THE UNIVERISTY OF MICHIGAN
COLLEGE OF ENGINEERING
CURRICULUM COMMITTEE

November 19, 2013

AGENDA

1. **Minutes of past meetings update**

2. **Course Approval form:**
   NEW: ENGR 345, effective WT 2014 – page 1

3. **Proposal for New Degree by ISD (Division of Integrative Systems and Design): -- page 8**
   Master of Engineering in Systems Engineering and Design
   Presented by Prof. Bogdan Epureanu

THE UNIVERSITY OF MICHIGAN -- COLLEGE OF ENGINEERING
Course Approval Request
College Curriculum Committee, 1420 Lurie Engineering Center Building

Form Number: 2440

Date: 10/28/2013

Effective Term: Winter 2014

Course Offer Freq: ☒ Indefinitely ☐ One term only

Action Requested
- ◉ New Course
- ○ Modification of Existing Course
- ○ Deletion of Course

Complete the following sections:
New Courses - B & C completely
Modifications - A modified information, B & C completely
Deletions - A & C completely

A. CURRENT LISTING

Home Department | Course Number

☐ Cross Listed Course Information

☐ Course Title

TITLE ABBREVIATION — Time Sched Max = 19 Spaces; Transcript Max = 20 Spaces

☐ Course Description

PROGRAM OUTCOMES: ☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ k

Degree Requirements: ○ Degree Requirement ○ Free Elective ○ Other ○ Core Course ○ Tech Elective

☐ Prereq: ○ Enforced ○ Advised

☐ Credit Restrictions

☐ Level of Credit: ☐ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☐ All Credit types ☐ Rckhm Grad w/add'l Work

Credit Hours: Min ___ Max ___

Contact Hrs/Wk ___ Number of Wks ___

B. REQUESTED LISTING

Home Department: ENGR Engineering

Course Number: 345

Cross Listed Course Information

Course Title: Introduction to Design Processes

TITLE ABBREVIATION — Time Sched Max = 19 Spaces; Transcript Max = 20 Spaces: Intro to Design Proc

Course Description for Official Publication (Max = 50 words)

Successful strategies experts use to achieve design success, and application of those strategies in real-life design situations.

PROGRAM OUTCOMES: ☐ a ☐ b ☒ c ☒ d ☒ e ☐ f ☐ g ☒ h ☐ i ☐ j ☒ k

Degree Requirements: ○ Degree Requirement ○ Free Elective ○ Other ○ Core Course ○ Tech Elective

Prereq: Permission of instructor
◉ Enforced ○ Advised

Credit Restrictions

Level of Credit: ☒ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☐ All Credit types ☐ Rckhm Grad w/add'l Work

Credit Hours: Min 2.0 Max

Contact Hrs/Wk 2.0

Number of Wks 14

Repeatability (Indi Research, Dir. Study, Dissertation: Is this course repeatable? ○ Yes ◉ No Max Hours? Max Times? Can it be repeated in the same term? ○ Yes ○ No

C.

☐ Class Type(s): ☐ Lec ☒ Sem ☐ Dis ☐ Other ___ ☐ Rec ☐ Lab ☐ Ind

Graded Section: ☐ Lec ☒ Sem ☐ Dis ☐ Other ___ ☐ Rec ☐ Lab ☐ Ind

Grading: ☒ A-E ☐ CR/NC ☐ P/F ☐ S/U

Location: ☒ Ann Arbor ☐ Biological Station ☐ Camp Davis ☐ Extension

Course Is Y Graded ☐

Cognizant Faculty Member: Shanna Daly [signature]
Title: Asst. Res. Sci

Grad Course: Attach nomination if Cognizant Faculty is not a regular graduate faculty

Submitted By: ☐ Home Dept. ☐ Cross-listed Dept.

Approval Info	Approved by Name	Approved Date
☐ Curriculum Comm.		
☐ Faculty		
☐ Cross listed Unit 1		
☐ Cross listed Unit 2		

	Department Chair Name	Chair Signature
Home Dept.	Lorelle Meadows	[signature]
Cross-listed Dept(s).		

Form Number

2440

SUPPORTING STATEMENT

Introduction to Design Processes provides students across engineering disciplines (and beyond) an opportunity to learn the design strategies of experts without being invested in the outcome of a particular design project. The course focus is on strategies rather than a design artifact, so students can invest in learning the strategy and why the strategy is important. Additionally, students get to practice the strategy on different design cases, some of which may be outside of their normal discipline, facilitating interdisciplinary thinking. Students can take their skills with them to their senior design courses as well as their professional practice. This course provides an opportunity for students to focus on design between the major design classes of freshman and senior years.

Are any special resources or facilities required for this course? ☐ Yes ☐ No

Detail the Special requirements

MICHIGAN ENGINEERING

UNIVERSITY of MICHIGAN • COLLEGE of ENGINEERING

ENGR 390.007 Introduction to Design Processes

Winter 2013

Tuesdays, 3:00 p.m. – 5:00 p.m.

GFL (Formerly known as EPB) 107

Shanna Daly, Ph.D.	srdaly@umich.edu	210 GFL	734.763.0822
Office Hours:	Wednesdays 12-1	210 GFL or by Appointment	

Course Description: This course will examine processes of design, focusing on the front-end of design, including opportunity discovery, problem definition, developing mechanisms to gather data from users and other stakeholders, translating user data into design requirements, creating innovative solutions during concept generation, and evaluating possible solutions. The strategies taught in the course are based on successful methods experts use to achieve design success, and are supplemented by readings on practice and research demonstrating their success. Coursework will focus on applications in various real-life design situations.

This is a great way to prepare for your future design and entrepreneurship projects, capstone classes, and career!

A joint offering of the Center for Entrepreneurship, Multidisciplinary Design Program, and the Design Science Program, this 2-credit course may be one of the most beneficial design courses of your academic career. The course is designed to augment current offerings across departments in the College of Engineering.

Class Policies: All students are expected to attend every session during the term. If you cannot make a seminar for a good reason, then you must contact Dr. Daly at least 24 hours in advance of the seminar via email (address above) explaining the reason for the absence.

Students are expected to ethically and professionally respect fellow classmates, the instructor, and guest lecturers. Hence:

1. Late entries and early departures from class are a sign of disrespect to your fellow classmates and your instructor.

2. Laptops are typically not necessary during class. Laptops, cellphones, and any other electronic files must be turned off and put away throughout the class unless otherwise indicated.

ASSIGNMENTS: Students will be responsible for completing the following types of assignments:

Weekly Homework: Students will be given a homework assignment each Tuesday to be completed by the following Tuesday and posted on cTools. The assignments include: "in the field" activities in which students practice the design strategies from class, readings and reading responses, and practice problems based on case studies. Homework assignments will also include short video assignments that will prepare students for the final project.

** Homework file naming convention: Last Name_Hmk#

In-Class Participation: Each week, activities and exercises will be included in class. Students are expected to participate in these exercises. On occasion, students will be required to give in class presentations to share their findings or results from a class exercise.

Final Project: Students will be responsible for developing a short video (10 minutes max) in conjunction with a team highlighting key strategies in design based on the material presented during the course. The final project will be viewed the final class of the semester.

EXAM: There will be one exam toward the end of the semester taken in class.

GRADING: Grades in this class will be based on the following:

Class Attendance and Participation	10%
Weekly Homework	60%
Exam	20%
Final Project	10%

TENTATIVE SCHEDULE:

Session	Date	Topic
1	1/15/13	What does it mean to be a reflective design practitioner? What is design?
2	1/22/13	Identifying Design Opportunities, Defining Problems, and Gathering Information
3	1/29/13	Ethnography and Observations
4	2/5/13	Interviews and Focus Groups
5	2/12/13	Synthesizing Data and Prioritizing Needs
6	2/19/13	Personas and Surveys
7	2/26/13	Design Requirements and Sustainable Design
	3/5/13	No Class- WINTER BREAK
8	3/12/13	Concept Generation and Creative Thinking
9	3/19/13	Ideation Tools and Strategies
10	3/26/13	Design Representations: Sketching, Prototyping, and Storyboarding
11	4/2/13	Feedback & Critique, Testing, and Iteration
12	4/9/12	Concept Selection and Realization, Demonstrating Value, Communicating Outcomes
13	4/16/12	Exam
14	4/23/12	Video presentations

University of Michigan
Office of the Registrar - Evaluations
ro.umich.edu/evals/

Winter 2012 Final
15 students responded out of the total enrolled 30

Instructor with Comments Report

2012-04-06 - 2012-04-18 Report ID: MSR04734

Instructor: Daly,Shanna
ENGR 490 008

		Responses from your Students**							Other Users of This Item* University Wide			School/College		
		5 SA	4 A	3 N	2 D	1 SD	NA	Your Median	75% Above	50% Above	25% Above	75% Above	50% Above	25% Above
1	Overall, this was an excellent course.	13	2	0	0	0	0	4.92	3.92	4.27	4.70	3.86	4.10	4.50
2	Overall, the instructor was an excellent teacher.	12	3	0	0	0	0	4.88	4.13	4.60	4.85	4.01	4.45	4.71
3	I learned a great deal from this course.	13	2	0	0	0	0	4.92	4.00	4.33	4.70	4.00	4.19	4.57
4	I had a strong desire to take this course.	12	3	0	0	0	0	4.88	3.63	4.13	4.60	3.67	4.00	4.39
140	I deepened my interest in the subject matter of this course.	12	3	0	0	0	0	4.88	3.83	4.20	4.63			
201	The instructor gave clear explanations.	12	3	0	0	0	0	4.88	4.08	4.50	4.78			
203	The instructor stressed important points in lectures/discussions.	13	2	0	0	0	0	4.92	4.11	4.50	4.78			
207	The instructor appeared to have a thorough knowledge of the subject.	13	2	0	0	0	0	4.92	4.50	4.79	4.92			
216	The instructor acknowledged all questions insofar as possible.	12	3	0	0	0	0	4.88	4.23	4.59	4.83			
218	The instructor encouraged constructive criticism.	12	3	0	0	0	0	4.88	4.13	4.53	4.79			
228	The instructor followed an outline closely.	8	6	0	0	0	1	4.63	4.10	4.50	4.79			
229	The instructor used class time well.	12	3	0	0	0	0	4.88	4.10	4.50	4.75			
230	The instructor seemed well prepared for each class.	13	2	0	0	0	0	4.92	4.30	4.67	4.86			
232	Work requirements and grading system were clear from the beginning.	8	5	0	1	0	0	4.63	4.00	4.33	4.67			
239	The amount of work required was appropriate for the credit received.	4	5	1	4	1	0	3.80	3.94	4.20	4.50			
240	The amount of material covered in the course was reasonable.	7	8	0	0	0	0	4.44	4.00	4.25	4.58			
1259	The project was a valuable part of this course.	8	5	2	0	0	0	4.56	n/a	n/a	n/a			
1260	Project assignments seemed carefully chosen.	7	8	0	0	0	0	4.44	n/a	n/a	n/a			
1261	Project assignments required a reasonable amount of time and effort.	6	8	0	1	0	0	4.31	n/a	n/a	n/a			
1262	Project assignments were relevant to what was presented in class.	8	7	0	0	0	0	4.56	n/a	n/a	n/a			
340	The textbook made a valuable contribution to the course.	1	1	1	0	0	12	4.00	3.38	4.00	4.43			
356	Examinations covered the important aspects of the course.	8	4	1	0	0	2	4.69	4.00	4.30	4.67			
365	Grades were assigned fairly and impartially.	8	6	1	0	0	0	4.56	4.00	4.25	4.62			
366	The grading system was clearly explained.	6	7	2	0	0	0	4.29	4.00	4.33	4.67			
972	The instructor uses techniques to foster class participation.	12	2	0	0	0	0	4.92	n/a	n/a	n/a			
19	I increased my ability to design a system, component, or process.	12	3	0	0	0	0	4.88	3.93	4.21	4.50			
20	My confidence in my design abilities increased because of this course.	13	2	0	0	0	0	4.92	3.92	4.25	4.64			
41	I would recommend this course to a friend.	11	4	0	0	0	0	4.82	4.50	4.71	4.80			
40	I would take another course with this instructor.	12	2	1	0	0	0	4.88	n/a	n/a	n/a			

Written Comments

900 Comment on the quality of instruction in this course.

Student 1
The way this course was structured was incredibly helpful and efficient. All lectures and other materials were posted to Ctools and available for the students.

University of Michigan
Office of the Registrar - Evaluations
ro.umich.edu/evals/

Winter 2013 Final
12 students responded out of the total enrolled 28

Instructor with Comments Report

2013-04-11 - 2013-04-24 Report ID: MSR04734

Instructor: Daly,Shanna
ENGR 390 007

		Responses from your Students**							Other Users of This Item* University Wide			School/College		
		5 SA	4 A	3 N	2 D	1 SD	NA	Your Median	75% Above	50% Above	25% Above	75% Above	50% Above	25% Above
1	Overall, this was an excellent course.	7	4	1	0	0	0	4.64	3.90	4.29	4.69	3.57	4.09	4.42
2	Overall, the instructor was an excellent teacher.	11	1	0	0	0	0	4.95	4.14	4.60	4.85	3.86	4.33	4.68
3	I learned a great deal from this course.	7	3	2	0	0	0	4.64	4.00	4.33	4.70	3.88	4.25	4.58
4	I had a strong desire to take this course.	5	6	0	1	0	0	4.33	3.67	4.13	4.61	3.57	4.00	4.50
140	I deepened my interest in the subject matter of this course.	6	5	0	1	0	0	4.50	3.83	4.24	4.63			
201	The instructor gave clear explanations.	11	1	0	0	0	0	4.95	4.00	4.50	4.75			
203	The instructor stressed important points in lectures/discussions.	10	2	0	0	0	0	4.90	4.17	4.50	4.79			
207	The instructor appeared to have a thorough knowledge of the subject.	12	0	0	0	0	0	5.00	4.50	4.79	4.92			
216	The instructor acknowledged all questions insofar as possible.	12	0	0	0	0	0	5.00	4.29	4.64	4.83			
218	The instructor encouraged constructive criticism.	9	2	1	0	0	0	4.83	4.17	4.58	4.83			
228	The instructor followed an outline closely.	10	1	1	0	0	0	4.90	4.01	4.46	4.67			
229	The instructor used class time well.	11	1	0	0	0	0	4.95	4.13	4.54	4.78			
230	The instructor seemed well prepared for each class.	12	0	0	0	0	0	5.00	4.31	4.68	4.86			
232	Work requirements and grading system were clear from the beginning.	7	5	0	0	0	0	4.64	4.00	4.38	4.67			
239	The amount of work required was appropriate for the credit received.	2	6	2	2	0	0	3.83	3.91	4.18	4.52			
240	The amount of material covered in the course was reasonable.	6	5	0	0	0	0	4.58	4.07	4.29	4.57			
318	Writing assignments seemed carefully chosen.	6	6	0	0	0	0	4.50	3.90	4.20	4.50			
331	The laboratory was a valuable part of this course.	3	0	0	0	0	9	5.00	4.00	4.25	4.67			
332	Laboratory assignments seemed carefully chosen.	2	1	0	0	0	9	4.75	3.88	4.08	4.38			
336	Laboratory assignments required a reasonable amount of time and effort.	2	0	1	0	0	9	4.75	3.88	4.07	4.25			
337	Laboratory assignments were relevant to what was presented in class.	3	0	0	0	0	9	5.00	4.00	4.29	4.64			
340	The textbook made a valuable contribution to the course.	1	0	0	0	0	11	5.00	3.40	4.00	4.50			
356	Examinations covered the important aspects of the course.	4	6	1	0	0	1	4.25	4.07	4.32	4.63			
365	Grades were assigned fairly and impartially.	9	3	0	0	0	0	4.83	4.00	4.33	4.63			
366	The grading system was clearly explained.	8	4	0	0	0	0	4.75	4.06	4.40	4.67			

Written Comments

900 Comment on the quality of instruction in this course.

Student 1
NA

Student 2
I think the opportunity for students to speak and discuss was an important part the learning experience for me.

Student 3
NA

MASTER OF ENGINEERING IN SYSTEMS ENGINEERING AND DESIGN

Draft 3.3
November 15, 2013

Proposal for a new degree to be awarded by the
Division of Integrative Systems and Design (ISD)
College of Engineering
The University of Michigan
Ann Arbor

Contacts
Panos Y. Papalambros, ISD Chair
Bogdan Epureanu, Degree Program Chair Designate

Program Working Group (PWG) Members
Carlos Cesnik, Professor, Aerospace Engineering
Bogdan Epureanu, Professor, Mechanical Engineering (PWG Chair)
John Foster, Associate Professor, Nuclear Engineering and Radiological Sciences
David Gorsich, Chief Scientist, TARDEC, US Army
Jerry Lynch, Associate Professor, Civil and Environmental Engineering
Marios Papaefthymiou, Professor, Chair of Computer Science and Engineering
Demos Teneketzis, Professor, Electrical Engineering and Computer Science
Donald Winter, Professor of Practice, Naval Architecture and Marine Engineering

Summary
This document describes a proposed Master of Engineering in Systems Engineering and Design (MEng SEND) program. SEND is a new graduate degree program to be awarded by the College of Engineering at the University of Michigan (UM), Ann Arbor, and administered by the Division of Integrative Systems and Design (ISD).

Section 1 presents the background and process that led to the development of this proposal, and the Master of Engineering (MEng) template. Section 2 provides details of the proposed new Masters of Engineering degree program in Systems Engineering and Design, including the degree objectives and requirements. Appendix 1 provides the course listing. Appendix 2 provides benchmarking information.

1. Introduction

<u>1.1. Background</u>

Over the past two years, there have been extensive deliberations among the College of Engineering (CoE) leadership and faculty, including professors of practice, and members of the wider community outside UM about the importance of systems thinking for our students. There is a broader context nationally about the need to approach the design of large complex engineered systems in a more comprehensive manner (see, e.g., Bloebaum and MacGowan 2011). Today's technology frontiers are defined by challenges in energy, the environment, vulnerability to human and natural threats, health care, manufacturing and production - all problems that involve complex engineered systems. Addressing these problems requires skills in systems engineering and design, integrating systems thinking and design thinking to pose, as well as to answer complex questions, to deal with uncertainty, and to appreciate the social and human aspects of complex engineered systems design processes. The goal of the proposed degree is to equip the students with such skills.

> *Systems engineering is defined as an interdisciplinary field of engineering that focuses on how to design and manage complex engineering projects over their life cycles. Issues such as reliability, logistics, coordination of different teams (requirements management), evaluation measurements, and other disciplines become more difficult when dealing with large, complex projects. Systems engineering deals with work-processes, optimization methods, and risk management tools in such projects. It overlaps technical and human-centered disciplines such as control engineering, industrial engineering, organizational studies, and project management. Systems Engineering ensures that all likely aspects of a project or system are considered, and integrated into a whole* (Wikipedia, accessed 11/12/2013).

At UM, there is general agreement that an understanding of engineering systems is a critical skill that should augment disciplinary skills. For example, engineers able to pose questions relevant to a specific product or system and to deal with partial and statistical information (rather than just answering already existing questions and using deterministic, precise information) are in high demand in industry (e.g., Bijker, Parke-Hughes, and Pinch 2012). The CoE Departments are recognized for their excellence in their respective disciplines, both at national rankings and through alumni surveys. Our graduates have stressed the value of learning the fundamentals of their disciplines, but they also express a desire for further appreciation that modern engineered systems require a multidisciplinary perspective and ability to innovate that close the gap between systems analysis and creative synthesis. The former tends to be the domain of systems engineering, while the latter the domain of design. The proposed degree aims to couple these two inherently interdisciplinary domains and emphasize the focus of systems engineering on design.

In the development of complex systems, tradeoff decisions among various forms of functionality must be made. All too often, this becomes an issue of trading off not just hardware vs. software, but hardware vs. software vs. human operators. Note, for example, the efforts to provide driver assists in vehicles such as adaptive cruise control, auto braking, lane drift control. These challenges apply broadly. Note, for example, the Aseana Airlines crash in San Francisco and the UPS aircraft that crashed in Birmingham AL, both apparently due to pilot dependency on instrument landing capabilities that were not available on those occasions. Thus, inclusion of human factors is an important element of a systems program. Furthermore, the interaction among the humans themselves during system development and deployment is also important, pointing to the need for exposure to organizational and social science thinking.

A good systems engineer must combine depth in at least one discipline with experience and appreciation for the other disciplines represented in the system. Acquiring such skill sets typically require many years of practical experience in diverse roles. While an academic education cannot replace such experience, there are individuals among our prospective students who have the talent and interest to develop such skills relatively quickly, or have acquired adequate experience to deeply inform further academic education in systems and design. In all such cases, an appropriate educational program will be highly beneficial to augment the obvious value of practical experience.

A well-documented approach to develop bridging skills across disciplines is the use of teams. Teaming helps students to learn how to integrate their knowledge within a system, but may not always provide a sufficiently wide variety of systems examples. A practicum developed as part of the program of study in conjunction with participating sponsoring organization can address such needs. For example, defense agencies and their prime contractors can provide many opportunities for an effective guided practicum. While a chief systems engineer or senior system architect may indeed evolve after decades of experience, there are many other positions in an organization where understanding of systems engineering methods is necessary in order to assist the chief engineer, for example through preparation of requirements or risk analysis. This type of experience can be facilitated through the practicum.

The need of disciplinary knowledge deployment in complex systems is well understood in medicine. Medical residency programs address exactly this need by enhancing intuitive skills and by repetitive deployment of discipline-specific knowledge. Medical residency programs typically require a specialist to interact with many cases and learn how to deploy their discipline knowledge effectively. For example, medical residents, under the supervision of practicing physicians and researchers, study the heart (or cardiovascular system) of each patient and deploy their knowledge of cardiology to the diagnosis and treatment plan. This is fundamentally distinct from teamwork used in engineering where there is a single case and many disciplines. The envisioned practicum is much closer to the residency concept than a traditional internship.

The current paradigm where students acquire knowledge now "to use it later" is increasingly challenged by the fast-pace technology advancements. The increased level of information connectivity allows one to obtain just-in-time education quite easily. Students with good disciplinary knowledge can benefit by a program where learning how to deploy that knowledge is delivered at the time it is required. The proposed program contains a component of just-in-time education.

1.2. Master of Engineering Degree

The Master of Engineering (M.Eng.) degree is available to all College of Engineering (CoE) Departments and Programs that wish to develop and award such a degree. This degree is intended to be more professional practice oriented terminal degree, when compared to Master of Science in Engineering (MSE) degree that might lead to further doctoral studies.

The M.Eng. degree aims to achieve the following goals:

(1) Provide *depth in the student's engineering discipline* (typically 6 credits or more)
  - Additional courses in the student's BSE degree discipline
  - Focused on courses relevant to the degree area

(2) Provide *breadth across engineering disciplines*, and a systems engineering perspective (typically 6 credits or more)
  - Fundamentals of other engineering fields affecting the degree area
  - Examples: auto engineering, design optimization, verification and validation

(3) Provide *breadth beyond engineering* (typically 6 credits or more)
  - Fundamentals of non-engineering aspects of the degree area
  - Examples: organizational behavior, marketing, finance, economics, languages

(4) Provide *industrially-relevant overview and project experience* (typically 6 credits or more)
  - Emphasize industry/government participation, industry sponsored projects
  - Examples: projects in interdisciplinary teams

The M.Eng. degree requires 30 credit hours of course work (at least 12 credit hours of technical courses at 500 level and above), of which at least 24 credit hours must be graded (i.e., they are not Pass/Fail), and 15 graded credit hours must be in engineering courses. The successful completion of the degree requires a minimum grade point average of B.

2. The Master of Engineering in Systems Engineering and Design

2.1. Degree Objective

The degree objective is to prepare engineers with knowledge and capabilities in the analysis, design and operation of complex engineered systems. The students will develop a broad systems engineering perspective that includes system architecting, specification development and management, system verification and validation, and delivery of complex systems. The program will augment and leverage the students' expertise in a core engineering discipline. Since the prospective student body will likely have a diversity of experience, the program will include an extended practicum option required for students whose previous experience is insufficient.

2.2. Streams

The M.Eng. program in Systems Engineering and Design is organized in two streams.

SE-1: *Integrated Hardware and Software Design*

(Example disciplines: Mechanical, Automotive, Aerospace, Naval)

SE-2: *Infrastructure Systems*

(Example disciplines: Civil, Mechanical, Transportation, Energy, Health)

2.2. Degree Requirements

2.2.a. *Admission Requirements*

a. 4-year Bachelor's degree in Engineering or Physical Sciences with good grade point average

b. Two letters of recommendation

2.2.b. *Program Requirements*

The M.Eng. in Systems Engineering and Design degree requires 30 credit hours of course work:

- At least 24 credit hours must be graded (not pass/fail)
- At least 18 credit hours must be in technical courses at the 500 level and above
- A minimum grade point average of B average is required
- Students must take ISD 520 (3 credit hours)
- Students must complete the Practicum course ISD 503 (6 credit hours)
- Students must take at least 3 courses of their choosing (technical depth) in one engineering discipline (9 credit hours)
- Students must take at least 4 courses of their choosing in systems engineering (12 credit hours); 3 credit hours of these can be additional to ISD 503 for students without extensive industry experience
- No more than 9 credit hours can be transferred (require approval of Program Committee)

In the Practicum course (6 credit hours), students will have the option of carrying out a faculty-guided project in an interdisciplinary team (on campus or on location at their place of employment) or participate in the Extended Practicum option (also in conjunction with an industrial or governmental sponsor for an additional 3 credits). In both cases, the students will have to submit a comprehensive report.

Incoming students must obtain the approval of the course advisor for the planned degree courses selected. A course advisor will be assigned to each student upon admission.

Students in the Engineering Residency will be temporary employees of the sponsors. Hence, safety training, intellectual property rights, nondisclosure agreements, and other employee agreements will be in effect. The details of these agreements will vary from sponsor to sponsor, but will not interfere with the ultimate goal of the program to prepare engineers with knowledge and capabilities in the analysis, design and operation of complex engineered systems.

2.2.c. *M.Eng. in Systems Engineering and Design Course Template*

A student will take courses in the following areas:

- Program Core Courses: 12 credit hours
- Engineering Specialties (Disciplines): 9 credit hours
- Practicum Course: 6 credit hours
- Fundamentals: 3 credit hours; can be added to the Practicum for a total of 9 credit hours

2.3. Faculty and Students

The program will leverage the existing curriculum of the departments in the College of Engineering. In addition, carefully selected courses under the instruction of faculty with the requisite experience will be integrated into the program core to form the basis of the program.

2.4. Description of Available/Needed Equipment

The program will not require new equipment or facilities for its administrative support. It will utilize resources and facilities allocated to the ISD Division. New resources to sustain the Practicum course are expected to be developed, which will require intramural and extramural funds.

2.5. Planned Implementation Date

The implementation date for the Program is Fall 2014, possibly with a small initial cohort drawn primarily from graduating CoE seniors.

2.6. Library and Other Learning Resources

The ISD online learning capabilities will be used. This involves both equipment and personnel. The Engineering Library, the Computer Aided Engineering Network, and other CoE resources (which support existing degrees) will also support the new degree. No new resources will be needed.

2.7. Space

Classroom and/or laboratory space for ISD 503 will be allocated by ISD with the support of the CoE. All the other courses in this program already exist in various Departments. No new space allocation is necessary.

References

Bloebaum, C.L, McGowan, A.M.R., Design of Complex Engineered Systems, *J. Mech. Des.* 133(10), 100201 (Oct 25, 2011) doi:10.1115/1.4005078

W. E. Bijker, T. Parke-Hughes, T. Pinch, The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology, MIT Press, 2012.

Appendix 1: Course Template

Program Core Courses (12 credit hours required)

- ISD 520 Systems Engineering (required in both streams)
- EECS 501 Probability and Random Processes
- EECS 502 Stochastic Processes
- EECS 558 Optimal Control
- EECS 557 Communication Networks
- IOE 434 Human Error and Complex System Failures
- IOE 510 Linear Programming I
- IOE 511 Continuous Optimization Methods
- IOE 536 Cognitive Ergonomics
- ECON 501 Applied Microeconomic Theory
- CEE 575 Sensing Technologies for Infrastructure Systems

Engineering Specialty (Discipline) Courses (9 credit hours required)

Aerospace

- AEROSP 483 Space Systems Design
- AEROSP 450 Flight Software Systems
- AEROSP 540 Intermediate Dynamics
- AEROSP 543 Structural Dynamics
- AEROSP 550 Linear Systems Theory
- AEROSP 575 Flight and Trajectory Optimization
- AEROSP 581 (AOSS 581) Space System Management
- AEROSP 582 (AOSS 582) Spacecraft Technology
- AEROSP 583 Management of Space Systems Design
- AEROSP 584 Avionics, Navigation and Guidance of Aerospace Vehicles
- AEROSP 588 Multidisciplinary Design Optimization

Civil and Environmental

- CEE 460 Design of Environmental Engineering Systems
- CEE 501 Infrastructure Systems
- CEE 526 Design of Hydraulic Systems
- CEE 567 Energy Infrastructure Systems
- CEE 611 Earthquake Engineering
- CEE 631 Construction Decisions under Uncertainty
- CEE 679 Infrastructure Systems Project
- CEE 810 Stochastic Systems

Energy / Electrical

- ESENG 567 (CEE 567) Energy Infrastructure Systems
- EECS 461 Embedded Control Systems
- EECS 481 Software Engineering
- EECS 484 Database Management Systems
- EECS 515 Integrated Microsystems
- EECS 598 Electricity Networks and Markets
- EECS 598 Power System Dynamics and Control
- CHE 696 Fuel Cells and Fuel Processors

Mechanical/Automotive

- ME 501 Analytical Methods in Mechanics
- ME 513 Automotive Body Structures
- ME 541 Mechanical Vibrations
- ME 542 Vehicle Dynamics

ME 552 Mechatronic Systems Design
ME 553 Micromechanical Systems
ME 555 Design Optimization
ME 559 Smart Materials and Structures
ME 560 Modeling Dynamic Systems
ME 561 (EECS 561) Design of Digital Control Systems
ME 563 (MFG 561) (IOE 565) Time Series Modeling, Analysis, Forecasting
MFG 502 Manufacturing Systems Design
MFG 539 (IOE 539) Occupational Safety Engineering
AUTO 501 Integrated Vehicle System Design

Naval

NA 562 Marine System Production Business Strategy and Operations Management
NA 570 Advanced Marine Design
NA 580 Optimization, Market Forecasts and Management of Marine Systems
NA 582 Reliability and Safety of Marine Systems

Nuclear Engineering

NERS 441 Nuclear Reactor Theory I
NERS 442 Nuclear Power Reactors
NERS 462 Reactor Safety Analysis
NERS 524 Nuclear Fuels
NERS 546 Thermal Fluids for Nuclear Reactor Safety Analysis
NERS 554 Radiation Shielding Design
NERS 561 Nuclear Core Design and Analysis I
NERS 535: Detection Techniques for Nuclear Nonproliferation

Fundamentals (3 credit hours required)

Any letter graded 400-level course in mathematics, physics, economics
ME 433 Advanced Energy Solutions
ME 458 Automotive Engineering
MFG 455 (IOE 452) Corporate Finance
MFG 456 (IOE 453) Derivative Instruments
MFG 535 (IOE 533) Human Motor Behavior and Engineering Systems
IOE 461 Quality Engineering Principles and Analysis
ECON 435 Financial Economics
EECS 402 Computer Programming For Scientists and Engineers
NERS 442 Nuclear Power Reactors
NERS 421 Nuclear Engineering Materials

Practicum 6 credit hours required; Extended Practicum can be 9 credit hours (ISD 503)

Appendix 2: Benchmarking

There are many programs nationally and internationally that address systems engineering as a discipline. None of the programs appear to meet the stated objective in the proposed degree is integrating systems engineering with design.

Table1: Summary of Programs at Other Institutions

School	Title	Completion Time
MIT	Systems Design and Management	66 credits = 1-2 years
	Leaders for Global Operations	2 years
Stanford	Masters in Management Science and Engineering	45 credits = 9 months - 1 year
UC Berkeley	Master's in Civil Systems Dept of Civil & Environmental Engineering	24 credits = 1 year
Georgia Tech	Professional Master's in Applied Systems Engineering	30 credits = 2 years
CalTech	Master's in Control and Dynamical Systems Dept. of Computing and Mathematical Sciences	1 year
University of Illinois	M.S. in Systems and Entrepreneurial Engineering	32-36 credits = 1 - 2 years (thesis vs. project)
Texas A&M University	Master's Concentration in Systems Engineering	30 credits = 1 year
Stevens Institute	M.E. in Systems Engineering	30 credits = 1 year
U. Toronto	M.E. in Mechanical & Industrial Engineering	10 half courses, or 7 half courses + project = 1-6 years
Cornell	M.E. in Systems Engineering	30 credits = 1 years
Penn State	M.E. in Systems Engineering	36 credits = 1 - 1.5 years
Boston University	M.S. in Systems Engineering or M.Eng in Systems	32 credits = 1 year
Colorado State	M.Eng. in Systems Engineering	30 credits = 1 year
Regis University	M.S. in Systems Engineering	36 credits = 1 - 1.5 years
Florida Inst. of Technology	M.S. in Systems Engineering	30 credits = 1 year
University of Maryland	M.S. in Systems Engineering	30 credits = 1 year
Johns Hopkins	M.S. or M.S. E. in Systems Engineering	30 credits = 1 year
University of Bristol (UK) Systems Centre	M.Res. Systems Engineering M.Sc in Systems Learning and Leadership	2 years 6 3-day workshops (1.5 years)
Loughborough University (UK)	M.Sc. Systems Engineering Electronic, Electrical & Systems Engineering	1 year (full time) 3 years (part-time)
RPI	Masters of Engineering in Systems Engineering	30 credits = 1 year