The University of Michigan
College of Engineering
Curriculum Committee

Agenda
November 6, 2012
1:30-3:00 p.m.

Room 265 Chrysler Center

1. Approval of Minutes
2. Course Approval Forms
3. IOE Masters Program: Concentration in Healthcare Engineering and Patient Safety ("HEPS")
4. BME Program Change Request
5. New Course and Curriculum Change for ECE

Course Aproval Forms

BME 350	Modification---Changing Degree Requirements from: Tech Elective ***to: Core Course***
BME 418	Modification—Changing Level of Credit and contact hours from:4 ***to: 3***
IOE 419	New Course
NAME 525	New Course (Revised from 9-18-12 Meeting

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

Form Number 2355
Date 9/18/2012
Effective Term Winter 2013
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		B. REQUESTED LISTING	
Home Department	Course Number	Home Department	Course Number
CEE Civil & Environmental Engin	319	CEE Civil & Environmental Engin	370
Cross Listed Course Information		Cross Listed Course Information	
Course Title		Course Title: Sensors, Electrical Circuits, and Signal Processing	
TITLE ABBREVIATION — Time Sched Max = 19 Spaces		TITLE ABBREVIATION — Time Sched Max = 19 Spaces: Sensors and Circuits	
TITLE ABBREVIATION — Transcript Max = 20 Spaces		TITLE ABBREVIATION — Transcript Max = 20 Spaces: Sensors and Circuits	
Course Description		Course Description for Official Publication (Max = 50 words): This course introduces students to the fundamentals of collecting and processing experimental data. The course begins with an introduction to DC and AC circuits. The design and operation of sensors are then introduced followed by an introduction to digital signal processing.	
PROGRAM OUTCOMES: ☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ k		PROGRAM OUTCOMES: ☒ a ☒ b ☒ c ☒ d ☒ e ☐ f ☐ g ☐ h ☐ i ☐ j ☒ k	
Degree Requirements: ○ Degree Requirement ○ Core Course ○ Free Elective ○ Tech Elective ○ Other		Degree Requirements: ◉ Degree Requirement ○ Core Course ○ Free Elective ○ Tech Elective ○ Other	
Prereq: ○ Enforced ○ Advised		Prereq: Physics 240. ○ Enforced ◉ Advised	
Credit Restrictions		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		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: ___ ___		Credit Hours Min Max: 3 3	
Contact Hrs/Wk: ___ Number of Wks: ___		Contact Hrs/Wk: 3 Number of Wks: 14	

C.

Repeatability (Indi Research, Dir. Study, Dissertation: Is this course repeatable? ○ Yes ◉ No Max Hours? 3 Max Times? 1 Can it be repeated in the same term? ○ Yes ◉ No

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
Course Is Y Graded ☐

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

Cognizant Faculty Member: Jerome P. Lynch
Title: Associate Professor

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

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

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

	Department Chair Name	Chair Signature
Home Dept.	Kim F. Hayes, Interim Chair & Professor	
Cross-listed Dept(s).	Civil & Environmental Engin	

Form Number

2355

SUPPORTING STATEMENT

We are renumbering CEE 319 to CEE 370 to fall in better alignment with course numbers in the Systems group in the department.

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

Detail the Special requirements

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

Form Number 2162
Date 9/28/2012
Effective Term Winter 2013
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	B. REQUESTED LISTING
Home Department / Course Number	Home Department: CEE Civil & Environmental Engin / Course Number: 573
Cross Listed Course Information	Cross Listed Course Information
Course Title	Course Title: Data Analysis in Civil and Environmental Engineering
TITLE ABBREVIATION — Time Sched Max = 19 Spaces	Data Analysis in CEE
TITLE ABBREVIATION — Transcript Max = 20 Spaces	Data Analysis in CEE
Course Description	Course Description for Official Publication (Max = 50 words): Course topics address practical problems of analysis of manipulation and monitoring datasets in environmental sciences and engineering: hypothesis testing, uncertainty, linear regressions, data of high dimension, and time domain and frequency domain analysis of series. Examples are drawn from the fields of environmental and civil engineering and surface and subsurface hydrology.
PROGRAM OUTCOMES: ☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ k	PROGRAM OUTCOMES: ☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ k
Degree Requirements: ○ Degree Requirement ○ Core Course ○ Free Elective ○ Tech Elective ○ Other	Degree Requirements: ○ Degree Requirement ○ Core Course ○ Free Elective ○ Tech Elective ◉ Other
Prereq: ○ Enforced ○ Advised	Prereq: CEE 270 or equivalent. ○ Enforced ◉ Advised
Credit Restrictions	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	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: ___	Credit Hours Min Max: 3 3 Contact Hrs/Wk: 3 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
Course Is Y Graded ☐

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

Cognizant Faculty Member: Valeriy Ivanov — Title: Assistant Professor

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

Approval Info | **Approved by Name** | **Approved Date**

☐ Curriculum Comm.
☐ Faculty
☐ Cross listed Unit 1
☐ Cross listed Unit 2

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

	Department Chair Name	Chair Signature
Home Dept.	Kim F. Hayes, Interim Chair & Professor	
Cross-listed Dept(s).	Civil & Environmental Engin	

Form Number

2162

SUPPORTING STATEMENT

The course objective is to address a range of practical problems frequently encountered in both civil and environmental engineering. These are related to repetitive sample collection in the field (environmental sciences, engineering), laboratory manipulation experiments with multiple stratification axes (biological and environmental engineering) as well as an analysis of monitoring time series aiming to identify underlying structures and physical processes (structural and geotechnical engineering, fluid mechanics, and hydrology). The course therefore represents a combination of topics from statistical inference and time series analysis that is best suited for addressing these specific needs. Dataset examples that will be used for concept demonstrations are drawn from the fields of environmental and civil engineering and surface and subsurface hydrology. The only other data-oriented course offered in the department is CEE 570 “Introduction to Geostatistics” that deals with specific issues of geospatial data. With the exception of the introductory material, the proposed course does not overlap with CEE 570.

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

Detail the Special requirements

University of Michigan, Department of Civil and Environmental Engineering

Winter 2013

CEE 573 "Data Analysis in Civil and Environmental Engineering"

Instructor-in-charge:
Valeriy Ivanov
1351 Beal Avenue, 105 EWRE
Ann Arbor, MI 48109-2125
Phone: 734-763-5068
E-mail: ivanov@umich.edu

Prerequisites: CEE 270 or equivalent course.
Basic knowledge of Matlab, R, or any other programming language is advised.

Description: Course topics address practical problems of analysis of manipulation and monitoring datasets in environmental sciences and engineering: hypothesis testing, uncertainty, linear regressions, data of high dimension, and time domain and frequency domain analysis of series. Examples are drawn from the fields of environmental and civil engineering and surface and subsurface hydrology.

Classes:
Tue., Thr.: 2.30-4.00pm; 1032 FXB

Office hours: Mon, Wed: 2.00-3.00pm.

References: There is no required textbook for the course. The topics explored are derived from various materials. The course approximately follows:

Rice, J. (1995) Mathematical statistics and data analysis. Duxbury Press. Available in Shapiro Science: QA 276.12 .R531 1995

Jenkins, G.M., and D.G. Watts (1968, 1998). *Spectral Analysis and its Applications*, Holden-Day (1968)/Emerson-Adams Press (1998). Available in Art Architecture & Engineering; Shapiro Science; CSCAR - Rackham Building (building use only): QA280.J52

* A list of additional textbooks is attached.

Grades:

Class participation	5%
Problem sets (5)	60%
Mid-term exam	15%
Final exam	20%

Grading policy: The letter grade for the class is based on a 100 point system for the assignments, test, and a project. The average grade for the class is a metric of assignment difficulty.

- (-5) – Erroneous numerics
- (-10) – Erroneous derivation/methodology
- (-1,-2) – Erroneous minor qualitative questions

Late returns: 25% of the grade per day of late return.

Problem sets: Use a symbolic form in all your derivations before providing a numerical answer. Present a detailed methodology of how the answer is achieved. Provide numerical values wherever possible. Indicate units in all figures/estimation results. Attach the source code for computations that require more than several steps. Use metric units only.

Schedule:

Mid-term	February 24
Take home final test	April 19
Turn-in	April 26

Additional references (in alphabetical order):

Bras, R.L., and I. Rodriguez-Iturbe, *Random Functions and Hydrology*. Dover Books on Advanced Mathematics, 559 pp., 1994. (Available in Art Architecture & Engineering GB656.2.M33 B731 1985)

Priestly, M.B., *Spectral Analysis and Time Series*. Academic Press (1981)/ Elsevier (1991). (Available in Shapiro Science: QA280.P741)

Ramsey, F. L., and D. Schafer. *The Statistical Sleuth: A Course in Methods of Data Analysis*, Duxbury Press/Brooks Cole, 2nd/3rd ed., 2002/2012. (Available in Shapiro Science: QA 276 .R33 2002)

Zar, J.H., *Biostatistical analysis*. Upper Saddle River, N.J.: Prentice Hall, 4th ed., 1999. (Available in Shapiro Science: QH 323.5 .Z36 1999)

Week/ Class	Date	Topic
1/1		*Introduction and Review*: random variables; univariate probability distributions.
2/2		*Statistical Inference* (SI) from data: multivariate distributions; statistical dependence, moments.
2/3		SI: Sampling distributions of the mean, variance, ratio of variances.
3/4		SI: Monte-Carlo simulation. *Generation of synthetic series in sciences and engineering.*
3/5		SI: Sampling distribution approach in parameter estimation: confidence intervals and properties of estimators.
4/6		SI: Test of significance; hypothesis testing. *Analysis of environmental data.*
4/7		SI: Test the significance of correlation in the presence of spatially correlated data.
5/8		SI: Power analysis in sampling and experimental design. *Planning laboratory experiments.*
5/9		SI: Goodness of fit. *Distributions of flow annual maxima.*
6/10		SI: Single factor analysis of variance. *Graphical presentation of data in research papers.*
6/11		SI: Linear regression analysis: LSE and forecast variance. Data transformation.
7/12		SI: *Examples of environmental data and frequently encountered problems.*
7/13		SI: Analysis of data of high dimension: Principal Component Analysis (PCA). *Analysis of microbiological manipulation data.*
8/14		SI: PCA. *Examples*. Review of class material.
8/15		**Mid-term test.**
		SPRING BREAK
9/16		*Time Series Analysis* (TSA): trends in data; stationary and non-stationary processes; tests of stationarity in the mean and the variance. *Analysis of flood peaks.*
9/17		TSA: Autocovariance/correlation and cross covariance/correlation functions
10/18		TSA: Estimation of auto/cross covariance functions; tests of their significance. *Analysis of earthquake series.*
10/19		TSA: Linear autoregressive and moving average processes. *Analysis of a linear reservoir.*
11/20		TSA: Model identification and calibration. *Simulation and forecasting with linear models in surface and subsurface hydrology.*
11/21		Fourier analysis: series, integrals, transforms. *Periodogram of empirical series.*
12/22		*Spectral Analysis* (SA): spectral density functions; power spectrum
12/23		SA: Spectra of white noise, linear, AR(1), and MA processes. Sampling properties of power spectrum.
13/24		SA: Smoothing of spectral estimators; spectral windows and their properties.
13/25		SA: *Uses and examples of spectral analysis in environmental sciences and civil engineering.*
14/26		SA: *Spectral estimation and spectrum sampling of flow velocity and road roughness.*
14/27		SA: *Spectral estimation and spectrum sampling of water quality and soil moisture data.*
15/28		**Review of class material. Take-home final test.**
		Quiz turn-in

Office of Evaluations & Examinations
University of Michigan
Report ID: MSR04732 2011-04-08 - 2011-04-20

Winter 2011 Final

Instructor Report

11 students responded out of the total enrolled 11

Instructor: Ivanov,Valeriy Y
CEE 622 040

		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.	6	4	1	0	0	0	4.58	3.90	4.25	4.67	4.07	4.29	4.58
2	Overall, the instructor was an excellent teacher.	7	4	0	0	0	0	4.71	4.08	4.56	4.83	4.20	4.50	4.75
3	I learned a great deal from this course.	8	3	0	0	0	0	4.81	4.00	4.30	4.67	4.08	4.32	4.63
4	I had a strong desire to take this course.	4	4	2	1	0	0	4.13	3.67	4.10	4.59	4.10	4.33	4.63
15	I increased my ability to apply math and science knowledge to engineering problems.	7	4	0	0	0	0	4.71	3.94	4.17	4.38			
17	I increased my ability to analyze and interpret data.	9	1	0	0	0	0	4.94	4.00	4.20	4.43			
20	My confidence in my design abilities increased because of this course.	2	5	3	0	0	1	3.90	4.00	4.13	4.38			
21	I gained valuable experience working in teams in this course.	2	2	2	0	0	5	4.00	3.70	4.00	4.38			
23	I increased my ability to formulate, and solve engineering problems.	2	7	0	0	0	2	4.14	3.98	4.14	4.33			
25	I developed a greater understanding of my responsibilities as a professional.	1	4	5	0	0	1	3.50	3.93	4.17	4.63			
28	Course improved my ability to communicate technical information, designs, and analyses.	3	4	1	0	0	3	4.25	3.90	4.08	4.25			
30	I developed a greater understanding of the impact of engineering on the environment.	1	3	2	1	1	3	3.50	3.63	3.90	4.14			
32	This course increased my desire to learn more about this subject in the future.	1	10	0	0	0	0	4.05	3.79	4.08	4.34			
34	I have a greater understanding of how course concepts apply to contemporary problems.	4	7	0	0	0	0	4.29	4.06	4.20	4.50			
35	I increased my ability to apply engineering tools and methods.	5	4	1	0	0	0	4.50	4.00	4.17	4.40			
121	I gained a good understanding of concepts/principles in this field.	4	6	0	1	0	0	4.25	3.96	4.20	4.50			
125	I developed the ability to solve real problems in this field.	4	6	1	0	0	0	4.25	3.86	4.14	4.50			
201	The instructor gave clear explanations.	6	5	0	0	0	0	4.58	4.02	4.42	4.75			
203	The instructor stressed important points in lectures/discussions.	7	3	0	0	0	0	4.79	4.13	4.50	4.75			
207	The instructor appeared to have a thorough knowledge of the subject.	7	4	0	0	0	0	4.71	4.40	4.75	4.91			
216	The instructor acknowledged all questions insofar as possible.	9	2	0	0	0	0	4.89	4.21	4.56	4.80			
229	The instructor used class time well.	6	5	0	0	0	0	4.58	4.07	4.44	4.71			
230	The instructor seemed well prepared for each class.	7	4	0	0	0	0	4.71	4.25	4.64	4.84			
232	Work requirements and grading system were clear from the beginning.	4	6	1	0	0	0	4.25	4.00	4.25	4.57			
239	The amount of work required was appropriate for the credit received.	5	6	0	0	0	0	4.42	3.90	4.17	4.44			
356	Examinations covered the important aspects of the course.	4	7	0	0	0	0	4.29	4.00	4.25	4.56			
360	Exams were reasonable in length and difficulty.	5	6	0	0	0	0	4.42	3.83	4.10	4.44			
366	The grading system was clearly explained.	4	6	0	1	0	0	4.25	4.00	4.25	4.58			

* The quartiles are calculated from Winter 2011 data. The university-wide quartiles are based on all UM classes in which an item was used. The school/college quartiles in this report are based on graduate level students in College of Engineering.
** SA - Strongly Agree, A - Agree, N - Neutral, D - Disagree, SD - Strongly Disagree, NA - Not Applicable.

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

Form Number 2346
Date 9/14/2012
Effective Term Winter 2013
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		B. REQUESTED LISTING	
Home Department	Course Number	Home Department	Course Number
CEE Civil & Environmental Engin	554	CEE Civil & Environmental Engin	574
Cross Listed Course Information		Cross Listed Course Information	
		ARCH Architecture	595
Course Title		Course Title	
		Materials Selection for Sustainable Design	
TITLE ABBREVIATION — Time Sched Max = 19 Spaces		TITLE ABBREVIATION — Time Sched Max = 19 Spaces	Matl Sel Sus Des
TITLE ABBREVIATION — Transcript Max = 20 Spaces		TITLE ABBREVIATION — Transcript Max = 20 Spaces	Matl Sel Sus Des
Course Description		Course Description for Official Publication (Max = 50 words)	
		Integrated study of materials properties, performance, and economic and environmental cost, as related to engineering and architectural design. Topics include material properties and selection, materials database, processing and design, ecological considerations, and optimization. Examples will be drawn from cementitious materials and ceramics, metals, polymers and composites.	
PROGRAM OUTCOMES: ☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ k		**PROGRAM OUTCOMES:** ☒ a ☐ b ☒ c ☒ d ☐ e ☐ f ☒ g ☒ h ☒ i ☒ j ☒ k	
Degree Requirements ○ Degree Requirement ○ Core Course ○ Free Elective ○ Tech Elective ○ Other		**Degree Requirements** ○ Degree Requirement ○ Core Course ○ Free Elective ◉ Tech Elective ○ Other	
Prereq ○ Enforced ○ Advised		Prereq CEE 212 or ARCH 324 or equivalent. ○ Enforced ◉ Advised	
Credit Restrictions		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		**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		Credit Hours Min 3 Max 3	
Contact Hrs/Wk		Contact Hrs/Wk 3	
Number of Wks		Number of Wks 14	

Repeatability (Indi Research, Dir. Study, Dissertation: Is this course repeatable? ○ Yes ◉ No Max Hours? 3 Max Times? 1 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
Course Is Y Graded ☐

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

Cognizant Faculty Member: Victor C. Li
Title: Professor

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

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

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

	Department Chair Name	Chair Signature
Home Dept.	Kim F. Hayes, Interim Chair & Professor	
Cross-listed Dept(s).	Civil & Environmental Engin	

Form Number

2346

SUPPORTING STATEMENT

CEE 554 is being re-numbered to CEE 574 for better alignment within the Systems group in the department.

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

Detail the Special requirements

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

Form Number 2347
Date 9/14/2012
Effective Term Winter 2013
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		B. REQUESTED LISTING	
Home Department	Course Number	Home Department	Course Number
CEE Civil & Environmental Engin	638	CEE Civil & Environmental Engin	575
☐ Cross Listed Course Information		Cross Listed Course Information	
☒ Course Title	Sensing for Civil Infrastructure Development	Course Title	Sensing for Civil Infrastructure Systems
TITLE ABBREVIATION — Time Sched Max = 19 Spaces	Infrastruct Sensing	TITLE ABBREVIATION — Time Sched Max = 19 Spaces	Infrastruct Sensing
TITLE ABBREVIATION — Transcript Max = 20 Spaces	Infrastruct Sensing	TITLE ABBREVIATION — Transcript Max = 20 Spaces	Infrastruct Sensing
☒ Course Description	Civil infrastructure sensors for spatial data acquisition and analysis. Introduction to multi-dimensional signal processing for pattern recognition in sensor data with a focus on constructions materials, personnel and equipment. Segmentation, clustering, and filtering techniques. 3D reconstruction of civil infrastructure elements. Defects detection and system health monitoring.	Course Description for Official Publication (Max = 50 words)	Sensor technologies for civil infrastructure. Fundamentals of sensor theory, fabrication, operation and deployment. Data acquisition and management methods for large-scale sensor networks. Optimal sensor placement. Data to decision support systems. Physics-based and data-driven interrogation methods for system identification, estimation and control. Case studies of deployments in built and natural environments.
PROGRAM OUTCOMES:	☐ a ☐ c ☐ e ☐ g ☐ i ☐ k ☐ b ☐ d ☐ f ☐ h ☐ j	**PROGRAM OUTCOMES:**	☐ a ☐ c ☐ e ☐ g ☐ i ☐ k ☐ b ☐ d ☐ f ☐ h ☐ j
Degree Requirements	○ Degree Requirement ◉ Free Elective ○ Other ○ Core Course ○ Tech Elective	**Degree Requirements**	○ Degree Requirement ◉ Free Elective ○ Other ○ Core Course ○ Tech Elective
☐ Prereq	○ Enforced ○ Advised	Prereq	Physics 240. ○ Enforced ◉ Advised
☐ Credit Restrictions		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	**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	/	Credit Hours Min / Max	3 / 3
Contact Hrs/Wk		Contact Hrs/Wk	3
Number of Wks		Number of Wks	14

Repeatability (Indi Research, Dir. Study, Dissertation: Is this course repeatable? ○ Yes ◉ No Max Hours? 3 Max Times? 1 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
Course Is Y Graded ☐

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

Cognizant Faculty Member: Jerome P. Lynch
Title: Associate Professor

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

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

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

	Department Chair Name	Chair Signature
Home Dept.	Kim F. Hayes, Interim Chair & Professor	
Cross-listed Dept(s).	Civil & Environmental Engin	

Form Number

2347

SUPPORTING STATEMENT

The course is being renumbered from CEE 638 to CEE 575 to put the course in alignment with the course numbers in the systems group. In addition, a new cognizant faculty member will be teaching the course which is why the course description is being slightly adjusted; however, the general content of the course remains unchanged.
CEE 575 will be a core course for the Infrastructure Systems Specialization in the MSE in Civil Engineering.

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

Detail the Special requirements

CEE575 - Sensing for Civil Infrastructure Systems

Motivation: This course is being modified slightly to emphasize a broader perspective in the development and application of sensing technologies for civil infrastructure systems. While the course has been successfully taught on two prior occasions, the course had a heavy emphasis on construction applications. Our request for the title change (from "Sensing for Civil Infrastructure Development" to "Sensing for Civil Infrastructure Systems") is to underscore our effort to draw on a broader set of illustrative application areas to which sensors are impacting the civil infrastructure field. The theoretical foundation of the course remains unchanged; rather, a new set of illustrative examples are being introduced spanning the full life-cycle of civil infrastructure: from cradle (*i.e.,* construction) to grave (*e.g.,* performance during extreme load events).

Course Overview: This course will address the increasing importance of automated measurements, instrumentation design, system integration, control and the analysis of "big data" across a broad range of Civil and Environmental Engineering domains. Students will acquire an in-depth knowledge of sensing technologies, with the ability to directly apply these state of the art tools to their projects. Sensor physics will be discussed to illustrate how physical processes can be measured through electrical signals and converted to digital information. Extensive theory behind leading sensing technologies and data acquisition systems will be discussed. Large-scale sensor networks will be investigated as real-time data acquisition platforms for measuring distributed systems. Signal processing, estimation, parameter identification, and machine learning techniques will be introduced to illustrate how system states can be inferred from real-time measurements. Formal experimental design techniques and optimal sensor placement theory will be covered. Commercial as well as open-source platforms will be explored, with an emphasis for developing an in-depth understanding of the benefits and limitations of various technologies. Real-time data collection and analysis will be discussed and cast into the larger framework of system integration to enable the development and fabrication of fully automated civil system. All measurements and system designs will be motivated by real-world case studies across a broad set of domains, including, but not limited to, structures, hydraulics, hydrology, geo-tech, environmental engineering, materials and construction. Along with supporting a deep theoretical understanding, a strong hands-on component of the course will enable students to directly integrate these lessons into their own projects or existing capstone courses.

Fifty word official catalog description: Sensor technologies for civil infrastructure. Fundamentals of sensor theory, fabrication, operation and deployment. Data acquisition and management methods for large-scale sensor networks. Optimal sensor placement. Data to decision support systems. Physics-based and data-driven interrogation methods for system identification, estimation and control. Case studies of deployments in built and natural environments.

Weekly Course Schedule:

Week 1: Introduction to sensing theory, physical principles and measurement quantities.
Week 2: Resistive, capacitive and inductive sensors.
Week 3: Sensor technologies (continued). MEMS systems.
Week 4: Analog to digital conversion, discretization, data acquisition systems.
Week 5: Signal processing, signal interpretation, frequency based methods.
Week 6: Data mining, estimation, parameter identification.
Week 7: Physics-based and statistical estimation methods, dimensional analysis.
Week 8: Formal experimental design methods and optimal sensor placement.
Week 9: Distributed sensing and sensor networks.
Week 10: Energy consumption for long-term deployments and studies. Wireless sensor networks and low-power system design.
Week 11: Actuation, control and loading systems. System integration methods.
Week 12: Real-time data management for state estimation, system identification, and control.
Week 13: Formal system design methods, interface development, data to decision support systems. Networking and the *Internet of Things*.

Grading and Deliverables:
The grade for this course will be based on homework assignments, one term project, midterm and final exam. Regular class attendance is also expected of all students.

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

Form Number 2348
Date 9/14/2012
Effective Term Winter 2013
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	B. REQUESTED LISTING
Home Department / Course Number	Home Department: CEE Civil & Environmental Engin / Course Number: 679
Cross Listed Course Information	Cross Listed Course Information
Course Title	Course Title: Infrastructure Systems Project
TITLE ABBREVIATION — Time Sched Max = 19 Spaces	Infr Sys Project
TITLE ABBREVIATION — Transcript Max = 20 Spaces	Infr Sys Project
Course Description	Course Description for Official Publication (Max = 50 words): This course provides students in the Infrastructure Systems program with an integrated view of how fundamental system theory is applied to the civil and environmental engineering domains. Students undertake a semester long research project as an independent study effort and are expected to attend weekly seminars involving students and faculty.
PROGRAM OUTCOMES: ☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ k	PROGRAM OUTCOMES: ☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ k
Degree Requirements: ○ Degree Requirement ○ Core Course ○ Free Elective ○ Tech Elective ○ Other	Degree Requirements: ◉ Degree Requirement ○ Core Course ○ Free Elective ○ Tech Elective ○ Other
Prereq: ○ Enforced ○ Advised	Prereq: ○ Enforced ○ Advised
Credit Restrictions	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	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: ___	Credit Hours Min Max: 3 3 Contact Hrs/Wk: 3 Number of Wks: 14

Repeatability (Indi Research, Dir. Study, Dissertation: Is this course repeatable? ○ Yes ◉ No Max Hours? 3 Max Times? 1 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
Course Is Y Graded ☐

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

Cognizant Faculty Member: Jerome P. Lynch
Title: Associate Professor

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

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

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

	Department Chair Name	Chair Signature
Home Dept.	Kim F. Hayes, Interim Chair & Professor	
Cross-listed Dept(s).	Civil & Environmental Engin	

Form Number

2348

SUPPORTING STATEMENT

This 3-credit course is a required course of the new M.S. concentration in Infrastructure Systems offered every Winter semester (see accompanying MS concentration guidelines). The intent of the course is to provide M.S. graduate students with an opportunity to apply their knowledge of system engineering derived from rigorous coursework in system theory with a specialization study track (e.g., structures, geotechnical engineering, materials, construction, hydraulics, environmental) within the Civil and Environmental discipline. To accomplish these goals, the course is designed to be a hybrid between a seminar course and a directed studies course. The directed study component of the course is done by a student under the direction of a faculty member. To reinforce the student's perspectives on how systems theory can solve vexing problems in the Civil and Environmental specializations areas, a weekly seminar will be established where students in the program will present their research to other students in the program. The weekly seminar series will also be used for faculty and invited campus visitors to present their research to students.

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

Detail the Special requirements

CEE679 Infrastructure Systems Project

Introduction:
This 3-credit course is a required course of the new M.S. concentration in Infrastructure Systems offered every Winter semester (see accompanying MS concentration guidelines). The intent of the course is to provide M.S. graduate students with an opportunity to apply their knowledge of system engineering derived from rigorous coursework in system theory with a specialization study track (e.g., structures, geotechnical engineering, materials, construction, hydraulics, environmental) within the Civil and Environmental discipline. To accomplish these goals, the course is designed to be a hybrid between a seminar course and a directed studies course. The directed study component of the course is done by a student under the direction of a faculty member. To reinforce the student's perspectives on how systems theory can solve vexing problems in the Civil and Environmental specializations areas, a weekly seminar will be established where students in the program will present their research to other students in the program. The weekly seminar series will also be used for faculty and invited campus visitors to present their research to students.

Deliverables:
The primary deliverable for the course is a semester long term project termed the "capstone project". The capstone project is a directed studies effort on the part of the student to deepen their expertise in applying system theory to pressing problems in the fields of Civil and Environmental Engineering. Towards this end, each student will be paired with a faculty member in the Infrastructure Systems group (Profs. Kerkez, Li, Lynch, and Scruggs) or with a faculty member affiliated with the group (Profs. Athanasopoulus-Zekkos, Junghans, Keoleian, Love, Xu) who will oversee and mentor the student in their research plan. The final grade for the course will be based on faculty evaluation of the final report and presentation prepared by the student.

Catalogue Description:
This course provides students in the Infrastructure Systems program with an integrated view of how fundamental system theory is applied to the civil and environmental engineering domains. Students undertake a semester long research project as an independent study effort and are expected to attend weekly seminars involving students and faculty.

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

Introduction

The economic prosperity of our nation is dependent upon massive networks of infrastructure systems including transportation networks, waterway networks, pipelines, and electrical grids, just to name a few. Furthermore, urban environments can be viewed as a system of systems with complex interactions and interdependencies existing between individual systems. Historically, the civil engineering profession has emphasized the resilient design of the individual infrastructure components that make up these systems. Comparatively less attention has been paid to how infrastructure components interrelate and interact to make up a dynamic system. As a result, recent natural catastrophes such as Hurricane Katrina (2005) and the Northridge Earthquake (1994) have revealed that society is vulnerable to catastrophic cascading failures that occur due to a lack of resiliency in the points of interconnection between individual infrastructure systems. Today, infrastructure systems are growing even more interdependent through information and sensing technologies being introduced for the monitoring and control of infrastructure systems. As urban environments grow to keep pace with trends in population densification, a balance must be struck between community resiliency and sustainable use of natural resources. This is fundamentally a systems problem defined by the flow of the natural resources that go into the construction and operation of infrastructure system and the negative consequences (*e.g.*, greenhouse gases) that result over the full life-cycle of infrastructure systems. This graduate program emphasizes the analysis, design, and optimization of civil infrastructures, using the concepts from systems theory, information theory, decision theory, and sustainable design. The program also focuses on the enhancement of resiliency and sustainability of infrastructure systems via integration of nontraditional technologies, such as embedded sensing, intelligent control, and advanced materials technologies.

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 infrastructure systems 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 five of the following core systems courses:
  - CEE574: Materials Selection for Sustainable Design –OR- ME589:Sustainable Design of Tech Systems
  - CEE619: Advanced Structural Dynamics and Smart Structures[1]
  - CEE575: Sensing for Civil Infrastructure Systems
  - EECS560: Linear System Theory[2]
  - EECS501: Probability and Random Processes
  - EECS551: Mathematical Signal Processing
  - IOE510: Linear Programing

  Note that any combination of these five courses satisfies both the math and cognate course requirements for the MSE degree in Civil and Environmental Engineering.
- 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 <u>two</u> graduate level courses (cognate courses), with a minimum of 3 credit hours each, in a department other than Civil and Environmental Engineering. Courses cross-listed with CEE courses do not qualify as cognates.

[1] To be retitled, "Dynamics and Control of Infrastructure Systems"

[2] To be cross-listed with CEE (in process)

- Students in the systems area 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 are acceptable. Of these 12 hours, a maximum of 9 hours can be in CEE courses.
- SGUS students with undergraduate specialization in any area of CEE may pursue a MS degree in Infrastructure Systems. SGUS students are permitted to double count up to 9 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 infrastructure systems.

Grades

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

A+ = 9; A = 8; A- = 7; B+ = 6; B = 5; B- = 4; C+ = 3; C = 2; C- = 1

A minimum cumulative graduate grade point average (GPA) of 5 on this 9-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/.

List of Suggested Elective Courses in the Infrastructure Systems Concentration

Signal and System Theory
EECS 565 (AE 580) - Linear Feedback Control Systems
EECS 562 (AE 551) - Nonlinear Systems
EECS 558 - Stochastic Control
EECS 662 (ME 662) - Advanced Nonlinear Control
PHY508 - Network Theory
EECS 551 - Mathematical Methods in Signal Processing
EECS 559 - Advanced Signal Processing
EECS 564 – Estimation, Filtering, and Detection
IOE 565 (ME 563) (MFG 561) – Time Series Modeling and Analysis
AE566 - Data Analysis and System Identification

Applied Mechanics and Dynamics
ME 501 - Analytical Methods in Mechanics
ME 502 - Methods of Differential Equations in Mechanics
ME 511 - Theory of Solid Continua
CEE 509 (ME 512) – Elasticity
ME 519 - Plasticity I
ME 541 - Mechanical Vibration
ME 543 - Analytical and Computational Dynamics I
AE 540 (ME 540) - Intermediate Dynamics
CEE 617 (AE 615) (ME 649) - Random vibrations
ME 641 - Advanced Vibration of Structures
ME 643 - Analytical and Computational Dynamics II
CEE511 - Structural Dynamics

Applied Probability, Statistics, and Decision Theory
EECS 501 - Probability & Rand Process
EECS 502 - Stochastic Process
IOE 560 (Stats 550) - Bayesian Decision Analysis
IOE460 - Decision Analysis
CEE517 - Reliability of Structures
IOE 465. Design and Analysis of Experiments
IOE 562 – Reliability

Simulation, Computation, and Optimization
CEE539 - Discrete Event Simulation
MSE556 - Molecular Simulation of Materials
IOE574 - Simulation Analysis
EECS587 - Parallel Computing
ME505 - FE Methods in Mechanical Engineering
CEE510 - FE Methods in Solid & Structural Mechanics
ME523 - Computational Fluid Dynamics
MATH571 – Num. Methods in Scientific Computing I
MATH572 – Num. Methods in Scientific Computing II
ME605 - Advanced Finite Element Methods in Mechanics
ME 555 (MFG 555) - Design Optimization

IOE 511 (Math 562) - Continuous Optimization Methods
IOE 512 - Dynamic Programming
IOE 610 (Math 610) - Linear Programming II

Artificial and Embedded Intelligence
EECS461 - Embedded Control Systems
EECS492 - Introduction to Artificial Intelligence
EECS545 - Machine Learning
EECS567 (ME567) - Introduction to Robotics

Sustainability and Design
ARCH507 (BA605) (NRE605) - Green Development
NRE574 - Sustainable Energy Systems
CEE586 (NRE 557) - Industrial Ecology[1]
CEE650 - Advanced FRC Design for Sustainable Infrastructure

1: Due to significant overlap, cannot count both this class and ME589 toward the 30 credit degree requirement

Critical Infrastructure Systems Technologies
CEE567 - Energy Infrastructure Systems
CEE611 - Earthquake Engineering
UP527 - Infrastructure Planning in the US & Dev. Count.
EECS463 - Power Systems Design and Operation
ME559 - Smart Materials and Structures
EECS414 - Introduction to MEMS
EECS418 - Power Electronics
EECS515 - Integrated Microsystems

Concentration in Infrastructure Systems:
WORKSHEET

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

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

STEP 2: Core System Courses:
Please select courses taken or to be taken (select 5).

Core Course	Term Taken	CEE Credits	Non-CEE Credits*
CEE574 Mat. Selection for Sustainable Design *(OR ME589 Sustainable Design of Tech)*			
CEE619 Dynamics and Control of Infrastructure Systems			
CEE575 Sensing for Civil Infrastructure			
EECS560 Linear System Theory			
EECS551 Mathematical Sig Processing			
EECS501 Probability and Random Processes			
IOE510 Linear Programming			
* If course is cross-listed in CEE, it counts as CEE credits	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: Program Requirements:

Requirement	Credits	Limit
Total Number of Credits Taken		≥ 30
Number of CEE Credits Taken		≥ 18
Total Number of 400-Level Credits		≤ 12
Total Number of 400-Level Credits in CEE		≤ 9

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

Form Number 2350
Date 9/17/2012
Effective Term Winter 2013
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	B. REQUESTED LISTING
Home Department:	Home Department: EECS Elec Engin & Computer Sci
Course Number:	Course Number: 510
☐ Cross Listed Course Information:	Cross Listed Course Information:
☐ Course Title:	Course Title: RF MEMS
TITLE ABBREVIATION — Time Sched Max = 19 Spaces:	RF MEMS
TITLE ABBREVIATION — Transcript Max = 20 Spaces:	RF MEMS
☐ Course Description:	Course Description for Official Publication (Max = 50 words): This course covers the principles of operation, design, fabrication, and technology trends of micro-electromechanical devices for high frequency applications with a focus on communications. Micro-devices covered include resonators, switches, filters, tunable passive devices, and reconfigurable modules. The physical phenomena limiting the performance and scaling of RF MEMS devices are discussed.
PROGRAM OUTCOMES: ☐a ☐c ☐e ☐g ☐i ☐k ☐b ☐d ☐f ☐h ☐j	PROGRAM OUTCOMES: ☐a ☐c ☐e ☐g ☐i ☐k ☐b ☐d ☐f ☐h ☐j
Degree Requirements: ○ Degree Requirement ○ Free Elective ○ Other ○ Core Course ○ Tech Elective	Degree Requirements: ○ Degree Requirement ○ Free Elective ○ Other ○ Core Course ◉ Tech Elective
☐ Prereq: ○ Enforced ○ Advised	Prereq: EECS 414 ○ Enforced ◉ Advised
☐ Credit Restrictions:	Credit Restrictions:
☐ Level of Credit: ☐ Undergrad only ☐ Ugrad or Rckhm Grad ☐ R ☐ Rackham Grad ☐ Ugrad or Non-Rckhm Grad ☐ Non-Rckhm Grad ☐ All Credit types	Level of Credit: ☐ Undergrad only ☐ Ugrad or Rckhm Grad ☐ I ☐ Rackham Grad ☐ Ugrad or Non-Rckhm Grad ☐ Non-Rckhm Grad ☒ All Credit types
Credit Hours Min Max:	Credit Hours Min: 4 Max: 4
Contact Hrs/Wk:	Contact Hrs/Wk: 4
Number of Wks:	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

Course Is Y Graded ☐

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

Cognizant Faculty Member: Mina Rais-Zadeh
Title: Prof. Asst

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

Approval Info | **Approved by Name** | **Approved Date**

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

☐ Curriculum Comm.
☐ Faculty
☐ Cross listed Unit 1
☐ Cross listed Unit 2

Department Chair Name | **Chair Signature**

Home Dept. EECS ECE Assoc. Chair [signature]

Cross-listed Dept(s). ____

Form Number

2350

SUPPORTING STATEMENT

This course is intended for graduate students, and complements the series of MEMS courses offered as part of a comprehensive MEMS educational program developed by the Center for Wireless Integrated MicroSensing and Systems (WIMS2 (formerly WIMS), http://wims2.org/). The rest of MEMS courses are EECS 425, 509, 514, and 515– see the chart below. The only pre-requisites of this course is EECS 414 to allow students from many engineering or science disciplines, including mechanical, electrical, and aerospace engineering students to take the course. This is a modular course (similar to EECS 514 and EECS 515) and is organized into lectures but can also be offered as separate lecture (3hrs) and discussion (1hr) sessions (per week). The course includes a semester-long project. The requested credit hour for the course is 4, and the class will span over 14 weeks.

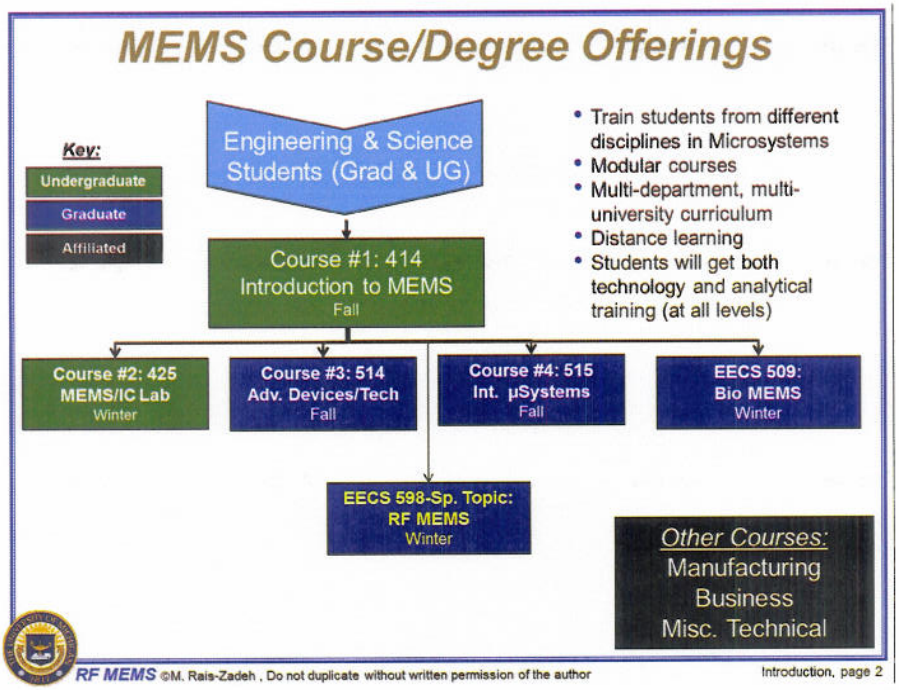
This course was offered as 598 in Fall 2010 and Fall 2011.
Here is Q1 and Q2 scores.
Fall 2011 (enrollment 10): Q1: 4.79; Q2: 4.79
Fall 2010 (enrollment 19): Q1:4.30; Q2: 4.50

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

Detail the Special requirements

This course is intended for graduate students, and complements the series of MEMS courses offered as part of a comprehensive MEMS educational program developed by the Center for Wireless Integrated MicroSensing and Systems (WIMS2 (formerly WIMS), http://wims2.org/). The rest of MEMS courses are EECS 414, 425, 509, 514, and 515– see the chart below. The only pre-requisites of this course is EECS 414 to allow students from many engineering or science disciplines, including mechanical, electrical, and aerospace engineering students to take the course. This is a modular course (similar to EECS 514 and EECS 515) and is organized into lectures but can also be offered as separate lecture (3hrs) and discussion (1hr) sessions (per week). The course includes a semester-long project. The requested credit hour for the course is 4, and the class will span over 14 weeks.

This course was offered as 598 in Fall 2010 and Fall 2011.
Here is Q1 and Q2 scores.
Fall 2011 (enrollment 10): Q1: 4.79; Q2: 4.79
Fall 2010 (enrollment 19): Q1:4.30; Q2: 4.50



EECS 598 – RF MEMS INTEGRATED MICROSYSTEMS FALL 2011

COURSE INFORMATION

September 6th, 2011

Instructor: Prof. Mina Rais-Zadeh
Email: minar@umich.edu
(Email is the most reliable and preferred way for contact. When you do send an email, please put "EECS 598" in the subject line)
Office phone: 734-764-4249
Fax: 734-763-9324
Office Hours: Tuesdays-Thursday 2:00 pm–3pm. Location: 2406 EECS

Grader: Binod Karki
Email: bkarki@umich.edu

Lecture: TuTh 3:00 PM – 5:00 PM, 1024 FXB.

Topics: This course covers the operation principle, design, fabrication, and technology trend of high-frequency micromechanical devices with focus on those most used for communication application. Devices and systems covered in this course include resonators, switches, filters, tunable passives, and reconfigurable modules. The need for high-Q devices will be explained in detail and the physical phenomena that limit the performance and scaling of RF MEMS will be discussed. In addition, students will learn about accurate modeling of MEMS in electrical domain, transduction mechanism commonly used in MEMS, and design techniques used to achieve high performance (high power handling, high linearity, low-loss, etc). Other topics will be covered as time permits, and as warranted by the general preparedness of the students. Students are responsible for all materials distributed or covered in the lectures, assigned as reading or homework, etc.

Registration: Overrides will be granted as necessary. Please email me if you need an override.

Prerequisites: **EECS 414 and 411 or MEMS equivalent course approved by instructor;**
In addition to knowing the fundamental of MEMS (standard surface and bulk Si machining techniques, capacitive, piezoresistive, and thermal transduction methods, elementary beam theory, diaphragm deflection, etc.), the students should understand basic IC fabrication technologies (diffusion, implant, oxidation, metallization, RIE, CVD, etc.); **Basic transmission line theory and electromagnetics,** and best if know basic Op-Amp concepts (offset voltage, gain, input and output impedance).

Students should be aware that *this course is not fully self-contained*, i.e. students lacking background knowledge in a particular area will have to do some reading on their own. Since this is a graduate level course, the expectation is that students will be able to learn independently. I am available to help.

Website: The course website is on CTools, UM's web-based course management tool. To reach the website, go to the university CTools homepage at http://ctools.umich.edu

and login with your unique name and password. After you log in, you can click on EECS 598 001 F11. The website will contain course announcements and materials, lecture slides, course assignments, homework and exam solutions, discussion board, and archives of emails sent to the class list. Please check the CTools site regularly.

Email: The class email list is eecs598RFMEMS@ctools.umich.edu. All emails sent to this address will be archived on the CTools website, so if needed you can always look up any old emails sent to the class. Students are free to use this list to email the class as necessary, but keep in mind that it will go to everyone registered for the course.

Again, if you send me an email, please put "EECS 598" in the subject line.

Discussion Board: CTools has a discussion board which we will use this term. Answers to student questions will be posted on the discussion boards so that you can find them quickly. Before emailing me a question, please check the discussion board to see if it has been answered already. Students are also encouraged to post to the discussion board.

Grading: *(Subject to revision)*
Tests: 50% (20% Midterm, 30% Final) Homework: 10%
Project: 40%

Tests: There will be one midterm exam and one final exam. These are closed book tests. One page of notes is allowed for the first one, and two pages are allowed for the second one. See the class schedule for dates.

Homework: There will be only a few homework assignments because students are expected to study the topics covered in lectures in detail on their own. Since there are only a few homework assignments, the relative grade fraction of each assignment can be rather significant. It is possible, for example, to miss a letter grade if you skip even one homework assignment.

All assignments are due at the ***beginning*** of the lecture on the dates specified. Assignments that are turned in after the instructor starts the lecture will be considered late and will be marked off 20% of the maximum grade for that assignment. In general, it is better to do your homework late rather than not at all. Therefore, late homework assignments up to 24 hours late will be accepted for this 20% penalty.

Projects: The project is a very important part of this course, and has a number of components. Students will first work in teams of 3–4 to develop research pre-proposals around RF devices and microsystems. The students will decide on the application of the device or the system proposed. In addition to electromechanical analysis, the RF response of the device should exhibit some advantages over existing art. Once approved, the same teams will develop full proposals, with technical details taken from literature surveys, analytical calculations, and numerical simulations resulting in detailed designs. The proposals will also include research schedules. There will be oral presentations of the proposals, and they will be reviewed by panels formed by the

students based on technical merit and other criteria. Each student will also write an independent evaluation of each proposal. The final grade for each student will depend upon a number of things, including the quality of the team proposal, the level of participation in the panel discussion, and the insight shown in the individual written review. ***The project will be assigned by the end of September and will be ongoing through the semester*** (see the class schedule for dates).

Reading: The students are responsible for all material covered in the lectures, and in supplementary materials assigned for reading or handed out in class. **Please be prepared for reading a lot of material on your own as this is a graduate level class.**

Honor Code: All assignments are to be completed independently by all students, except as specified. Although no interaction is permitted during tests, students are encouraged to discuss other assignments **at a conceptual level** with others taking the same course. Copying any components from any source, be it another student, an assignment from a preceding term, etc., defeats the educational intent of the effort, and will be subject to disciplinary action. In particular, using research materials or projects of other students for your own purpose is not permitted. This course is governed by the Engineering Honor Code.

Attendance: In the interest of promoting classroom discussion, ***students are required to attend all lectures unless special arrangements have been made***. ***There are several days of mandatory attendance.*** These include ALL days of project presentations and project panel evaluations, quiz days, and others. A calendar of these days is attached and will be updated as needed. ***If you have a conflict with any of the yellow-highlighted dates in the course calendar, please email me within the first week of the semester.***

Course Plan: Subject to change; the duration of time spent on each topic depends to some extent on the preparation and background of the students. In general, we will look at RF front end modules and methods of their design and fabrication. The treatment will be as case studies.

Approximate plan:

Introduction (1 lecture)
Basic concepts in RF design (1-2 weeks)
Common mechanical structures in MEMS (1-2 lectures)
Drop Bordoni paper; include G&M notes + Pierce paper
Mechanical Modeling of MEMS Devices (1-2 weeks)
Switches (2 weeks)
Add the. noise from Bordoni + mix in th. oscillators from Yoon or Makinwa
Tunable Capacitors, VCOs (1 weeks)
Add Gabrielson noise; ADXL architecture; Haluk and Jun
High-Q inductors and tunable inductors (1 lecture)
Tunable filters (and phase shifters if time permits) (1 week)
Mechanical resonators (2-3 lectures)
Micromachined antennas (2 lectures)

Packaging, reliability and power handling (1 week)
Add DeHennis, Fatih Kocer stuff
Packaging: Arvind Salain Chapter

Text: Recommended: Theory, Design and Technology, *John Wiley & Sons, Inc.*, Gabriel M. Rebeiz (available online at

http://proxy.lib.umich.edu/login?url=http://dx.doi.org/10.1002/0471225282)

Supplementary Materials and References:

A handful of relevant references are being placed on reserve for this course in the Art, Architecture & Engineering Library (Duderstadt Center). You are encouraged to use these resources. In addition, a list of potential reference is provided below for your convenience:

References – Books

D. Pozar, *Microwave Engineering*, Wiley; 2 Edition, 1997
R. R. Tummala, M. Swaminathan, *Introduction to system-on-package (SOP): miniaturization of the entire system,* McGraw-Hill Professional, 2008
S.D. Senturia, *Microsystem Design,* Boston: Kluwer Academic Publishers , 2001
T. H. Lee, *Planar Microwave Engineering: A Practical Guide to Theory, Measurement, and Circuits*, Cambridge University Press, 2004
G. T.A. Kovacs, *Micromachined Transducers Sourcebook,* McGraw Hill, 1998
S.M. Sze, ed., *Semiconductor Sensors*, New York: John Wiley, 1994
M. Madou, *Fundamentals of Microfabrication*, New York: CRC Press, 1997
S. Wolf, *Silicon Processing for the VLSI Era, Vol. 2 – Process Integration,* Sunset Beach, California: Lattice Press, 1990
R.S. Muller and T.I. Kamins, *Device Electronics for Integrated Circuits*, New York: John Wiley
S.M. Sze, *Physics of Semiconductor Devices,* New York: John Wiley, 1981
A.S. Sedra and K. C. Smith, *Microelectronic Circuits*, 4th ed., NY: Oxford University Press, 1998
Richard C. Jaeger, *Microelectronic Circuit Design*, McGraw Hill, 1997

References – Journals

IEEE Journal of Microelectromechanical Systems (JMEMS)
IEEE Transaction on Ultrasonics, Ferroelectrics, and Frequency Control
IOP Journal of Micromechanics and Microengineering (JMM)
IEEE Transaction on Microwave Theory and Technique (TMTT)
IEEE Transactions on Components and Packaging Technology (TCPT)
Sensors and Actuators
Sensors and Materials
IEEE Sensors
IEEE Transactions on Electron Devices

References – Conference Proceedings

IEEE Micro Electro Mechanical Systems Workshop (MEMS, every year)
International Conference on Solid-State Sensors and Actuators (Transducers, odd years)
Solid-State Sensor and Actuator Workshop (Hilton Head Island, even years)
IEEE International Electron Devices Meeting (IEDM, every year)
IEEE International Microwave Symposium (IMS, every year)
IEEE Silicon Monolithic Integrated Circuits in RF Systems (SiRF, every year)
Various other conferences held by the IEEE, American Vacuum Society, or the Electrochemical Society sometimes have special sessions devoted to MEMS-related topics

Online Tools

Note that some of the links include 'proxy.lib.umich.edu', which takes you to the websites through UM's proxy server. If you use these links you will be able to access the journal articles while you are off-campus. You will need to login with your unique name to access the proxy link.

- **Engineering Village** (http://www.engineeringvillage.org.proxy.lib.umich.edu)
  Engineering/Science articles – INSPEC and COMPENDEX databases
- **IEEE Explore** (http://ieeexplore.ieee.org.proxy.lib.umich.edu)
  IEEE journals and conference proceedings
- **ISI Web of Science** (http://www.isiknowledge.com.proxy.lib.umich.edu)
  Science and engineering articles, good for citation searching
- **Google Scholar** (http://scholar.google.com.proxy.lib.umich.edu)
  All articles, easy search.
- **UMich Search Tools** (http://searchtools.lib.umich.edu)
  New tool for searching online journal articles and books owned by the library
- **UMich library website** (http://www.lib.umich.edu/ejournals)
  Access all of UMich's subscribed journals (humanities/sciences/engineering)

EECS 598 Fall 2011 - Course Calendar

(as of 12/01/2011, subject to change)

	Mandatory Attendance on highlighted days	
Date	**Topic**	**Assignments/Due Dates**
Tuesday, September 06, 2011	Class Introduction and Outline	Student Information Survey
Thursday, September 08, 2011	Basic Concepts in RF Design	
Tuesday, September 13, 2011	Common Mechanical Structures in MEMS	
Thursday, September 15, 2011		Project Teams are defined Homework #1 assigned
Tuesday, September 20, 2011	Common Mechanical Structures, Electrostatic Force	
Thursday, September 22, 2011	Mechanical Modeling of MEMS Devices	**Homework #1 Due**
Tuesday, September 27, 2011	Switches	**Preproposals due**
Thursday, September 29, 2011		
Tuesday, October 04, 2011	Tunable Capacitors	Homework #2 assigned
Thursday, October 06, 2011	Tunable Capacitors & VCOs	
Tuesday, October 11, 2011		**Homework #2 Due,** Homework #3 assinged
Thursday, October 13, 2011	***Midterm***	
Tuesday, October 18, 2011	No class-- Fall Study Break	**Project Proposals Due**
Thursday, October 20, 2011	Mechanical Resonators	**Homework #3 Due**
Tuesday, October 25, 2011	***Project updates***	**Project update slides Due-9AM**

Thursday, October 27, 2011	Mechanical Resonators	
Tuesday, November 01, 2011	Guest Lecture on PN limit of Q	
Thursday, November 03, 2011		
Tuesday, November 08, 2011	Inductors	**Project Updates Due**
Thursday, November 10, 2011	Tunable Filters	
Tuesday, November 15, 2011		Homework #4 assigned
Thursday, November 17, 2011		
Tuesday, November 22, 2011	Mechanical Filters	**Homework #4 Due**
Thursday, November 24, 2011	No class- Thanksgiving recess	
Tuesday, November 29, 2011	***Project presentations- Panel review***	**Project Presentations Due- 9AM**
Thursday, December 01, 2011	***Project presentations- Panel review;*** Finish mechanical filter	
Tuesday, December 06, 2011	No class	**Project report due**
Thursday, December 08, 2011	***Final***	
Tuesday, December 13, 2011	No class	**Project Evaluations Due**

INDUSTRIAL AND OPERATIONS ENGINEERING

UNIVERSITY of MICHIGAN ■ COLLEGE of ENGINEERING

IOE Masters Program:

Concentration in **Healthcare Engineering and Patient Safety ("HEPS")**

The HEPS concentration is a three semester program
that is conducted while simultaneously fulfilling the IOE masters requirements.

For those IOE masters students who plan to use their degree to work in the healthcare industry, this concentration will uniquely position you for success in your field. This is a small, selective program in which students not only fulfill the requirements of an IOE masters but simultaneously:

- Work closely with and form a community of other HEPS students as well as students of medicine, nursing and public health; faculty members; clinicians; and healthcare industry mentors
- Attend monthly dinners for socializing and networking as well as learning about important topics in the healthcare industry
- Complete a year-long project (January to December, part time during the winter and fall semesters and full time during the summer) solving a real-world problem within a multi-disciplinary team of engineering and healthcare students and faculty
- Have opportunities to tour healthcare facilities and "shadow" physicians and other practitioners within hospital and other clinical settings
- Get customized guidance from a faculty advisor to help select courses and shape your program

To apply for the HEPS concentration, the following materials are required:

- A one-to-two page statement of interest, explaining your background, your reasons for choosing an IOE masters, and your interests in healthcare.
- A 1 - 3 minute video about who you are and why you want to join the concentration. This can be as simple as a video shot from your cell phone or computer camera, or you narrating a short Powerpoint presentation of why you are interested in the program. Feel free to be creative! If your video is too large to send as an attachment, please post it to the internet (e.g. YouTube) and send us the link.
- A copy of your resume and transcript.

⇒ Application deadline: **June 1** (prior to Fall start)

⇒ Acceptance notification: **July 1**

⇒ ***Applications*** to Mr. Gene Kim, CHEPS Administrator: genehkim@umich.edu

⇒ ***Questions*** to Professor Amy Cohn, Program Advisor: amycohn@umich.edu

⇒ For IOE Masters candidates interested in a Winter start, or for interested IOE undergrad students, please contact us and we will address case by

Revised October 2012

IOE Masters Program:

Concentration in **Healthcare Engineering and Patient Safety ("HEPS")**

Requirements for Concentration in HEPS

- Fulfill all requirements for IOE masters program
- 3 semesters (Fall, Winter, Fall)
- Complete year-long program-designed hands-on project (3 credits 2nd semester, full-time summer, 3 credits 3rd semester)
- Satisfy the following course requirements:
    - IOE 691: Providing Better Healthcare Through Systems Engineering: Seminars and Discussions—*must be taken first semester* (Fall):
    - Statistics/Data Analysis: 1 course
    - Intro to Healthcare: 2 courses
    - Technical Core: 2 courses
    - Methodology: 2 courses
    - Program Focus: 2 courses

One of the most critical challenges faced by our society is the need for safe, effective, affordable, and accessible healthcare. Industrial engineers can play a high-impact role in achieving this through taking a systems-based approach to manage healthcare delivery. To that end, the Center for Healthcare Engineering and Patient Safety ("CHEPS") brings together engineers, healthcare providers, and many others to tackle these important problems. UM is uniquely positioned for such a Center, with a world-class College of Engineering, Medical School, School of Public Health, Nursing School, Business School, and more. And even more uniquely, these units are all within close proximity to each other, facilitating tight-knit collaborations.

- Professor Jim Bagian, MD, PE
  Director, CHEPS
- Professor Amy Cohn, PhD
  Associate Director, CHEPS
  HEPS Program Advisor

CHEPS Center for Healthcare Engineering & Patient Safety

Sample Course Schedule for Concentration in HEPS

First semester (Fall)

- IOE 691: Providing Better Healthcare through Systems Engineering: Seminars & Discussions (2 cred.)
- IOE 413: Optimization Modeling in Health Care (3 cred.)
- STATS 500: Applied Statistics I (3 cred.)
- HMP 600: The Health Services System I (3 cred.)
- HMP 610: Cost-Effectiveness Analysis in Health (3 cred.)

Second semester (Winter)

- Project (3 cred.)
- HMP 601: Control of Quality & Costs of Health Care (3 cred.)
- IOE 463: Measurement & Design of Work (3 cred.)
- IOE 434: Human Error & Complex System Failures (3 cred.) or IOE 474: Simulation (4 cred.)
- IOE 510: Linear Programming (3 cred.)

Third semester (Fall)

- Project (3 cred.)
- IOE 513: Providing Better Health Care through Systems Engineering: Operations Research Applications & Techniques (3 cred.)
- IOE 515: Stochastic processes (3 cred.)
- IOE 425: Manufacturing Strategies (2 cred.)

Thanks to a generous gift from **The Seth Bonder Foundation**, students may apply for competitive scholarships to assist in paying tuition costs. For more details and to apply for scholarship support, contact the program director, Professor Amy Cohn, at amycohn@umich.edu.

IOE Masters Degree Concentration in Healthcare Engineering and Patient Safety (*HEPS*)

One of the most critical challenges faced by our society is the need for safe, effective, affordable, and accessible healthcare. Industrial engineers can play a high-impact role in achieving this through taking a systems-based approach to manage healthcare delivery. To that end, the University of Michigan has recently launched a new Center for Healthcare Engineering and Patient Safety (http://sitemaker.umich.edu/cheps/about_cheps) to bring together engineers, healthcare providers, and many others to tackle these important problems. UM is uniquely positioned for such a Center, with a world-class College of Engineering, Medical School, School of Public Health, Nursing School, Business School, and more. And even more uniquely, these units are all within close proximity to each other, facilitating tight-knit collaborations.

For those IOE masters students who plan to use their degree to work in the healthcare industry, we offer a concentration in healthcare engineering and patient safety (*HEPS*) that will uniquely position you for success in your field. This is a small, selective program in which students not only fulfill the requirements of an IOE masters but simultaneously:

- Work closely with and form a community of other HEPS students as well as students of medicine, nursing and public health; faculty members; clinicians; and healthcare industry mentors
- Attend monthly dinners for socializing and networking as well as learning about important topics in the healthcare industry
- Complete a year-long project (January to December, part time during the winter and fall semesters and full time during the summer) solving a real-world problem within a multi-disciplinary team of engineering and healthcare students and faculty
- Have opportunities to tour healthcare facilities and "shadow" physicians and other practitioners within hospital and other clinical settings
- Get customized guidance from a faculty advisor to help select courses and shape your program

The HEPS concentration is a three semester program with its own requirements that is conducted while simultaneously fulfilling the IOE masters requirements. The remainder of this document explains these requirements and provide a sample course of study.

To apply for the HEPS concentration, please send the following materials electronically to Mr. Gene Kim (genehkim@umich.edu) by June 1:

- A one-to-two page statement of interest, explaining your background, your reasons for choosing an IOE masters, and your interests in healthcare.
- A brief (1 - 3 minute) video introducing yourself and telling us a little bit about who you are and why you want to join the concentration. This can be as simple as a video shot from your cell phone or computer camera. Alternatively, the video can simply be you narrating a short Powerpoint presentation of why you are interested in the program. Feel free to be creative! If

your video is too large to send as an attachment, please post it to the internet (e.g. YouTube) and send us the link.

- A copy of your resume and transcript.

For more information, please contact Professor Amy Cohn by email (amycohn@umich.edu) or phone (734 615-7258).

Requirements for Concentration in Healthcare Engineering and Patient Safety

1) Fulfill all requirements for the IOE masters program
    a. At least 30 hours of graduate credit, at least 14 of these at 500 level
    b. At least 8 IOE credits at 500 level
    c. At least 18 credits in IOE
    d. See IOE masters documentation for remaining requirements

2) Three semesters (Fall, Winter, Fall)

3) Complete year-long program-designed hands-on project (3 credits 2nd semester, full-time summer, 3 credits 3rd semester)

4) Satisfy the following course requirements:

    a. **IOE 691: Providing Better Healthcare Through Systems Engineering: Seminars and Discussions** – Must be taken first semester (fall)

    b. At least one course in statistics/data analysis:
        i. IOE 460: Decision Analysis
        ii. IOE 465: Design and Analysis of Experiments
        iii. IOE 466: Statistical Quality Control
        iv. STATS 500: Applied Statistics I
        v. STATS 503: Multivariate Statistics
        vi. IOE 560 / STAT 550: Bayesian Decision Analysis
        vii. IOE 562: Reliability
        viii. IOE 565: Time Series Modeling, Analysis, Forecasting
        ix. IOE 570: Experimental Design
        x. BIOSTAT 513: Application of Regression Analysis to Public Health Studies
        xi. BIOSTAT 523: Biostatistical Analysis for Health-Related Studies
        xii. BIOSTAT 605: Intro to SAS Statistical Programming
        xiii. BIOSTAT 675: Survival Time Analysis
        xiv. BIOSTAT 682: Applied Bayesian Inference

    c. At least two of the following courses (Intro to Healthcare):
        i. HMP 601: Control of Quality and Costs of Health Care
        ii. HMP 602: Survey of the U.S. Health Care System
        iii. EPID 503: Strategies and Uses of Epidemiology
        iv. ANAT 403: Human Anatomy: Structure and Function
        v. PHYS 502: (Human Physiology)
        vi. BME 519: Bioengineering Physiology

d. At least two of the following courses (Technical Core):
    i. IOE 425: Manufacturing Strategies
    ii. IOE 432: Industrial Engineering Instrumentation Methods
    iii. IOE 434: Human Error and Complex System Failures
    iv. IOE 463: Measurement and Design of Work
    v. IOE 474: Simulation
    vi. IOE 574: Simulation Analysis

e. At least two of the following courses (Methodology):
    i. IOE 416: Queueing Systems
    ii. IOE 421: Work Organizations
    iii. IOE 440: Operations Analysis and Management
    iv. IOE 449: Material Handling Systems
    v. IOE 510: Linear Programming I
    vi. IOE 511: Continuous Optimization Methods
    vii. IOE 512: Dynamic Programming
    viii. IOE 515: Stochastic Processes I
    ix. IOE 516: Stochastic Processes II
    x. IOE 518: Introduction to Integer Programming
    xi. IOE 519: Introduction to Nonlinear Programming
    xii. IOE 522: Theories of Administration
    xiii. IOE 534: Occupational Biomechanics
    xiv. IOE 536: Cognitive Ergonomics
    xv. IOE 541: Inventory Analysis and Control
    xvi. IOE 543: Scheduling
    xvii. IOE 545: Queueing Networks
    xviii. IOE 551: Benchmarking, Productivity Analysis and Performance Measurement
    xix. IOE 566: Advanced Quality Control
    xx. IOE 567: Work-Related Musculoskeletal Disorders
    xxi. IOE 615: Advanced Stochastic Processes
    xxii. IOE 616: Queueing Theory
    xxiii. IOE 640: Mathematical Modeling of Operational Systems
    xxiv. EECS 484: Database Management Systems
    xxv. EECS 558: Stochastic Control

f. At least two of the following courses (Program Focus):
    i. IOE 413: Optimization Modeling in Health Care
    ii. IOE 438: Occupational Safety Management
    iii. IOE 513: Providing Better Health Care through Systems Engineering: Operations Research Applications and Techniques
    iv. IOE 533: Human Motor Behavior and Engineering Systems

v. IOE 534: Occupational Biomechanics
vi. IOE 539: Safety Engineering Methods
vii. IOE 567: Work-Related Musculoskeletal Disorders
viii. HMP 553: Data Management in Health Care
ix. HMP 610: Cost-Effectiveness Analysis in Health
x. HMP 612: Medical Management of Disease
xi. HMP 625: Health Law
xii. HMP 654: Operations Research and Control Systems
xiii. HMP 655: Decision Making Models in Health Care
xiv. HMP 668: Introduction to Health Informatics
xv. HMP 669: Database Systems and Internet Applications in Health Care
xvi. HMP 826: Applied Econometrics in Health Services Research
xvii. NURSING 636: Patient Safety and Quality Outcomes: Methods and Leadership
xviii. BME 510: Medical Imaging Laboratory
xix. BME 516: Medical Imaging Systems
xx. EECS 556: Image Processing
xxi. NERS 583: Applied Radiation Dose Assessment

Sample Template for Concentration in Healthcare Engineering

First semester (Fall)

- IOE 691: Providing Better Healthcare through Systems Engineering: Seminars and Discussions (2 credits)
- IOE 413: Optimization Modeling in Health Care (3 credits)
- STATS 500: Applied Statistics I (3 credits)
- HMP 600: The Health Services System I (3 credits)
- HMP 610: Cost-Effectiveness Analysis in Health (3 credits)

Second semester (Winter)

- Project (3 credits)
- HMP 601: Control of Quality and Costs of Health Care (3 credits)
- IOE 463: Measurement and Design of Work (3 credits)
- IOE 434: Human Error and Complex System Failures (3 credits) or IOE 474: Simulation (4 credits)
- IOE 510: Linear Programming (3 credits)

Third semester (Fall)

- Project (3 credits)
- IOE 513: Providing Better Health Care through Systems Engineering: Operations Research Applications and Techniques (3 credits)
- IOE 515: Stochastic processes (3 credits)
- IOE 425: Manufacturing Strategies (2 credits)

Aug 27, 2012

Requirements for Concentration in Healthcare Engineering

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    b. At least 8 IOE credits at 500 level
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4) Satisfy the following course requirements:

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        viii. IOE 565: Time Series Modeling, Analysis, Forecasting
        ix. IOE 570: Experimental Design
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    xvi. IOE 543: Scheduling
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    xviii. IOE 551: Benchmarking, Productivity Analysis and Performance Measurement
    xix. IOE 566: Advanced Quality Control
    xx. IOE 567: Work-Related Musculoskeletal Disorders
    xxi. IOE 615: Advanced Stochastic Processes
    xxii. IOE 616: Queueing Theory
    xxiii. IOE 640: Mathematical Modeling of Operational Systems
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    iii. IOE 513: Providing Better Health Care through Systems Engineering: Operations Research Applications and Techniques
    iv. IOE 533: Human Motor Behavior and Engineering Systems

v. IOE 534: Occupational Biomechanics
vi. IOE 539: Safety Engineering Methods
vii. IOE 567: Work-Related Musculoskeletal Disorders
viii. HMP 553: Data Management in Health Care
ix. HMP 610: Cost-Effectiveness Analysis in Health
x. HMP 612: Medical Management of Disease
xi. HMP 625: Health Law
xii. HMP 654: Operations Research and Control Systems
xiii. HMP 655: Decision Making Models in Health Care
xiv. HMP 668: Introduction to Health Informatics
xv. HMP 669: Database Systems and Internet Applications in Health Care
xvi. HMP 826: Applied Econometrics in Health Services Research
xvii. NURSING 636: Patient Safety and Quality Outcomes: Methods and Leadership
xviii. BME 510: Medical Imaging Laboratory
xix. BME 516: Medical Imaging Systems
xx. EECS 556: Image Processing
xxi. NERS 583: Applied Radiation Dose Assessment

Proposal for a Concentration in Healthcare Engineering and Patient Safety within the IOE Masters Program

Amy Cohn, IOE

November, 2012

CHEPS Center for Healthcare Engineering & Patient Safety

Proposal

- We have introduced a new “concentration” within the IOE masters program, entitled “Healthcare Engineering and Patient Safety”
- We seek approval to have the concentration title appear on the student transcript, and seek to clarify our understanding of the issues of having this appear (or, more likely, not) on the diploma

CHEPS Center for Healthcare Engineering & Patient Safety

Motivation

- Target audience: Students desiring an IOE masters with plan to apply their degree in a healthcare setting upon graduation
- Goal is to complement their technical education in core IOE methodology with language, culture, and communication skills needed to work in healthcare, and develop hands-on, open-ended problem solving skills

Background

- Creation of *CHEPS*
- Educational mission:
  - "To improve patient outcomes, reduce risk of harm, and increase the efficiency of the healthcare system by educating current and future healthcare providers, public health officials, engineers, administrators and others working in the healthcare industry about how and why to apply systems-based engineering approach to healthcare"

Program Description

- Three-semester masters, beginning in the fall semester
- Course requirements supplemental to the Rackham requirements
- Monthly informal networking events
- Year-long applied, multi-disciplinary, open-ended project

CHEPS Center for Healthcare Engineering & Patient Safety

Course Requirements

- **IOE 691: Providing Better Healthcare Through Systems Engineering: Seminars and Discussions** – Must be taken first semester (fall)
- At least one course in statistics/data analysis
- At least two courses on the healthcare system
- At least two courses in the IOE technical core
- At least two methodology courses
- At least two courses in the area of program focus

Networking Events

- Monthly informal opportunities to interact with other students (from multiple disciplines), engineering faculty, clinicians, faculty in other units (medicine, nursing, public health, etc.), and healthcare officials
- September 2012: Back-to-school barbeque
- October 2012: Healthcare reform on the 2012 election

Applied Project

- Part of a 4+ person team
  - Student from medicine, nursing, etc.
  - Engineering faculty member
  - Clinician or project expert
- Winter Semester: 3 credits directed study
  - Weekly meetings, shadowing, site visits
  - “The Engineer’s Guide to …”
  - Scoping the project
- Summer: “Full” time
  - Largely in the clinical environment
- 2nd Fall Semester: 3 credits directed study
  - Journal article or poster prepared
  - National professional society meeting
  - Compete to present in seminar series

CHEPS Center for Healthcare Engineering & Patient Safety

Application Process

- Upon successful application to IOE masters
- 1 – 2 page statement of interest
- Brief video statement
- Resume and transcript

CHEPS Center for Healthcare Engineering & Patient Safety

Funding Issues

- Support for summer projects
- Fellowships

CHEPS Center for Healthcare Engineering & Patient Safety

Current State

- Approved within IOE
- First two students enrolled September 2012
  - Description of students
  - Description of projects
- Potential for “late starts” in January 2012
- Actively recruiting for September 2013

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