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GUIDELINES FOR M.S.E. DEGREE IN CIVIL ENGINEERING: CONCENTRATION IN INTELLIGENT SYSTEMS ENGINEERING

Introduction

It is becoming increasingly common for civil infrastructures to incorporate intelligent and autonomous subsystems. Examples include decision systems, feedback control, and advanced artificial intelligence, as well as sensor and actuation networks. These technologies can be utilized to make infrastructures more responsive to uncertain and dynamically-changing environments and loads, thus enhancing their resilience and reliability. They can also be used to enable real-time, automated adaptation and reconfiguration of infrastructures, for the purpose of enhancing their efficiency and sustainability. Cultivation of an expertise in this area requires exposure to many concepts from Systems Engineering (e.g., dynamical systems, control theory, sensing and signal processing, and optimization theory), which historically have not been part of a traditional Civil Engineering curriculum. CE Students who specialize in Intelligent Systems Engineering pursue a rigorous curriculum of systems engineering courses. However, they also complete coursework a practice-oriented sub-discipline within Civil Engineering (e.g., Structures, Hydrology, Transportation, etc.) and must conduct a research project in this area, which applies concepts and technologies from systems engineering. Recent research project topics include:

- Autonomous sensing systems to monitor evaporation in the Great Lakes
- Design of vibration energy harvesters for wireless structural monitoring applications
- Probabilistic optimization of damage inspection scheduling for offshore wind turbines
- Automated sensing and control of building environments
- Soil safety inspection using unmanned aerial vehicles, with application to natural disaster monitoring
- Optimal feedback control of semi-active damping devices for seismically-excited structures
- Real-time control of urban water networks

General

An applicant for the M.S.E. degree must present the equivalent of an undergraduate civil engineering program as preparation. If the applicant's undergraduate degree is not in civil engineering, then some undergraduate prerequisite courses may be required. See the CEE Department Guidelines for additional information.

Coursework

A student pursuing an M.S.E. degree in Civil Engineering with a concentration in Intelligent Systems Engineering must complete at least 30 credit hours of acceptable graduate work. A thesis is not required for the M.S.E. degree. In satisfying the credit hour requirement, the following requirements must be satisfied:

- To be defined as proficient in infrastructure systems, a student must elect three of the four following core systems courses to constitute the system theory/engineering core:
  - CEE572: Dynamics Infrastructure Systems
  - CEE575: Sensing for Civil Infrastructure Systems
  - CEE571: Linear System Theory
  - CEE501: Infrastructure Systems Optimization[1] –OR- IOE510: Linear Programing
- The student is required to elect two more course from the following "core plus" set of courses to further their foundation in system theory/engineering:
  - CEE574: Materials Selection for Sustainable Design
  - CEE576: Stochastic Systems
  - CEE573: Data Analysis in Civil and Environmental Engineering
  - EECS460: Control Systems Analysis and Design
  - CEE501: Intelligent Transportation Systems [to be introduced by Henry Liu]
- With the guidance and approval of a systems-area faculty member, a student must plan their program of study so as to establish a more advanced level of proficiency in a topic of their choice (*e.g.*, materials, structures, hydraulics, *etc*.) pertaining to infrastructure systems.
- At least 18 of the credit hours must be in Civil and Environmental Engineering (CEE) courses.
- A student must satisfactorily complete at least one course (cognate course) with a minimum of 4 credit

[1] To be given a permanent number (in process)

hours in a department other than Civil and Environmental Engineering. Courses cross-listed with CEE courses do not qualify as cognates. A core course is suitable for use to satisfy this requirement.

- A student must satisfactorily complete at least one course (math course) with a minimum of 3 credits in a course that provides an extensive mathematical foundation. While a course from the Mathematics Department is preferred, CEE571, IOE510, and EECS460 may count as satisfying this requirement.
- Students are required to take CEE 679, a 3-credit course in which they conduct a project which integrates systems engineering with the specialization study track the student selected in CEE. Besides this course, no other credit hours in directed studies, seminars or research (including credit hours received for CEE 910 and 950) can be counted toward the 30-credit requirement.
- No more than 12 credit hours at the 400 level listed in the bulletin of the Rackham School of Graduate Studies are acceptable. Of these 12 hours, a maximum of 9 hours can be in CEE courses.
- SUGS students with undergraduate specialization in any area of CEE may pursue an M.S.E. degree in Civil and Environmental Engineering with a concentration in Intelligent Systems. SUGS students are permitted to double count up to 6 credit hours.
- A maximum of 6 graduate level semester hours (with a grade of B or better) can be transferred from other institutions approved by Rackham.
- Table 1 provides students with guidance on courses (both CEE and cognate courses) pertinent to the concentration in Intelligent Infrastructure Systems.

Grades

The grading system used for graduate studies is based on the following 9-point scale:

A+ = 4.3; A = 4.0; A- = 3.7; B+ = 3.3; B = 3; B- = 2.7; C+ = 2.3; C = 2; C- = 1.7

A minimum cumulative graduate grade point average (GPA) of 3 on this 4.0-point scale is required for all graduate courses taken for credit and applied toward the Master's Degree.

Diploma

To be considered for a master's degree diploma, a student must submit a formal application to the Office of Graduate Academic Records of the Graduate School. The deadline for the Graduate School to receive the degree application form is four weeks after the first day of classes in a full term and one week after the first day of classes in a half term. These dates can usually be found on the Rackham Graduate School web site (http://www.rackham.umich.edu/).

Additional Information:

For additional information on M.S.E. degree requirements, see the *Graduate Student Handbook* (prepared by the Horace H. Rackham School of Graduate Studies) and the CEE Department Guidelines. The *Graduate Student Handbook* is available on the World Wide Web at http://www.rackham.umich.edu/.

Table 1: Example Course Sequences for ISE Students to Follow:

Degree Req.	Structures	Hydraulics	Sustainability	Transportation
Systems Core (3 courses)	CEE571: Linear Systems	CEE571: Linear Systems	CEE 501: Infrastructure Sys Optimization	CEE 501[2]: Infrastructure Sys Optimization
	CEE572: Dynamics Infrastructure Systems	CEE572: Dynamics Infrastructure Systems	CEE572: Dynamics Infrastructure Systems	CEE571: Linear Systems
	CEE575: Sensing for Civil Infrastructure	CEE575: Sensing for Civil Infrastructure	CEE575: Sensing for Civil Infrastructure	CEE575: Sensing for Civil Infrastructure
Core Plus (2 course)	CEE576: Stochastic Systems	CEE573: Data Analysis in Civil and Env. Eng.	CEE574: Materials Selection for Sustainable Design	CEE501[3]: Intelligent Transportation Systems
	EECS460: Control Systems Analysis and Design	EECS460: Control Systems Analysis and Design	CEE573: Data Analysis in Civil and Env. Eng.	EECS460: Control Systems Analysis and Design
Concentration Electives	CEE511: Structural Dynamics	CEE521: Flow in Open Channels	CEE 650: Advanced FRC for Sustainable Infrastructure	ME548 - Applied Nonlinear Dynamics
	CEE611: Earthquake Engineering	CEE 520: Physical Processes of Land-Surface Hydrology	CEE510: FEM in Solid & Structural Mech.	UP572: Transportation and Land Use Planning
	CEE510: FEM in Solid & Structural Mech.	CEE 526: Design of Hydraulic Systems	CEE586: Industrial Ecology	CEE576: Stochastic Systems
	CEE 512: Nonlinear Analysis of Structures	NRE 501: Urban Stormwater: Science, Design, and Management	NRE574: Sustainable Energy Systems	NRE501: Urban Sustainability
Capstone Course	CEE679: Infrast. Systems Project	CEE679: Infrast. Systems Project	CEE679: Infrast. Systems Project	CEE679: Infrast. Systems Project

[2] To be renumbered when first introduced (anticipate Fall 2015)
[3] To be named when first introduced in 2015

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Concentration in Intelligent Systems Engineering:
WORKSHEET

STEP 1: Identify Specialization Area of CEE:
Select your area of disciplinary specialization.

□ Structures □ Materials □ Hydraulics □ Geotechnical
□ Construction □ Environmental □ Transportation

STEP 2: Core Systems Courses:
Please select courses taken or to be taken (select 3).

Core Course	Term Taken	CEE Credits	Non-CEE Credits*
CEE572 Dynamic Infrastructure Systems			
CEE575 Sensing for Civil Infrastructure			
CEE571 Linear System Theory			
CEE501: Infrastructure Systems Optimization (or IOE510)			
	TOTAL		

STEP 3: Core Plus System Courses:
Please select courses taken or to be taken (select 2).

Core Course	Term Taken	CEE Credits	Non-CEE Credits*
CEE574: Materials Selection for Sustainable Design			
CEE576: Stochastic Systems			
CEE573: Data Analysis in Civil and Env. Engineering			
EECS460: Control Systems Analysis and Design			
CEE501: Transportation Course (To Be Introduced in 2015)			
	TOTAL		

STEP 3: Other Courses:
Please identify other courses taken. Directed studies, seminar or independent research credits are not acceptable to satisfy course requirements.

Non-core Course	400-Level (Yes/No)	Term Taken	CEE Credits	Non-CEE Credits*
		TOTAL		

STEP 4: Research Project:
Please provide details on your research project.

Research Project Title	Term Taken	CEE Credits	Non-CEE Credits*
CEE679 (Title: _____)			
	TOTAL		

STEP 5: Cognate Requirements:

Check to ensure you met the math and cognate requirements:

Cognate Course	Math Course

STEP 6: Program Requirements:

Check to ensure all other program requirements have been met.

Requirement	Credits	Limit
Total Number of Credits Taken		$\geq$ 30
Number of CEE Credits Taken		$\geq$ 18
Total Number of 400-Level Credits		$\leq$ 12
Total Number of 400-Level Credits in CEE		$\leq$ 9