THE UNIVERSITY OF MICHIGAN
COLLEGE OF ENGINEERING
CURRICULUM COMMITTEE

AGENDA

February 11

Tuesday, ~~January 28~~, 2014

1:30-3:00pm

1180 Duderstadt Center

1. Minutes Update: in drafting stage, not ready to be approved

2. Course Approval Forms

Summary of Submitted Course Approval Request Forms:

BIOMEDE 458: Modification of Existing Course (with supporting documentation) PAGE 2
– Course Description/PreReq/Effective WT 2014

ENGR 345: New Course (with supporting documentation) PAGE 13
--Effective WT 2014

IOE 432: Modification of Existing Course PAGE 19
--Prereq/Effective FT 2014

IOE 438: Modification of Existing Course PAGE 21
--Prereq/Effective WT 2014

ISD 503: New Course – NOTE: Level of Credit is "Non-Rckhm Grad" PAGE 23
--Effective WT 2014

MECHENG 584(MFG 584): Modification of Existing Course (with supporting statement) PAGE 25
--NOTE: Level of Credit is "Rackham Grad"
--Title/Description/Prereq/Section C/Effective WT 2014

NAVARCH 514: New Course (with supporting documentation) PAGE 28
--Effective FT 2014

ROBOTICS 501(AEROSP 501/EECS 501/MECHENG 501/NAVARCH 501): New Course PAGE 36
– NOTE: Level of Credit is "All Credit Types"/Effective FT 2014

ROBOTICS 550 (AEROSP 550/EECS 550/MECHENG 550/NAVARCH 550): New Course PAGE 38
– NOTE: Level of Credit is "All Credit Types"/Effective FT 2014

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

Form Number 2352

Date 3/5/2013

Effective Term ~~Fall 2013~~ 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	B. REQUESTED LISTING
Home Department / Course Number		BIOMEDE Biomedical Engineering 458
☐ Cross Listed Course Information		EECS Elec Engin & Computer Sci 458
☐ Course Title		Biomedical Instrumentation and Design
TITLE ABBREVIATION – Time Sched (Max = 19 Spaces)		Biomed Instrum Des
TITLE ABBREVIATION – Transcript (Max = 20 Spaces)		BiomedInstrum Des
X Course Description / Course Description for Official Publication (Max = 50 words)	Measurement and analysis of biopotentials and biomedical transducer characteristics; electrical safety; applications of integrated circuits and operational amplifiers for signal processing and computer interfacing; signal analysis and display on a personal computer; invasive and noninvasive biosensors; noninvasive pressure and flow measurements. Lectures and lalboratory.	Students design and construct functioning biomedical instruments. Hardware includes instrumentation amplifiers and active filters constructed using operational amplifiers. Signal acquisition, processing analysis and display are performed using LabVIEW software. Project modules include measurement of respiratory volume and flow rates, biopotentials (electrocardiogram), and optical analysis of arterial blood oxygen saturation (pulse-oximetry).
PROGRAM OUTCOMES	☐a ☐b ☐c ☐d ☐e ☐f ☐g ☐h ☐i ☐j ☐k	☒a ☒b ☒c ☒d ☒e ☒f ☒g ☐h ☒i ☒j ☒k
Degree Requirements	○ Degree Requirement ○ Core Course ○ Free Elective ○ Tech Elective ○ Other	◉ Degree Requirement ○ Core Course ○ Free Elective ○ Tech Elective ○ Other
X Prereq	○ Enforced ○ Advised	BiomedE 211 and 241, or at least one of EECS 215, EECS 314, or have graduate standing. ◉ 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 ☐ R	☐ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☒ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☐ All Credit types ☐ I
Credit Hours (Min / Max)		4 / 4
Contact Hrs/Wk		4
Number of Wks		14

C.

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

☐ **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:	Title
Sherman Fan	Assoc. Professor
Dennis Claflin	Res. Scientist

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.	Biomedical Engineering		DCM
Cross-listed Dept(s).	Elec Engin & Computer Sci		[signature]

Form Number

2352

SUPPORTING STATEMENT

The change in course description is to keep the course current with the updating of modules within the course. The change in prerequisites is to ensure students have the appropriate background to perform well in the course.

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

Detail the Special requirements

Dry lab, 1105 LBME

Course Profile: Biomedical Engineering Program

COURSE #: BIOMEDE 458	**COURSE TITLE:** BIOMEDICAL INSTRUMENTATION AND DESIGN
TERMS OFFERED: Fall and Winter	**PREREQUISITES:** BIOMEDE 211 and 241 or at least one of EECS 215 or EECS 314, or have graduate standing.
TEXTBOOK/REQUIRED MATERIAL: none	**COGNIZANT FACULTY:** X. Fan, D. Claflin **DATE OF PREPARATION:** 3/5/2013
INSTRUCTOR(S): Various	**SCIENCE/DESIGN:** 2/2
CATALOG DESCRIPTION: Students design and construct functioning biomedical instruments. Hardware includes instrumentation amplifiers and active filters constructed using operational amplifiers. Signal acquisition, processing analysis and display are performed using LabVIEW software. Project modules include measurement of respiratory volume and flow rates, biopotentials (electrocardiogram), and optical analysis of arterial blood oxygen saturation (pulse-oximetry).	**COURSE TOPICS:** 1. Transducer operations and design. 2. Differential and instrumentation amplifiers. 3. Signal and data processing. 4. Biological interface. 5. System integration.

COURSE OBJECTIVES*	1. To teach students how to design, select, and configure the appropriate transducer to acquire a biopotential from a living system. [1,2,3,4,5,6,9,10,11,12,13,14] 2. To teach students how to select and configure the appropriate biosensor to acquire physiologic information from a living system. [1,2,3,4,5,6,9,10,11,12,13,14] 3. To teach students how to interface sensing devices to an appropriate digital acquisition system. [1,2,3,4,5,9,10,11] 4. To teach students how to process experimental data for quantitative analysis. [1,2,4,5,6,11,13,14] 5. To enhance students' communication skills through formal reports and presentations. [7]

COURSE OUTCOMES*	1. Measure properties of polarizable and non-polarizable bioelectrodes. [1,2,4,5,6,8,9,10,11] 2. Construct an instrumentation amplifier interfacing a biosensor to a data acquisition system. [1,2,4,5,6,8,9,10,11] 3. Develop controls for a digital data acquisition system. [1,2,4,5,6,8,9,10,11] 4. Develop data acquisition methods for synchronization and signal averaging, [1,2,4,5,6,8,9,10,11] 5. Learn simple statistical methods to analyze experimental data. [1,2,4,5,6,8,9,10,11,13,14] 6. Investigate biosensors and how to calibrate these sensors. [1,2,4,5,6,8,9,10,11] 7. Measure static and dynamic characteristics of several common biosensors. [1,2,4,5,6,8,9,10,11] 8. Learn techniques for general laboratory safety, especially electrical safety requirements for instruments interfacing with living systems. [6,8,9,10,14] 9. Document laboratory experiences in both laboratory notebooks and formal laboratory reports. [6,7,8,9,10]
ASSESSMENT TOOLS	1. In class examinations. 2. Individual laboratory notebooks. 3. Individual and group laboratory reports. 4. Written proposal of course project. 5. Oral presentation on results of course project. 6. Group final report on results of course project. 7. In-class demonstration of course project.

BME / EECS 458: Biomedical Instrumentation and Design (Fall 2012)

(Last updated: 08/20/2012)

Website: ctools.umich.edu

This syllabus contains important information regarding the grading criteria and course procedures. Please read this document carefully.

I. General information

Instructor: Xudong (Sherman) Fan, Ph.D. 2158 Lurie Biomedical Engineering Building Office: 734-763-1273 xsfan@umich.edu **Instructor:** Dennis R. Claflin, Ph.D. 2232 Lurie Biomedical Engineering Building Office: 734-615-2598 claflin@umich.edu	Office hours: Monday 5:00 – 6:00 pm or by appointment Office hours: Monday 5:00 – 6:00 pm or by appointment
Lab Manager & Safety Officer: Dana Jackson 2117 Lurie Biomedical Engineering Office: 734-647-9828 dmjackso@umich.edu	Office hours: by appointment
GSI: Abdulrahman Aref awaref@umich.edu	Section 2 (Tu, Th 2:30-5:30 PM) Office hours: Tuesday 1:30-2:30 PM
GSI: Patrick Ingram pni@umich.edu	Section 3 (Tu, Th 6:30-9:30 PM) Office hours: Tuesday 5:30 to 6:30 pm
GSI: Jing Liu eunicelj@umich.edu	Section 4 (Tu, Th 9:30 AM-12:30 PM) Office hours: Tuesday 12:30 - 1:30 PM
GSI: Sakib Elahi sfelahi@umich.edu	Section 5 (Mo, We 6:30-9:30 PM) Office hours: Wednesday 5:30 – 6:30 PM

Lecture: 1013 DOW, Monday 4:00 – 6:00 PM (4:00 – 5:00 is for lecture and 5:00 – 6:00 is reserved for possible additional lecture or office hour).

Laboratory: 1105 LBME

Course Materials

- Required: Course notes, lab handouts, and associated documents (available by download from CTools, Resources), 192-page-lab notebook (individual, can be purchased in LBME right before lab session. The cost will be $20 and can be paid in cash or check made out to Biomedical Engineering Society)
- Text book: *Medical Instrumentation: Application and Design*, J. G. Webster (Ed.), 4th edition. John Wiley & Sons. (not required, available in the library)

CTools course website

Refer to the CTools course website (BIOMEDE 458 001 F12) for all course information, including lab handouts, lecture slides and syllabus. Course communication will be via CTools "Announcements". Lab reports are submitted to group-specific CTools folders for archiving purposes (details below).

II. Lecture Topics, Lab Projects, Schedule

Lecture Topics: The following topics will be covered during the Monday lectures: overview of biomedical instrumentation, instrumentation basics, LabVIEW basics, circuit basics, operational amplifiers, active filters, analog-digital conversion, sampling, signal processing, spirometry, electrocardiography (ECG), pulse oximetry.

Lab Projects: The project topics and number of 3-hour lab periods devoted to each are listed below:

	Project Topic	Number of lab periods
1.	LabVIEW	1
2.	Module 1: Introductory Lab	5
3.	Module 2: Spirometry	4
4.	Module 3: ECG	4
5.	Module 4: Pulse Oximetry	4
6.	Design Project	7

Schedule: The links below point to Section-specific calendars that provide explicit lecture times, lab times and topics, due dates, etc. Note that you can toggle different aspects of the calendar (on/off) with checkboxes accessed using the small "down arrow" to the right of the "Agenda" tab (top-right of calendar). The calendars are also accessible via CTools (Resources, Calendars).

Sec 2 Calendar   Sec 3 Calendar   Sec 4 Calendar   Sec 5 Calendar

Important Dates: These are on the Course Calendars (links above), but repeated below for emphasis.

Date		Event
September	4	Lab Orientation
	5	Lab Orientation
	10	No lecture
	24	Homework 1 due
October	1	Homework 2 due
	11	Lab Practical deadline
	15 & 16	Fall Study Break (no lecture, labs)
	29	Design Project proposals due
November	5	Design Project proposals, parts lists & presentation schedules finalized
	12	Design Project proposal oral presentations
	22 & 23	Thanksgiving Break (no labs)
December	10	Design Project final oral presentations (final meeting of class)
December	14	Grades available

Lab Project Descriptions:

General introduction and guidelines for each lab project will be given in lecture. The GSI will also give a brief overview of the lab during the first lab session of each lab project. Lab project handouts will be posted on CTools prior to each lab.

- **LabVIEW** – Tutorial to introduce the LabVIEW graphical programming environment and "virtual instruments". Tutorial concludes with data acquisition using National Instruments A-D hardware.
- **Module 1: Introductory Lab** – Introduction to lab instruments, electronic circuits, programming, testing, data acquisition, signal processing theory, and lab safety.
- **Module 2: Spirometry** – Develop a spirometer system to measure respiratory flow rates.

- **Module 3: ECG** – Develop an electrocardiography (ECG) system to acquire, analyze, and display electrocardiograms.
- **Module 4: Pulse Oximetry** – Develop a system for determining the saturation level of hemoglobin in arterial blood using optical measurements.
- **Design Project** – Develop a prototype instrumentation system that demonstrates proof-of-concept of a biomedical instrument that is selected by the lab group. The project deliverables include design documents, a lab demonstration, an in-class presentation, and a final project report. The instructor(s) will post a list of projects in October for you to choose from. Each group needs to submit their design proposal to the instructor by October 29. The proposal should be 1 page long presenting the project they choose, overall project design, and a parts list. The parts list should contain the name, price, and quantity of the parts you need and where to order them, so that the appropriate parts can be ordered ahead of time. The budget for each design project is $50 per group. The proposal must be approved by the instructor and GSIs by November 5, 2012. If your group has justifiable reasons to change the design after November 5, discuss it with the instructor or your GSI. The parts list cannot be changed after November 5.

III. Lab Groups

The lab projects are performed in groups, with each group consisting of 3-4 students. The lab group will be assigned by GSIs during the first lab session for each Section and finalized by the end of the second lab session for each Section (week of September 10). Students will be assigned to groups with the goal of balancing expertise; each group will have at least one member with LabVIEW experience and one with circuit experience (based on a questionnaire you will fill out). For each lab project, each group will designate 1-2 hardware engineer(s) (breadboard circuit) and 1-2 software engineer(s) (LabVIEW). Each group member should alternate between hardware and software roles throughout the semester.

IV. Grading Criteria

Lab Practical (individual)	Pass/Fail
Homework (individual)	10 pts
Lab Notebook and Performance (individual)	40 pts
Lab Reports (group)	20 pts
Lab Design Project (group/individual)	30 pts
Total:	**100 pts**

The letter grade associated with the median score is expected to be in the range of "A-" to "B+"

More details on grading criteria for each item are described as follows:

Homework (10 pts) (2 sets, 5 pts for each set)

There will be two homework sets on circuit basics, LabVIEW, and signal processing theory, all covered during the first three weeks.

Due dates are on Course Calendars (see above). Only electronic submission to CTools Dropbox is accepted.

Individual Lab Notebook and Lab Performance (40 pts, 10 pts each for each Module – Introductory Lab, Spirometry, ECG, and Pulse Oximetry) → See Appendix I for details on grading of the Lab Notebook and Lab Performance

Each student should have a scientific lab notebook with a table of contents labeled. The lab notebook will be graded by the GSI after completion of each lab module based on correctness and completeness. You only need to record the notes related to your main responsibility (*i.e.*, software/hardware).

In addition to the Lab Notebook, your performance in lab will be evaluated by the GSI and your group peers for each lab module.

A photocopy of the lab notebook related to each lab module should be turned in to your GSI one week after the completion of the lab module. You keep the original lab notebook for your own lab use. Remember to sign and date the original lab notebook.

Group Lab Reports (20 pts, 5 pts each for each Module – Introductory Lab, Spirometry, ECG, Pulse Oximetry)

At the end of each lab module, each group turns in one lab report to the GSI. "Lab Report Guidelines" are posted on CTools for each module that requires a lab report. Page limits are stated in the guidelines and are strictly enforced. Please note that the page limits include figures (i.e. text + figures ≤ page limit). Use Times New Roman (11 pts or larger) or Arial (10 pts or larger), and 0.75-inch margins. The lab report will be graded by group, *i.e.*, your lab-mates and you will receive the same score for the lab report. You should participate in preparation of each lab report and each group member is required to write at least one report. Learn to be concise and emphasize all key points.

The lab report is due one week after the completion of each lab module. Submission of the lab report consists of 4 steps: 1. giving a hard-copy to the Section GSI and uploading 2. an electronic version of the lab report, 3. the LabVIEW VI, and 4. a photograph of the hardware circuit (breadboard) to your group-specific folder on CTools (Resources, Lab Group Uploads...).

Group Final Lab Design Project (30 pts)

Each group is required to develop a prototype instrumentation system that demonstrates proof-of-concept of a biomedical instrument that is selected by the lab group. Each group will give a 10-minute proposal presentation in the lecture session on November 14 (Monday). The schedule will be determined and notified by November 7. The lab demo of the project will be evaluated in the lab sessions on December 5 and 6 (your last lab session) and the final project presentations will be given on December 10, 2012 (Monday).

The 30 pts will be distributed as follows:

	GSI	Instructor	Peers
Final oral presentation	5 pts	5 pts	-
Final lab demo	5 pts	5 pts	-
Final report	4 pts	-	-
Individual effort	3 pts	-	3 pts

Note: *An assessment of your lab notebook entries for the Final Design Project will be incorporated in the individual effort evaluation given by your GSI.*

Individual Lab Practical (Pass/Fail) → See Appendix II for details

The Lab practical is designed to evaluate the basic skills required for this course (*e.g.*, construct breadboard circuits and build LabVIEW VI). The lab practical handout is given in Appendix II. Complete the Lab Practical yourself without help from others. You are encouraged to complete your Lab Practical test as early as the end of the Introductory Lab module. You can take the Lab Practical as many times as you want, but you have to pass it no later than 5 weeks after the class begins in order to continue the class.

Appendix I

Laboratory Notebook Guidelines

Maintaining a lab notebook is a valuable skill required for work in any lab (academic or industrial). A good lab notebook should allow a second party to read what you did, understand your analysis and, if necessary, repeat your experiment exactly. A useful guideline to keep in mind while maintaining your notebook is that you should be able to pick up your notebook two years later and, given the same apparatus, repeat the experiment to obtain a similar data set. This is not only useful to other parties who need to use your notebook, but can save hours of frustration when preparing manuscripts for scientific publication. More immediately, a well-maintained notebook facilitates trouble-shooting, either on your own or with the assistance of the course instructor or teaching assistants.

You should only write in your lab notebook using a pen, and all entries should be dated. Pages should be numbered, and you are required to sign each page. This is a common practice in both academic and industrial research labs whereby the signee certifies that the work contained on that page is authentic. Your lab notebook should have a table of contents so that it is easy to find your entries.

It is important that the student acknowledge references wherever necessary. Students should however be wary of using internet resources as primary references. In general, you should not use an internet reference unless no other references could be found. In many cases, you may find a primary reference by consulting a particular web page, but in this case it is the primary reference that should be cited.

What is expected for our lab notebook entries?

We do *not* expect you to write a full "formal lab report" in your lab notebook for each project that is performed. This is not the role of a lab notebook. Instead, your lab notebook should be thought of as a log book for each project. Keep the following checklist in mind as you make entries in your notebook.

Laboratory Notebook checklist

- Keep up with the table of contents
- Date and sign each page
- Mark clearly where each new entry begins
- *Do not* tear pages. *Do not* erase or white-out any entries (you can use a single strikethrough line to "correct" an error, but the error must remain legible after the strikethrough).
- Use continuation notes when necessary
- Properly void all blank pages or portions of pages (front and back)
- Enter all information directly into the notebook
- Properly introduce and summarize each experiment
- Include complete details of all first-time procedures
- Include calculations
- Properly cite all references for background materials, designs, *etc.*
- Use a pen (not pencil) for all entries in the notebook

How are your lab notebook and lab performance graded? (10 pts each for Introductory Lab, Spirometry, ECG, and Pulse Oximetry; 40 pts in total)?

Each student should have a scientific lab notebook with a completed table of contents. The lab notebook will be graded by the GSI after completion of each lab module based on correctness and completeness. You only need to record the notes related to your main responsibility (*e.g.*, software/hardware). A photocopy of the lab notebook is due one week after each lab module.

Pre-lab problem set (10% of grade, 1 pt for each module)

Pre-lab problem sets will be given in the lab handouts prior to each lab. Answer and date the pre-lab questions on your lab notebook before the lab. The pre-lab problem sets should be answered by you without consulting other students.

Lab preparation (20% of grade, 2 pts for each module)

Putting some effort into preparation before beginning each lab project will pay large dividends in both your understanding of the project and your ability to finish in a reasonable amount of time. When grading your lab notebook, the GSIs will be looking for evidence that the student prepared for the project in advance. In particular, the student should have read the lab outline provided for the assignment and summarized its objectives in their own words. The student should also have created an brief, informal checklist of what needs to be done to complete the assignment, *i.e.*, what calibrations need to be completed, what samples need to be studied, what data needs to be collected. This will not necessarily be complete, but some forethought by the student will save time during the execution of the project. Remember that you only have a few sessions to complete each project and, due to the nature of some projects, this will require that the student has thought through them in advance. This section should also contain a brief review or discussion of relevant theoretical considerations (both electrical and physiological) and any background that you found useful in terms of understanding the material. Further background may be included in subsequent sections as it is needed. Finally, you should include a preliminary design for your portion of the project. This entails different tasks for each engineering role and would include such things as circuit diagrams and hardware specs for the hardware engineer and LabVIEW screenshots or pseudo-code and system diagrams for the software engineer. References for all information should be properly cited in your notebook.

To summarize, your lab preparation should include:

- Responses to lab-specific questions (pre-lab questions)
- Summary of lab objectives
- Review of theoretical background
- General task checklist
- Student engineering role (hardware or software)
- Preliminary design

Project execution (20% of grade, 2 pts for each module)

As you perform the project, you should keep a running log of what was done *in your own words*. Data should be recorded as it is collected, with units included. If appropriate, the data should be presented in a clearly labeled table. If a mistake is made, do *not* erase the data. Instead, draw a single line neatly through the data, as this data may in the future prove to not be incorrect after all. Note sources of error.

Basic analysis of your data should be performed as you work to verify that your results are reasonable and/or expected. This can save much frustration later when you attempt to perform more rigorous calculations based on your data. Furthermore, this is a good time to ask the GSI or the instructor if things are on the right track. You might discover, too late, that you had a problem in the way a piece of apparatus was used or put together. Since part of the grade for lab notebooks will be derived from the quality of the experimental data, it is better to find a mistake when you can do something about it.

The design process for your instrumentation system will likely be iterative. After collecting a data set from your preliminary design, you may find it necessary to change your design and repeat the experiment(s), *etc*. This process should be outlined as succinctly and clearly as possible, with relevant data being shown for each design phase (data relevant to the engineering role of the student).

This section should include:

- Actual experimental setup
- Information about equipment and components used
- Description of how data were collected

- Raw data
- Preliminary analysis and design iteration, as relevant to student role (hardware/software).
- Any other details necessary to evaluate what you did and/or recreate your experiments exactly.

Data analysis (20% of grade, 2 pts for each module)

Upon completion of the data collection portion of the project (collection of final data set), you should immediately analyze your data as recommended in the lab outline. Graphs should be fixed into your lab notebook using tape or glue, not staples. Graphs should be clearly labeled, and any curve-fitting that was performed should be shown together with the raw data so that the reader can judge how well the fit agrees with the experimental data. This section should be roughly similar for every lab group member.

This section should include:

- Description and justification of analytical techniques/algorithms used
- Processed/derived data
- Calculations

Conclusions (10% of grade, 1 pt for each module)

You should include a *concise* conclusion for each project in which you comment on how well the project and associated experiments met your initial objectives, on systematic vs. experimental errors that may be responsible for discrepancies between experimental and expected/theoretical values, and on any problems that were encountered over the course of the experiment. Note that this should be more a summary of the Lab Report conclusions, not a repetition.

Overall lab performance (20% of grade, 2 pts for each module)

Your performance in each lab will be evaluated by the GSI (50% of 2 pts) and your group peers (50% of 2 pts) for each lab module.

Appendix II

Design Lab Practical

Objectives: The Lab Practical is designed to validate your knowledge and lab skills in basic circuit design and testing, signal acquisition, and software development. You must pass the lab practical to pass this course.

Grading: The lab practical is graded as Pass/Fail. In order to pass the course, you must pass the lab practical. You can take the lab practical as many times as necessary, without penalty. However, the professor will be notified of your progress after two failed attempts.

Requirements: Outside materials (*e.g.*, notes) or resources (*e.g.*, LabVIEW files) are *not* allowed. You will be given 1.5 hours to complete the Lab Practical (office hours, overflow lab stations). If you do not complete the practical within the allotted time, you must start from the beginning on your next attempt. If you are taking the practical more than once, bring in all documentation from your previous attempts.

Tasks:

1. Design and build a LabVIEW VI to acquire one analog channel (voltage) and display the sampled waveform and power spectrum for a 2-second block. The VI must save the raw data to disk. Take screenshots of your block diagram and front panel and paste them to a MS Word file.
2. Use your VI to acquire 3 signals with different frequencies from the function generator. Show screenshots of the raw data and its power spectrum. Verify that the power spectrum is accurate and the acquired signal is not aliased by comparing the maximum power spectrum frequency to the input frequency. Be sure to document the amplitude, frequency, and offset settings on the function generator.
3. Use Excel or Matlab to open the data you saved in step 2. Calculate the mean, standard deviation, and RMS for each of the signals using either Excel or Matlab. Verify that the calculated RMS matches what you would expect from the input. Include a plot of one of the signals showing time *vs.* voltage. Indicate the frequency of the signal on the plot. Put the Matlab code or the formulas used in Excel into the MS Word file.
4. Design and build a specified active filter using the LM741 chip. The filter type (low, high, or band-pass), cutoff frequencies, and gain will be specified by the GSI. Please document these design specifications. If the exact specs cannot be met due to limitations in component selection, use the closest possible values.
5. Create a Bode plot for your designed filter to verify that the filter meets the design specs.
6. Turn in all documentation, figures, plots, and codes to the GSI for evaluation.
7. Sign the honor code.

Suggestion: In order to complete the Lab Practical under the 1.5-hour time constraints, it is recommended that you practice the tasks during office hours.

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 ○ Core Course ○ Free Elective ○ Tech Elective ○ Other

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): Intro to Design Proc; Transcript (Max = 20 Spaces):

Course Description for Official Publication (Max = 50 words)

Processes of design, focusing on front-end strategies, including opportunity discovery, problem definition, developing robust mechanisms to gather information from users and other stakeholders, data synthesis methods for translating user data into design requirements, creating innovative solutions during concept generation, and decision-making systems for evaluating possible solutions.

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

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

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

C.

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

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
Title:

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.	Lorelle Meadows	
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/ 345 Introduction to Design Processes

Winter 2014

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, representing design ideas, 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.

The major focus of the course is learning how to take an idea that is based on users and stakeholders through a design process so that it can have an increased likelihood of success in the market. You will explore and apply theories and approaches of engineering and engineering design, as well as understand how design approaches span multiple disciplines. Coursework will focus on applications of design strategies in various real-life design situations.

A joint offering of the Multidisciplinary Design Program, Center for Entrepreneurship, 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 session for a good reason, then you must contact Dr. Daly at least 24 hours in advance of the session 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, work with other students, and share ideas with the larger class group.

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	Methods and Theories Covered
1	1/14/14	What is design? What does it mean to be a reflective design practitioner?	Descriptive and prescriptive design models, problem-solution co-evolution, divergence & convergence models, design build test, user-centered design, design metacognition
2	1/21/14	Identifying Design Opportunities, Defining Problems	Problem spaces, problem scoping, problem framing, implied solutions
3	1/28/14	Engineering Design Ethnography and Observations	Emic and etic observations, compensatory behaviors, observation frameworks
4	2/4/14	Interviews and Focus Groups	Semi-structured interview anatomy, deep dive
5	2/11/14	Surveys, Usability Tests, and Design Ethnography Plans	Structured, partially structured, and open-ended questions and analysis, bias, levels of measurement, usability pitfalls and experiment design
6	2/18/14	Synthesizing Data, Developing Personas, and Prioritizing Needs	Thematic analysis, evidence-based stakeholder needs categories, personas versus user archetypes, needs filtering, needs screening factors
7	*2/25/14* 4-6 pm	Sustainable Design	Life cycle analysis
	3/4/14	No Class- WINTER BREAK	
8	3/11/14	Design Requirements	"Mission" measurables, design independence, quantifying qualitative voice of the customer themes, developing tests for verification
9	3/18/14	Concept Generation and Creative Thinking	Ideation best practices, brainstorming, brainwriting
10	3/25/14	Ideation Tools and Strategies	Morphological analysis, Design Heuristics, analogical thinking, biomimicry
11	4/1/14	Design Representations: Sketching, Prototyping, and Storyboarding	Representation tools for communication and feedback; lateral and vertical transformations; thinking, talking, and prescriptive sketching; alpha and beta prototypes; engineering design versus cinematic storyboarding
12	4/8/14	Concept Development and Selection through Iteration, Feedback, Self and Team Evaluation, and Testing	Design critique, conducting and trouble-shooting experiments, decision matrices, paired comparison analyses, 6 thinking hats, design build test

13	4/15/14	Exam
14	4/22/12	Video presentations

Resources

AIGA. (2007). *An ethnography primer.* http://www.aiga.org/content.cfm/ethnography-primer

Cross, N., & Cross, N. (2000). *Engineering design methods: strategies for product design* (Vol. 58). Chichester: Wiley.

Dym, C. L., Little, P., Orwin, E. J., & Spjut, R. E. (2004). *Engineering design: A project-based introduction*. New York: Wiley.

Huthwaite, B. (2007). *The rules of innovation*. Institution for Lean Innovation.

IDEO. (2008). *Human-centered design toolkit.* http://www.ideo.com/thinking/focus/social-impact/

Isaksen, S. G., Dorval, K. B., & Treffinger, D. J. (2000). *Creative approaches to problem solving: A framework for change*. Creative Problem Solving Group--Buffalo.

Norman, D. A. (2002). *The design of everyday things.* New York: Basic Books.

Pahl, G. (2007). *Engineering design: a systematic approach* (Vol. 157). K. Wallace, & L. Blessing (Eds.). Springer.

Patnaik, D., & Becker, R. (1999). Needfinding: the why and how of uncovering people's needs. *Design Management Journal (Former Series)*, *10*(2), 37-43.

Petroski, H. (1996). *Invention by design: How engineers get from thought to thing.* Harvard University Press.

Petroski, H. (1992). *To engineer is human: The role of failure in successful design*. New York: Vintage books.

Sherwin, D. (2010). *Creative Workshop: 80 Challenges to Sharpen Your Design Skills.* HOW Books.

Zenios, S., Makower, J., & Yock, P. (Eds.). (2010). *Biodesign: the process of innovating medical technologies*. Cambridge University Press.

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

Form Number 2443

Date 11/5/2013

Effective Term Fall 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	B. REQUESTED LISTING
Home Department / Course Number:	Home Department: IOE Industrial & Operations Engin / Course Number: 432
☐ Cross Listed Course Information:	Cross Listed Course Information:
☐ Course Title:	Course Title: Industrial Engineering Instrumentation Methods
TITLE ABBREVIATION – Time Sched (Max = 19 Spaces):	TITLE ABBREVIATION – Time Sched (Max = 19 Spaces): IE Instrumentation Methods
TITLE ABBREVIATION – Transcript (Max = 20 Spaces):	TITLE ABBREVIATION – Transcript (Max = 20 Spaces): IE Instrumentation Methods
☐ Course Description:	Course Description for Official Publication (Max = 50 words): The characteristics and use of analog and digital instrumentation applicable to industrial engineering problems. Statistical methods for developing system specifications. Applications in physiological, human performance, and production process measurements are considered.
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
x Prereq: IOE 265; C- or better or graduate standing ◉ Enforced ○ Advised	Prereq: IOE 334; C- or better or senior standing or graduate standing ◉ 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; Credit Hours Min ___ Max ___; Contact Hrs/Wk ___; Number of Wks ___	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 3 Max 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.

x **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: Prof. Yili Liu — 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.	IOE, Mark Daskin	Mark S. Daskin
Cross-listed Dept(s).		

Form Number

2443

SUPPORTING STATEMENT

Change in enforced prerequisite.

Prerequisite:

IOE 334; C- or better senior standing or graduate standing

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: **2444**

Date: 11/5/2013

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	B. REQUESTED LISTING
Home Department / Course Number		IOE Industrial & Operations Engin / 438
☐ Cross Listed Course Information		
☐ Course Title		Occupational Safety Management
TITLE ABBREVIATION: Time Sched (Max = 19 Spaces)		Occup Safety Mgmt
TITLE ABBREVIATION: Transcript (Max = 20 Spaces)		Safety Management
☐ Course Description (for Official Publication (Max = 50 words))		Survey of occupational safety management methods, theories and activities. Topics include: history of safety engineering, management, and worker compensation; collection and critical analysis of accident data; safety standards, regulations and regulatory agencies; theories of self-protective behavior and accident prevention; and analysis of safety program effectiveness.
PROGRAM OUTCOMES	☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ k	☒ a ☐ b ☐ c ☐ d ☐ e ☒ f ☒ g ☒ h ☒ i ☐ j ☐ k
Degree Requirements	○ Degree Requirement ○ Core Course ○ Free Elective ○ Tech Elective ○ Other	○ Degree Requirement ○ Core Course ○ Free Elective ○ Tech Elective ○ Other
☒ Prereq	IOE 265; C- or better or Graduate Standing — ○ Enforced ◉ Advised	IOE 333; C- or better or Senior Standing or Graduate Standing — ◉ 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	☒ 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)		2 / 2
Contact Hrs/Wk		4
Number of Wks		4

C.

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

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: W. M. Keyserling — 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.	IOE, Mark Daskin	[signature]
Cross-listed Dept(s).		

Form Number

2444

SUPPORTING STATEMENT

Change in enforced prerequisite.

Prerequisite:

IOE 333: C- or better or Senior Standing or Graduate Standing

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: 2456
Date: 12/3/2013
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)	
Title Abbreviation — Transcript (Max = 20 Spaces)	
Course Description	
PROGRAM OUTCOMES:	☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ k
Degree Requirements	○ Degree Requirement ○ Core Course ○ Free Elective ○ Tech Elective ○ Other
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	ISD Integrative Systems & Design
Course Number	503
Cross Listed Course Information	
Course Title	Integrative Systems + Design Project
Title Abbreviation — Time Sched (Max = 19 Spaces)	ISD Project
Title Abbreviation — Transcript (Max = 20 Spaces)	ISD Project
Course Description for Official Publication (Max = 50 words)	This project course is intended to provide students with an industry-relevant team project experience.
PROGRAM OUTCOMES:	☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ k
Degree Requirements	◉ Degree Requirement ○ Core Course ○ Free Elective ○ Tech Elective ○ Other
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: 3 Max: 6
Contact Hrs/Wk	
Number of Wks	

C.

Repeatability (Indi Research, Dir. Study, Dissertation: Is this course repeatable? ◉ Yes ○ No
Max Hours? 6 Max Times? 1
Can it be repeated in the same term? ○ Yes ◉ No

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

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

Grading: ☐ A-E ☐ CR/NC ☐ P/F ☒ S/U

Course Is Y Graded ☐

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

Cognizant Faculty Member: Panos Papalambros
Title: ISD ~~Director~~ Chair

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.	Integrative Systems & Design	PapaVail
Cross-listed Dept(s).		

Form Number

2456

SUPPORTING STATEMENT

This course is intended to provide students with an industry-related, interdisciplinary experience. It may be repeated once, for a total of 6 credit hours, with faculty approval and advising. The course may be preceded by ISD 590.

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 2415
Date 5/31/2013
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		B. REQUESTED LISTING	
	Home Department	Course Number	Home Department	Course Number
	MECHENG Mechanical Engineering	584	MECHENG Mechanical Engineering	584
☐	Cross Listed Course Information		Cross Listed Course Information	
	MFG Manufacturing	584	MFG Manufacturing	584
X	Course Title: Control of Machining Systems		Course Title: Advanced Mechatronics for Manufacturing	
	TITLE ABBREVIATION – Time Sched (Max = 19 Spaces): Machine Control		TITLE ABBREVIATION – Time Sched (Max = 19 Spaces): Adv Mechatronic Mfg	
	Transcript (Max = 20 Spaces): Machine Control		Transcript (Max = 20 Spaces): Adv Mechatronic Mfg	
X	Course Description		Course Description for Official Publication (Max = 50 words): Theoretical principles and practical techniques for controlling mechatronic systems are taught in the context of advanced manufacturing applications. Specifically, the electro-mechanical design/modeling, basic/advanced control, and real-time motion generation techniques for computer-controlled manufacturing machines are studied. Hands-on labs and industrial case studies are used to re-enforce the course material.	
	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 ○ Free Elective ○ Other ○ Core Course ○ Tech Elective		Degree Requirements: ○ Degree Requirement ● Free Elective ○ Other ○ Core Course ○ Tech Elective	
X	Prereq: ○ Enforced ○ Advised		Prereq: ME 461 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; Credit Hours Min ___ Max ___; Contact Hrs/Wk ___; Number of Wks ___		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 3 Max 3; 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

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

Grading: ☒ A-E ☐ CR/NC ☐ P/F ☐ S/U

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

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

Course Is Y Graded ☐

Cognizant Faculty Member:	Title
Chinedum Okwudire	Asst. Professor

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.	Mechanical Engineering	[signature]
Cross-listed Dept(s).	Manufacturing	[signature] 11/20/2013

Form Number

2415

SUPPORTING STATEMENT

ME 584 students have to complete 4 on-machine labs in lieu of homework assignments. Each 2-hour lab session is performed in small groups of 4 students, meaning that for a class of 20 students, 10 hours of on-machine time are needed per lab. Due to safety concerns, the students need to be supervised by a GSI throughout the on-machine portion of the labs. For the 4 labs, there are therefore 40 contact hours of supervised lab time during the term, or approximately 3 hours per week.

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

Detail the Special requirements

Same as previously: CNC machine tool(s) for course labs, qualified technician to help with labs, small budget (<$500) to purchase metal stock and tools used for labs.

JUSTIFICATION FOR PROPOSED CHANGES

The current course name and description highlight the manufacturing (specifically CNC machining) thrust of the course but the mechatronics content is only implied. The objective of the proposed changes is to highlight the mechatronics content of the course while maintaining its manufacturing relevance by teaching it in the context of CNC machines. Note that the controls emphasis and practical thrust of the course are kept intact.

The proposed name and description offer several advantages, including:

1) Emphasizing mechatronics broadens the scope of the course and clearly puts forward its interdisciplinary nature. Today's students (and their potential employers) are more likely to be drawn to content that is perceived as inter-disciplinary rather than content which is seen as narrow.
2) There has been a desire in the Design & Manufacturing group of the Mechanical Engineering Department to integrate mechatronics into manufacturing (and not only design). The proposed changes will help to clearly demonstrate the concepts of mechatronics in manufacturing applications as well as the effects of mechatronics considerations on the design of control systems. The changes will help ME 584 to be a natural sequel to ME 552 (MFG 552), while maintaining its connection to controls courses (e.g., ME 461 and ME 561) as well as manufacturing courses (e.g., ME 585).
3) De-emphasizing the machining content of the course will allow non-traditional manufacturing techniques which have strong controls/mechatronics aspects (e.g., E-jet printing) to be easily added into the content of the course. This will both enhance its breadth for students and increase the flexibility of its content for instructors with a non-machining background who are interested in teaching it.

Regarding the proposed lab designation, ME 584 students complete 4 on-machine labs in lieu of homework assignments. Each 2-hour lab session is performed in small groups of 4 students, meaning that for a class of 20 students, 10 hours of on-machine time are needed per lab. For both technical assistance and safety concerns, the students need to be supervised by a GSI throughout the on-machine portion of the labs. For the 4 labs, there are therefore 40 contact hours of supervised lab time during the term, or approximately 3 hours per week.

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

Form Number: 2459
Date: 1/16/2014
Effective Term: Fall 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)	
Title Abbreviation – Transcript (Max = 20 Spaces)	
Course Description	
Program Outcomes	☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ k
Degree Requirements	○ Degree Requirement ○ Core Course ○ Free Elective ○ Tech Elective ○ Other
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	NAVARCH Naval Arch & Marine Engin
Course Number	514
Cross Listed Course Information	
Course Title	Fatigue of Structures
Title Abbreviation – Time Sched (Max = 19 Spaces)	Fatigue of Structures
Title Abbreviation – Transcript (Max = 20 Spaces)	Fatigue of Structures
Program Outcomes	☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ k
Degree Requirements	○ Degree Requirement ○ Core Course ○ Free Elective ○ Tech Elective ◉ Other
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	4 / 4
Contact Hrs/Wk	4
Number of Wks	14

Course Description for Official Publication (Max = 50 words)

Fundamental concepts associated with fatiguc damage and failure in engineering structures and contemporary design and analysis procedures with an emphasis on fatigue of welded structures, including most recent developments in finite element based fatigue design and analysis procedures, e.g., mesh-insensitive structural stress method and master S-N curve approach.

C.

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

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: Pingsha Dong — 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.	Naval Arch & Marine Engin	[signature]
Cross-listed Dept(s).		

Form Number

2459

SUPPORTING STATEMENT

Structural fatigue is one of major failure modes of concern in design, manufacture, and analysis of engineering structures spanning aerospace, automotive, earth-moving equipment, marine/offshore, petrochemical and power generation industries. With an increasing pressure for cost reduction, product durability, environmental safety, computational methods that are capable of predicting fatigue life at final product level has been identified as a key enabler to achieving competitive edge in global market place. At present, there is no equivalent course offering at College of Engineering. This course should complement ME 576 (Fatigue in Mechanical Design) by focusing on computational fatigue analysis theories and methodologies at structural level, particularly on as fabricated structures such as ship and offshore structures subjected to random wave loadings.

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

Detail the Special requirements

NA 599: Fatigue of Structures (4 hrs)

Instructor: Dr. Pingsha Dong
Office: 216 NAME Building
Email: dongp@umich.edu
Phone: 734 615 7484

Prerequisites:

Prior exposures in finite element procedures would be highly desirable.

Course Description:

This course intends to prepare students with fundamental concepts of fatigue damage and failure in engineering structures and contemporary design and analysis procedures. A particular emphasis will be placed upon fatigue of welded structures and most recent developments in finite element based fatigue design and evaluation procedures. Limitations in existing design and analysis procedures experienced by industry and research community will be discussed. On-going research in addressing some of the limitations will also be highlighted.

Class Schedule:

Lecture Hours:	Monday and Wednesday 3PM-4:30PM; NAME RM 236
FEA Lab Hour:	Friday 3-4PM, NAME RM 236

References:

1) Class Handouts
2) WRC Bulletin No. 523: "The Master S-N Curve Method: An Implementation for Fatigue Evaluation of Welded Components in the ASME B&PV Code, Sec. VIII Div 2 and API 579-1/ASME FFS-1
3) Bureau Veritas NT 3199: "Guide for Application of the Mesh-Insensitive Methodology – Welded Steel Plates of Ship and Offshore Structures"

Student Learning Objectives:

1) Understand the basic concepts of fatigue damage in engineering structures
2) Understand the uniqueness of fatigue behavior in welded structures and effective analysis and design methods
3) Learn basic fatigue design and analysis procedures stipulated in relevant national and internationhal Codes and Standards and underlying assumptions
4) Learn finite element implementation of modern fatigue assessment procedures for solving practical fatigue problems in engineering structures.

Course Topics (Weekly):

Week 1.	Introduction: importance of fatigue considerations in engineering design Fatigue damage definitions: perspectives from material science and structural mechanics
Week 2.	Laboratory fatigue test requirements and data interpretation Smooth bar versus structural specimens
Week 3.	Fracture mechanics approach Limitations in fatigue design
Week 4.	Fatigue behaviors of welded joint Classical fatigue evaluation methods and assumptions
Week 5.	Weld classification method Hot spot stress method and local approach
Week 6.	Mesh-insensitive structural stress method – Part 1: Traction stress definition and simple calculation examples Measurement technique and examples Test data correlation
Week 7.	Mesh-insensitive structural stress method – Part 2: Generalized solution procedure and numerical implementation Calculation examples Virtual node method for in-plane notch effects
Week 8.	Master S-N curve method – Part 1: formulation and validation Generalized K solution – edge cracks and elliptical cracks Two-stage growth model and validation Equivalent traction stress parameter
Week 9.	Master S-N curve method – Part 2: Applications in structural life predictions Tubular joints Ship structural connections Bridge connections Automotive components Pressure vessel and piping components
Week 10.	Structural strain method for low-cycle fatigue: Elastic core definition Structural strain formulation Data correlation in low-cycle regime Structural strain based master S-N curve
Week 11.	Multi-axial fatigue Cycle definition in stress/strain space Load path length based damage parameter Path-dependent maximum range (PDMR) cycle counting method Linear damage summation rule Worked examples
Week 12.	Cycle counting law for arbitrary variable amplitude multiaxial loading

Fracture mechanics basis
Thermodynamics basis
Numerical Implementation of PDMR and "divide and conquer" algorithm
Rainflow counting method recovered
Application examples

Week 13. Implementation in national and international Codes and Standards
ASME
Class societies
IIW
Application examples

Week 14. Applications for Fitness-for-Service (FFS)
Further research topics and progress to date
Course summary

FEA Lab topics (Weekly):

Week 1. Get started with using general purpose FE software for this course:

Week 2. 1D (beam) stress analysis problem

Week 3. 2D (plane stress, plane stress, generalized plane-strain, axisymmetric problems)

Week 4. Hot spot stress method and mesh-sensitivity

Week 5. Nodal force based structural stress method (1D) and its mesh-insensitivity

Week 6. Nodal force based structural stress method (2D) and its mesh-insensitivity

Week 7. Nodal force based structural stress method (3D - shell) and its mesh-insensitivity

Week 8. Nodal force based structural stress method (3D - solid) and its mesh-insensitivity

Week 9. Virtual node method (VNM) and its application

Week 10. Treatment of weld throat cracking

Week 11. Treatment of multiaxial stress state

Week 12. Implementation of simultaneous equations and coordinate transformation

Week 13. Miscellaneous topics involved in term projects - I

Week 14. Miscellaneous topics involved in term projects - II

Grading:

1) Homework assignments (7~8): 20%
2) Term project and final presentation: 20%
3) One mid-term: 25%
4) Final exam: 35%

Class attendance: Mandatory

Honor Policy:

The CoE Honor Policy applies. Collaborations on homework problems are encouraged, as long as final solutions are developed independently.

Fall 2013 Final
10 students responded out of the total enrolled 11

Instructor with Comments Report

2013-12-12 - 2013-12-17 Report ID: MSR04734

Instructor: Dong,Pingsha
NAVARCH 599 060

		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	60% Above	25% Above	75% Above	60% Above	25% Above
1	Overall, this was an excellent course.	8	1	1	0	0	0	4.88	3.92	4.30	4.71	4.23	4.50	4.75
2	Overall, the instructor was an excellent teacher.	8	2	0	0	0	0	4.88	4.17	4.63	4.85	4.25	4.67	4.83
3	I learned a great deal from this course.	8	1	1	0	0	0	4.88	4.00	4.36	4.71	4.22	4.55	4.80
4	I had a strong desire to take this course.	7	1	2	0	0	0	4.79	3.56	4.13	4.60	4.13	4.50	4.72
201	The instructor gave clear explanations.	5	3	1	0	0	0	4.60	4.07	4.50	4.77			
216	The instructor acknowledged all questions insofar as possible.	9	1	0	0	0	0	4.94	4.33	4.67	4.83			
229	The instructor used class time well.	8	1	1	0	0	0	4.88	4.10	4.50	4.75			
230	The instructor seemed well prepared for each class.	8	1	1	0	0	0	4.88	4.32	4.69	4.86			
232	Work requirements and grading system were clear from the beginning.	6	2	2	0	0	0	4.67	4.00	4.34	4.67			
239	The amount of work required was appropriate for the credit received.	7	2	0	0	1	0	4.79	4.00	4.25	4.57			

Written Comments

900 Comment on the quality of instruction in this course.

Student 1
NA

Student 2
The amount of work was disproportionate to the credits earned. The HW assignments were far too lengthy. I suggest a wider breadth of covered topics with less focus on the professor's methods.

Student 3
Great course! A completely new and useful method is introduced.

Student 4
The instruction in this course was fantastic for the first portion of the course. I found the second half less organized and somewhat sporadic. The movement from topic to topic seemed to follow the research career of the professor rather then establishing the logical linkages. In addition i do worry that some of the state of the art was not covetred because it potentially conflicts with the reserach being done by the professors lab. This was incredibly evident in the rainfall counting vs Path dependent length discussion. Rainfall is an accepted standard worldwide, but it was dismissed in favor of the professors own research. The professor obviously has great knowledge of the subject matter. I would have liked to see more prepared/finished homework assignments. Almost every assignment required amendments and corrections. This is acceptable because i understand mistakes happen.. I was often unsatisfied with the time at which the clarification or extension came. Additionally, i wish the homeworks early in the class had not been extended. It hurts the students who put in the work and balance their schedule to complete the assignment on time. In addition the homework solutions presented to us had minor mistakes or inconsistencies. This makes it very difficult to learn if we have simply made a small error in calculation or if we have a failure of logic in the thought process to analyze the problem. Overall though the course was very valuable.
The final project was also very poorly explained. It never appeared as if 60% of my grade would come from evaluations and participations other than the professor.

Student 5
NA

Student 6
NA

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

Fall 2013 Final
10 students responded out of the total enrolled 11

Instructor with Comments Report

2013-12-12 - 2013-12-17 Report ID: MSR04734

Instructor: Dong,Pingsha
NAVARCH 599 060

Student 7
NA

Student 8
good course overall, homework load should be reduced though.

Student 9
NA

Student 10
NA

* The quartiles are calculated from Fall 2013 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 2447
Date 11/12/2013
Effective Term FT 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)	
Title Abbreviation – Transcript (Max = 20 Spaces)	
Course Description	
PROGRAM OUTCOMES:	☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ k
Degree Requirements	○ Degree Requirement ○ Core Course ○ Free Elective ○ Tech Elective ○ Other
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	ROBOTICS
Course Number	501
Cross Listed Course Information	EECS Elec Engin & Computer Sci AEROSP Aerospace Engineering MECHENG Mechanical Engineering NAVARCH Naval Arch & Marine Engin
Course Title	Mathematics for Robotics
Title Abbreviation – Time Sched (Max = 19 Spaces)	Math for Robotics
Title Abbreviation – Transcript (Max = 20 Spaces)	Math for Robotics
Course Description for Official Publication (Max = 50 words)	Applied mathematics for robotics engineers. Topics include vector spaces, orthogonal bases, projection theorem, least squares, matrix factorizations, Kalman filter and extensions, particle filters, underlying probabilistic concepts, norms, convergent sequences, contraction mappings, Newton Raphson algorithm, nonlinear constrained optimization, local vs global convergence, convexity, linear and quadratic programs, and randomized search strategies.
PROGRAM OUTCOMES:	☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ k
Degree Requirements	◉ Degree Requirement ○ Core Course ○ Free Elective ○ Tech Elective ○ Other
Prereq	Differential equations and matrix algebra (recommended), Graduate Standing or Approval of the 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 / Max	3 / 3
Contact Hrs/Wk	3
Number of Wks	14

C.

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

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:	Title
Jessy Grizzle EECS	Prof.
James Forbes AERO,Ryan Eustice NAME	Asst Pof
Arthur Kuo ME	Prof

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.	Dawn Tilbury	[signature]
Cross-listed	Robotics Steering Committee chair	

Dept(s).

Form Number

2447

SUPPORTING STATEMENT

This course is intended to streamline the mathematics preparation for graduate students who otherwise may be required to take several different courses to gain the literacy necessary for research in robotics. Other degree programs, such as control systems, will find the topics important for their students.

Detailed set of topics. (3 to 5 weeks per topic, for a total of 14 weeks) Notes for the course will be developed by robotics faculty. The Linear Algebra and Analysis sections will be presented with emphasis on mathematical rigor, with the exception of the matrix factorization results. The Filtering-Estimation and Parameter Optimization topics will be presented more from a user's point of view.

Linear Algebra (R^n, R) and (C^n,C) as the primary vector spaces we use; Linear independence and span; Subspaces; Bases (geometric interpretation); Inner products and orthogonal vectors; Orthogonal Projection; Least squares problems; rank of a matrix; LU decomposition and Cholesky factorization; SVD.

Filtering and Estimation Discrete-time dynamical systems; Observability of discrete-time LTI systems; Jacobians, chain rule, and linear approximation; Local exponential stability via Jacobians and e-values; Probabilistic background (what is a pdf, conditional probabilities, Bayes rule, properties of gausssian random variables); How to estimate mean and variance from data; Covariance; Linear discrete-time Kalman Filter and relation to recursive least squares; Extended Kalman filter; Unscented filter; Particle filters.

Analysis Formal logic and how to write math (one hour or two); Notion of distance (metrics, norms); Sequences and limits; Contraction Mapping Theorem; Newton Raphson Algorithm as a local contraction mapping; Optional: functionals, calculus of variations, application to mechanics.

Parameter Optimization Nonlinear constrained optimization; what is it and example uses; local vs global convergence; Gradient Descent; Convexity; Quadratic programs; what are they and example uses; Linear programs; what are they and example uses; Randomized search strategies.

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

Detail the Special requirements

Course Approval Request
College Curriculum Committee, 1420 Lurie Engineering Center Building

Form Number 2451

Date 11/27/2013

Effective Term Fall 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	B. REQUESTED LISTING
Home Department / Course Number:	Home Department: ROB Robotics / Course Number: 550
Cross Listed Course Information:	Cross Listed Course Information: AEROSP Aerospace Engineering; EECS Elec Engin & Computer Sci; MECHENG Mechanical Engineering; NAVARCH Naval Arch & Marine Engin
Course Title:	Course Title: Robotic Systems Laboratory
TITLE ABBREVIATION — Time Sched (Max = 19 Spaces):	TITLE ABBREVIATION — Time Sched (Max = 19 Spaces): Robotic Sys Lab
TITLE ABBREVIATION — Transcript (Max = 20 Spaces):	TITLE ABBREVIATION — Transcript (Max = 20 Spaces): Robotic Sys Lab
Course Description:	Course Description for Official Publication (Max = 50 words): Multidisciplinary laboratory course with exposures to sensing, reasoning, and acting for physically-embodied systems. Intro to kinematics, localization and mapping, planning, control, user interfaces. Design, build, integration, and test of mechanical, electrical, and software systems. Projects based on a series of robotic platforms: manipulators, mobile robots, aerial or underwater vehicles.
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 ○ Free Elective ○ Other ○ Core Course ○ Tech Elective	Degree Requirements: ○ Degree Requirement ○ Free Elective ○ Other ◉ Core Course ○ Tech Elective
Prereq: ○ Enforced ○ Advised	Prereq: Graduate standing or permission of instructor ◉ 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; Credit Hours Min ___ Max ___; Contact Hrs/Wk ___; Number of Wks ___	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 4 Max 4; Contact Hrs/Wk 8; 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

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:	Title
Ella Atkins (AEROSP)//Ryan Eustice	Associate Professor
(NAVARCH)/Brent Gillespie (MECHENG)	Associate Professor
Ed Olson (EECS)	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.	Dawn Tilbury	Dawn Tilbury
Cross-listed Dept(s).	Robotics Steering Committee Chair	

Form Number

2451

SUPPORTING STATEMENT

This course will serve as a core course required for all students entering the Robotics PhD program. This course will expose students to hands-on robotics so that even robotics students who will eventually work solely on theory or algorithms will gain practical experience from laboratory experiments. The course is intended to provide a major technical challenge that will serve as a memorable foundation for graduate coursework and will also provide experience with self-directed teamwork. The course will provide hands-on experience in the design and use of electrical, mechanical, and software systems. Students will "close the loop" with integrated systems that combine all three system aspects.

We anticipate students with diverse engineering backgrounds. The multidisciplinary nature of course projects will offer every student dual opportunities to work within and outside their major areas of expertise. As such, students will be offered new and challenging exposures but will also be asked to serve as mentors when appropriate.

The course will be divided into three parts, one for each class of robot platform. Although robot platforms and course goals will evolve with technology and the instructor team, we envision a sequence of exposures ranging from in-place (fixed-base) to mobile. Initially, we propose a sequence of three platforms. A manipulator will introduce motors and embedded sensors, computer vision, and feedback control. A ground robot will introduce sensor-based localization, two-dimensional path planning, communication protocols, and operator interfaces. A quadrotor will provide three-dimensional high-speed mobility and will support projects with multi-vehicle coordination. In projects, students will often be asked to design a component (e.g., a better sensor) that plugs into an existing system. Rigorous modeling, development, and evaluation will be central to projects and exams.

The robotics faculty offers significant experience with course development and teaching that covers and that complements proposed course material. Ed Olson and Shai Rezven have developed hands-on robotics courses for undergraduates. EECS 467 is an undergraduate course that offers more computer programming depth but very little content related to mechanical and electrical systems. Robotics 550 provides students hands-on experience to support existing ME and EECS courses such as robot kinematics and dynamics, control, localization and mapping.

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

Detail the Special requirements

Substantial hardware and lab technician support are required for this course.
We will need ~$200K for initial materials and equipment purchases, including manipulator and mobile robot platforms with instrumentation for each lab station. We anticipate a need of ~$40K per year to update and repair equipment. Robotic hardware evolves rapidly; this course must keep pace to ensure relevance. We assume standard electronics bench equipment, electronics prototyping, and machining facilities are available.