace; activities include the Cultural Intelligence (CQ) assessment and mapping of cultural values and case studies for innovation; students use CQ dimensions to develop a plan to deepen CQ skills; exploration of culturally intelligent collaboration and problem solving in science, technology, engineering, and mathematics (STEM) fields; how to represent these skills in professional settings. Requirements: upper-level undergraduate or graduate standing.

ENGR:4010 Engineering Grand Challenges Program Fellow 0 s.h.
The Engineering Grand Challenges Program is designed to prepare tomorrow's engineering leaders to solve the grand challenges facing society during the next century; through completion of components of the program, students have the opportunity to engage in research relating to their selected grand challenge, explore interdisciplinary course work, gain an international perspective, engage in entrepreneurship, and give back to the community through service learning; for students who have been accepted as a fellow into the Engineering Grand Challenges Program and are working on completion of the program requirements. Requirements: acceptance to the Engineering Grand Challenges Program.

ENGR:4011 Engineering Grand Challenges Program Scholar 0 s.h.
The Engineering Grand Challenges Program is designed to prepare tomorrow's engineering leaders to solve the grand challenges facing society during the next century; through completion of components of the program, students have the opportunity to engage in research relating to their selected grand challenge, explore interdisciplinary course work, gain an international perspective, engage in entrepreneurship, and give back to the community through service learning; for students who have been accepted as a scholar to the Engineering Grand Challenges Program and are working on completion of the program requirements. Requirements: acceptance to the Engineering Grand Challenges Program.

ENGR:4012 Engineering Grand Challenges Program Final 0 s.h.
The Engineering Grand Challenges Program is designed to prepare tomorrow's engineering leaders to solve the grand challenges facing society during the next century; through completion of components of the program, students have the opportunity to engage in research relating to their selected grand challenge, explore interdisciplinary course work, gain an international perspective, engage in entrepreneurship, and give back to the community through service learning; for students who have been accepted to the Engineering Grand Challenges Program and are in the final semester of completing the program requirements. Requirements: acceptance to the Engineering Grand Challenges Program.

ENGR:7270 Engineering Ethics 1 s.h.
Introduction to practical issues associated with being a responsible scientist; topics in responsible conduct of research in engineering and the sciences using case studies, presentations, and discussions with visiting speakers; conforms to mandates set by the Office of the Vice President for Research and the Graduate College to train graduate students and postdoctoral scholars/fellows in responsible conduct of research. Requirements: first-year graduate standing in College of Engineering.

ENGR:7604 Engineering Ethics for Post Docs 0 s.h.
Introduction to practical issues associated with being a responsible scientist; topics in responsible conduct of research in engineering and the sciences using case studies, presentations, and discussions with visiting speakers; conforms to mandates set by the Office of the Vice President for Research and the Graduate College to train graduate students and postdoctoral scholars/fellows in responsible conduct of research. Requirements: new postdoctoral research scholar/fellow in College of Engineering.
Engineering and Information Technology Courses

**EIT:5120 Modern Automation and Control** 3 s.h.
Study of sensor, motors, control, process automation, and internet of things (IoT).

**EIT:5135 Modern Information Systems** 3 s.h.
Introduction to enterprise information systems; RESTful service model, cloud service models, data storage models, big data considerations, network basics, security and privacy considerations; blockchain technology and its applications.

**EIT:5150 Applied Artificial Intelligence** 3 s.h.
Artificial Intelligence (AI), search and logic, data science and analysis, advanced machine learning and deep learning, digital manufacturing and design, signal processing and fault diagnosis, AI robotics and computer vision, and applications in engineering.

**EIT:5155 Cyber-Physical Systems** 3 s.h.
Introduction to modern "smart" systems providing intelligent monitoring, control, and coordination of societal, environmental, and business infrastructure; layered architecture for, relevant applications of, and projects involving conceptual design of cyber-physical systems.

**EIT:5211 Machine Learning and Scientific Computing in Engineering** 3 s.h.
Numerical methods in scientific computing; root problems and optimization; linear algebraic equations; eigenvalue problems; numerical differentiation and integration; interpolation and curve fitting; initial value and boundary value problems; machine learning in regression, classification, and clustering problems; Python programming and scikit-learn packages.

**EIT:5216 Manufacturing Process and Modeling** 3 s.h.
Fundamental science, modeling, and simulation technologies in materials processing; essential knowledge in automation and control of manufacturing systems; material removal processes, forming, microfabrication, and nontraditional material processes; finite element modeling/simulation of material processes; automation and control of manufacturing systems and processes.

**EIT:5220 Advanced Control Engineering** 3 s.h.
State-space representation of linear systems, equilibrium points, linearization, controllability, observability, stability, state feedback control, linear observer design, and separation principle.

**EIT:5224 Mechanical Design and Realization** 3 s.h.
Solid modeling, assemblies, drawings, geometric dimensioning and tolerancing, and basic engineering design process; use of analysis tools (e.g., Finite Element Analysis), fatigue and durability, optimization software.

**EIT:5240 Kinematics of Modern Robotics** 3 s.h.
Robotics motion, configuration space, and path planning.

**EIT:5298 Mechanical Component Durability and Integrity Analysis** 3 s.h.
System and component design, stress analysis, static failure, fatigue, fracture mechanics, vibration, materials science, and product life cycle.

**EIT:5352 Modern Database Systems** 3 s.h.
Introduction to contemporary database architectures: relational, key-value, document store, and graph-based; relative strengths and weaknesses of database architectures; enterprise scalability issues; data aggregation and visualization; project work involving use of modern database systems (e.g., MySQL, Redis, MongoDB, Neo4j).

**EIT:5353 Big Data and Machine Learning** 3 s.h.
Storage, management, and analysis of very large data sets; distributed file systems and object stores; MapReduce framework for processing large data sets; machine learning techniques; classification and clustering; pattern recognition; projects involving big data and machine learning frameworks (e.g., Apache Hadoop).

**EIT:5380 Software Engineering Methods, Tools, and Frameworks** 3 s.h.
Modern agile software development practices for cloud and web-based applications using state-of-the-art software engineering languages, tools, and technologies; software as a service (SaaS) architecture; software testing; introduction to enterprise application development frameworks; team-based project.

**EIT:5381 Enterprise Software Engineering** 3 s.h.
Modern DevOps practices and toolchains for enterprise information systems; scalable architecture; cloud services (e.g., SaaS, PaaS, LaaS); load balancing/autoscaling; identity management and security; performance monitoring and tuning; continuous integration and hot deployment.

**EIT:5382 Human-Computer Interaction Design and User Experience** 3 s.h.
Principles and guidelines for design and evaluation of human-computer interactions (HCI); design methodologies (e.g., participatory design, low- and high-fidelity prototyping); user interface technologies (e.g., input and output devices, interaction styles); quantitative and qualitative evaluation of user interfaces (e.g., expert reviews, usability testing).