UNIVERSITY OF MICHIGAN
College of Engineering
Curriculum Committee Meeting
Tuesday, February 13, 2024

Attending: Achilleas Anastasopoulos, Robert Bordley, Yavuz Bozer, Chris Fidkowski, Fei Gao, Vineet Kamat, Amir Kamil, Leena Lalwani, Xiaogan Liang, Emmanuelle Marquis, Frank Marsik, Radoslaw Michalowski, Yulin Pan, Mika Panagou, Rachael Schmedlen, Ben Spector, Elyse Vigiletti, Roxanne Walker

Support Staff: Mercedes Carmona, Betsy Dodge, Matthew Faunce

Call to Order: 1:35 PM

Adjourned: 2:41 PM

Agenda:

1. Approval of 1.30.2024 Meeting Minutes - Page 3 - **APPROVED**
2. HLC Annual Audit Questions 3 & 4 for the CoE Curriculum Committee – Informational Item – Page 6 - **PENDING**
    a. Review UM Academic Unit Credit Hour Policies Document & HLC Discussion Draft Document created by the Chair, which contains all UM schools/colleges credit policies and highlights aspects discussed with the HLC Annual Audit Questions 3 & 4.
        i. The main changes made to the CoE Credit Policy are more information for laboratory sections and Hybrid and Online courses and a new section added for courses that do not fall into the categories already listed in the policy.
            1. EECS - CSE: Suggestion of removing Special Topics from the policy as this doesn't fit well with the section it is listed with. Courses are in development for the first or second time before becoming official and should be adjusted by the instructor and department once the course is permanent. These courses should not have the ability to violate the policy.
            2. UG Education: The Hybrid and Online courses section sentence that begins with, "…and an equivalent amount of instructor led instruction as required by in-person lecture sections is provided." Do online courses still need to be instructor led in some capacity?
                a. Chair/MECHENG: This has been the ongoing conversation that has been hard to define and where the boundary lies with online teaching. There needs to be an equivalent amount of instructor led teaching to represent the credit hour and be consistent with the credit hour policy.
                b. UG Education: If courses needed to prove online learning is align with the policy, can this be done in the form of instructors reviewing Piazza and GSI offered to assist students with incoming questions?
                c. Chair/MECHENG: Yes.
                    i. Similar question raised by ROB, but regarding laboratory remote learning and if there needs to be a remote instructor/GSI. Same response given by Chair/MECHENG that this needs to be synchronous and is more specified within the last sentence of the laboratory section in the revised policy. Could possibly be more specified, if necessary, in the policy.
                d. CLIMATE & SPACE: Can this sentence be removed as it sounds redundant to what has already been said or what is the reasoning for this?
                    i. UG Education in agreement with the sentence removal, but TCHNCLCM finds this helpful in further explaining what is required from hybrid and online courses.
                    ii. Chair/MECHENG: This sentence specifically answers the HLC Annual Audit Question 4.

3. ISD: Input measures as opposed to outcomes, such as students who take longer to grasp the course material versus others that learn the material quickly. How would this be monitored?
    a. Chair/MECHENG: Consider the feedback from the students (i.e., lectures are pointless, read the textbook to learn the material). Figure out what is the best method to teach the course for students to be successful and learn the course outcomes/goals.
4. EECS - CSE: Lecture recordings should not count as contact hours. Instructors posting old recordings and considering this as contact hours. CSE has courses that have multiple sections and due to capacity with rooms there are options for students to choose for lecture, such as in-person or remote, that still includes students for the interaction needed. Students who watch old recordings do not get the interaction needed to count as a contact hour.
    a. ISD: Some courses have lectures that are all pre-recorded and these are not updated or revised and follow the rest of the curriculum given online. No interaction given and credit is still given.
    b. Chair/MECHENG: If the course only involves watching recordings, then this is not compliant with the policy. Courses that have assignments that are associated with recordings count towards the policy as this is enough interaction for the student's online learning.

b. All CoE CC members have access to the HLC Discussion Draft Document so if there is a new idea, revision, etc. that can be left in a comment, it is encouraged to do so that everyone contributes to this revision of the credit policy. This topic will continue at the next meeting on 3.12.2024.

3. CoE/LSA Joint Meeting Agenda Items – Informational Item - **PENDING**
    a. We are reaching out to ADUE and LSA to determine if a joint meeting is of interest between both colleges and determining what topics are to be discussed.
        i. Are the following topics discussed thus far enough to have a joint CoE/LSA Meeting?
            1. Graduate Education to follow up with documentation of SUGS information to provide to LSA, if this is still a topic of interest.
                a. Graduate Education to reach out to CLIMATE AND SPACE about the programs that are to be included for the SUGS Information, which still needs time to be gathered to present.
            2. Incomplete Grade Policies and Course Withdrawals and the LSA I-Grade Policy
                a. RO Office: The Bulletin contains information on CoE's the Incomplete Grade Policy which states that at least 70% of the work for a course needs to be completed for an instructor to be able to apply an I grade for a student.
                    i. On the Bulletin website, this information is under the tab Academic Rules and Grades and Scholastic Standing.
                b. Same sentiments brought forward by CEE, TCHNCLCM, CLIMATE & SPACE, MATSCIE, and Chair/MECHENG that the I grade is a negative mark for a student and shouldn't be listed on a transcript.
                c. IOE: Not all situations are the same for students to receive an I grade and not in agreement that every I grade should disappear.
                    i. Graduate Education: There is some context that needs to be given in a situation such as a student's independent research expanding to another semester and reviewing an IA versus IB grade.
                    ii. IOE: Same as not completing work on time and submitting homework late. If a student is inconsistent with their work, then they should be graded because of that.
                    iii. EECS-CSE & MATSCIE in agreement that students should not have to reveal their personal and private reasons as to why they cannot complete the course. The reasoning needs to be justifiable to give an I grade but shouldn't have to ask students for a reason if they are not comfortable with giving this information.
                    iv. CLIMATE & SPACE: Sometimes it is best for the student to walk away with the low grade rather than give an I grade.
                d. More information needs to be gathered, so discussions will continue regarding CoE Incomplete Grade Policies and Course Withdrawals and the LSA I-Grade Policy at the next meeting on 3.12.2024.
            3. CEE suggested finding out if LSA has any topics to discuss to see if this mirrors with anything CoE may have.

CARF SUMMARIES

PAGE	SUBJECT	COURSE #	ACTION	SUMMARY	EFFECTIVE TERM	MIN. GRADE REQ. FOR ENF. PREPREQ	Is Course on LSA Course Guide?	APPROVED	NOTES & REVISIONS	TABLED
12	IOE	435	MOD	Change in Course Description, Full Term Credit Hours, Course Credit Type, and Enforced Prerequisite.	WT 2025	C-	YES	APPROVED	Cross listed with ROB 435.	
15	IOE	535	NEW		WT 2025	NO	NO	APPROVED	Cross listed with ROB 535.	
40	ROB	298	NEW		FT 2024	NO	NO	APPROVED		
43	ROB	311	MOD	Change to Course Description and Advisory Prerequisite.	FT 2024	C-	YES	APPROVED		
47	ROB	330	MOD	Change to Course Description.	FT 2024	C-	YES	APPROVED		
50	ROB	498	MOD	Change in Repeatability and Course Components.	FT 2024	NO	YES	APPROVED		

UNIVERSITY OF MICHIGAN
College of Engineering
Curriculum Committee Meeting
Tuesday, January 30, 2024

Attending: Achilleas Anastasopoulos, Sarah Barbrow, Yavuz Bozer, Chris Fidkowski, Fei Gao, Saadet Albayrak Guralp, Vineet Kamat, Amir Kamil, Ryan Latimer, Xiaogan Liang, Emmanulle Marquis, Radoslaw Michalowski, Mika Panagou, Ben Spector, Elyse Vigiletti, Roxanne Walker

Support Staff: Mercedes Carmona, Betsy Dodge, Matthew Faunce

Call to Order: 1:35 PM

Adjourned: 2:12 PM

Agenda:

1. Approval of 1.16.2024 Meeting Minutes - Page 2 - **APPROVED**
2. HLC Annual Audit Questions 3 & 4 for the CoE Curriculum Committee – Informational Item – Page 5 - **PENDING**
    a. ChE: This discussion was brought to our department meeting. Overall conclusion was that the department is not opposed to courses having online modules or components that count toward the contact hour as long as it is a small portion of the course. How this is defined needs to be specified, such as being able to watch the student's progression. There needs to be a deliverable assessment piece that proves the outcome was achieved and it should be standardized across the college. This is an acceptable and needed change of the policy, as the learning environment is constantly changing and there is a need to adapt for the students' learning outcomes.
    b. Graduate Education: Graduate and Undergraduate degrees completed online is the future. Policies, such as the credit policy, need to be adjusted as it will only be an issue later, and will position the college well. Another issue would be lab as online learning continues. How will this be monitored and affect the contact hours and credit hour overall? Examples that have been used through online learning for lab are sending lab equipment for the student to complete on their own and virtual learning through a shared, collaborative and possible virtual space. Institutions that are already incorporating this in undergraduate and graduate education are University of Illinois and Purdue University. Of course, this depends on the nature of the course to use online as a learning method, but collaborative work can be done this way and will become the standard for education.
    c. Chair/MECHENG: I will look at previous meeting minutes to include all feedback regarding this ongoing discussion and meet with the CoE Registrar Office to discuss revising the Credit Policy.
3. CoE/LSA Joint Meeting Agenda Items – Informational Item - **PENDING**
    a. We are reaching out to ADUE and LSA to determine if a joint meeting is of interest between both colleges and determining what topics are to be discussed.
        i. Previous Topics that were submitted for last year's Joint Meeting that was cancelled:
            1. Reciprocity for Minor Approvals between CoE and LSA
                a. Response from Kevin Pipe: Go through LSA/CoE Curriculum Committee and include Tim McKay. Not a blanket reciprocal policy, understanding between both schools.
                b. CoE Member who brought this topic forward has discussed with those needed and cleared up any issues.
            2. HLC Annual Audit Process within CoE
                a. Betsy Dodge reached out to LSA and they have no issues. CoE does have issues.
                b. This topic does not need to be pursued with LSA.
            3. The CoE Incomplete Grade Policy and Course Withdrawals

a. Response from Kevin Pipe: LSA is planning to move back to the 9th week for AY24-25. We don't have an incomplete policy written up yet.
b. Chair/MECHENG: We need to double check these policies compared between the two colleges and will provide the information to the committee at the next meeting.

4. Sharing of student credit hours
   a. Xiaogan asked, Is this for cross-listed courses? I know we mentioned this to the University Registrar Office, but I haven't talked with Tim about it.
   b. There is no background information from anyone in CoE for a reason as to why this was brought up as a topic to bring to LSA. Therefore, there is no need to bring this up to LSA, unless a member remembers the background information for this topic.

ii. Are these topics still of interest to bring to LSA? Any new topics?

1. EECS - CSE: Whether an I Grade shows up on a transcript. In LSA, they asked that we get rid of the I when we submit the final grade. There are Honor Code Issues with the I Grade. Student finishes the work and doesn't make sense for an I Grade to show up because of this. To post an I Grade for an LSA Student, LSA needs to approve this twice, which creates double the work for the department that is not needed.
   a. MECHENG: To keep or remove as this can affect students and their career development. I Grade is a temporary mark. We don't want this as a permanent mark.
   b. Graduate Education: The I Grade does not factor into the GPA, which can cause issues for students applying to graduate school. Doesn't leave a good impression on the student. I Grade vs F Grade. Students would rather choose the I Grade. Refer to ADGPE Policy and Process for Graduate Students with Incomplete Grades document shared in the chat as this includes instructions for graduate students and I Grades.
   c. CEE: Current rule has until the following semester to complete the work. The department recently had an issue with a student who applied to another school and had an I Grade listed on their transcript. I Grade is not for students to pass and make up the work. There needs to be a legitimate reason as to why the student didn't finish the course in time. Sort of a punishment as the student doesn't want the I Grade and affects the transcript. Does LSA have the same policy?
   d. Chair/MECHENG: Yes. We shouldn't let this affect the student. Not a good mark and shouldn't permanently appear.
   e. Graduate Education: More education needed for the advising faculty. Y grade is a work in progress and better to appear on transcripts.
   f. CoE Registrar Office: The URO is very clear that Y Grades should not be used for an I Grade. Y Grades are strictly used for multi semester courses and should only be the use of the Y grade.
   g. IOE: Courses that have a Summer term team project, but the course is taken in the Winter term. Work continues over two terms and therefore will then receive a grade once completed.
   h. Chair/MECHENG: Is this enough to take to the LSA to pursue as a topic of discussion?
   i. CEE: Would be good for LSA to also have a response and stay consistent with the policies.
   j. Chair/MECHENG: Change CoE's Incomplete Policy like the LSA policy.
      i. CEE: What is the rationale behind their updated policy?
      ii. Chair/MECHENG: I am unsure. There needs to be a review of their policy to continue our discussion on this topic.
2. Graduate Education: There needs to be more information provided for SUGS as this would benefit all students, campus wide. In April, ADUE will partner for a campus/cross campus reach for sessions providing a pathway for SUGS. To what extent would we need to formalize this with LSA? Pilot programs consisting of IOE and CLASP. These departments already had relationships with LSA faculty and programs so this could be a route to pursue to spread information and grow these programs.
   a. Chair/MECHENG: Please provide any documentation for this topic to further pursue if this is a topic to discuss with LSA.

CARF SUMMARIES

PAGE	SUBJECT	COURSE #	ACTION	SUMMARY	EFFECTIVE TERM	MIN. GRADE REQ. FOR ENF. PREPREQ	Is Course on LSA Course Guide?	APPROVED	NOTES & REVISIONS	TABLED
7	**ECE**	**517**	**MOD**	Changes in Course & Abbreviated Title, Course Description, and Advisory Prerequisite.	**FT 2024**	**NO**	**YES**	**CONDITIONAL APPROVAL**	Cross listed with NERS 578. Changes to Course Description and Advisory Prerequisite.	

HLC Annual Audit Questions for the CoE Curriculum Committee

1. **How should departments handle courses that are taught in combination with other institutions? How should departments handle it when the course is taught at UM? "Do courses that are a teaching collaborative need to follow CoE Policy for the Assignment of Credit Hours? Examples: ROB 498 and 599 (Robotics)**

ROB 498.004/ROB 599.010 was offered as part of our distributed teaching collaborative and was a course offered between U-M and FAMU. We aligned our course to the FAMU scheduling as their instructor was teaching the course. They plan to run this in WN 24 ROB 498.015/ROB 599.015

2. **When was the lab policy established? (IOE)**

   The Current CoE Policy for the Assignment of Credit Hours was approved October 13, 2020.

3. **Do labs need to be scheduled in a formal CoE Computer Lab space when the work can be done online? (EECS)**

Atul Prakash: I do think the definition of a lab course and the way contact hours are measured is not ideal for software courses in which the lab work can be done virtually at any time and any place by the students. I don't think it is ideal even for hardware courses in which students are able to use a virtual or portable kit and thus a physical lab is less critical. I would recommend another way to designate a course as a lab in CoE so that the courses can get sufficient SCH credit for supporting the teaching staff. A possible way to think about it is if the students are building real or virtual artifacts with software and hardware that requires technical support.

Question for CCC discussion: Does the CCC agree with the use of virtual technical support? How would that look, would students receive immediate feedback?

4. **Are the activities associated with the online, self-paced, asynchronous Canvas modules used in ENGR 101 and 110 and other departmental courses acceptable as CoE contact hours?** These course use contact hours as follows, per feedback from Rachael Schmedlen

The following feedback to define contact hours was gathered from Christne Gerdes, one of the Office of the Provost's identified curriculum specialists for HLC project, regarding guidance on using online self-paced, asynchronous Canvas modules as contact hours:

The Office of the Provost Guidance on Defining the Academic Credit Hour states: Faculty and instructors — with oversight and input from faculty-led curriculum committees — should determine the activities that would appropriately be viewed as faculty-led engagement within the context of a course and academic program.

Contact hours are defined as time spent by students engaged with the course instructor. This is academic engagement. Hybrid and online courses require an equivalent amount of instruction and student work as required by in-person courses.

Engagement with the course instructor/academic engagement is defined by federal guidance, and to be considered a contact hour, the activity in question must follow the regulations under letter (a):

(a) Participation in an interactive tutorial, webinar, or other interactive computer-assisted instruction

If it meets the standard of (a), as per CoE Curriculum Committee determination, then it is a contact hour. Letter (b) listed below would not follow the determination for the CoE contact hour:

(b) Logging into an online class or tutorial without any further participation

UM Academic Unit Credit Hour Policies

The Higher Learning Commission's Policy for the Assignment of Credit Hours

University of Michigan Office of the Registrar Credit Hour Guidance - Academic Unit Policies

School/College	Policy Status	Public Link
Architecture and Urban Planning	Final	https://taubmancollege.umich.edu/sites/default/files/files/policies/Taubman-College-Assignment-of-Credit-Hours.pdf
Art & Design	Final	https://stamps.umich.edu/undergraduate-current/resources/advising#determining_credit_hours
Business	Final	https://www2.bus.umich.edu/MyiMpact/academics/faculty/courses Document Link
Dentistry	Final; undergraduate Dental Hygiene program follows LSA policy	https://docs.google.com/document/d/1L8TIgqy4wMSu8L1MqhtzvOhru21jVOzm/edit Public Link, same document
Education	Final	https://drive.google.com/file/d/1Mw0ZdxZEZJxCQQriAiy

		JsX5fBtyRulAi/view
Engineering	Final	https://bulletin.engin.umich.edu/rules/registration/ https://docs.google.com/document/d/1zwGHBj-AC0RmC5gbAJtgYrHlZmx6tVqp/edit#heading=h.gjdgxs
Environment and Sustainability	Final	https://rackham.umich.edu/faculty-and-staff/resources-for-directors/guidelines-for-graduate-course-approval/assignment-of-credit-hours/
Information	Final	https://www.si.umich.edu/programs/courses/credit-hour-policy
Kinesiology	Final	https://www.kines.umich.edu/student-services/forms-bulletins
Law	Final	https://michigan.law.umich.edu/resource-center/degree-requirements#credit-hours
Literature, Science, and the Arts	Final	https://lsa.umich.edu/lsa/academics/lsa-academic-policies/registration-and-enrollment/course-credits-and-contact-hour

		s.html
Medicine	Final	https://medicine.umich.edu/medschool/sites/medicine.umich.edu.medschool/files/assets/Medical%20School%20Credit%20Hour%20Policy3-31-21.pdf
Music, Theatre & Dance	Final	http://smtd.umich.edu/current-students-2/policies-procedures/code-conduct-academic-policies/
Nursing	Final (follow's Rackham policy)	Will be placed in student handbooks PhD Program, Pg 62; Graduate Professional Programs, Pg 119; Undergraduate Programs, Pg 44
Pharmacy	Final; endorsed by PharmD Curriculum Committee, BSPS Curriculum Committee, Graduate Education Committee 9/20	https://pharmacy.umich.edu/sites/default/files/Credit%20Hours_COP.pdf
Public Health	Final	https://docs.google.com/document/d/1wJIT1t2NvvTNnN5fAs_-7t3VwJ1K3ZSid2zHImxhXA8/edit

Public Policy	Follows Rackham and Provost's guidance	Graduate: here Undergraduate: here
Rackham	Final	https://rackham.umich.edu/faculty-and-staff/resources-for-directors/guidelines-for-graduate-course-approval/assignment-of-credit-hours/
Social Work	Final	https://ssw.umich.edu/credit-hour-policy

Course Approval Request Form

Office of the Registrar, University of Michigan

1210 LSA Building
500 S. State Street
Ann Arbor, MI 48109-1382
Phone: 734.763.2113
Fax: 734.936.3148
ro.curriculum@umich.edu
ro.umich.edu

☑ **CHECK APPROPRIATE BOXES FOR ALL CHANGES**

Action Requested
- ☐ New Course
- ☑ Modification of Existing Course
- ☐ Deletion of Existing Course

Date of Submission: 2023-11-17
Effective Term: Winter 2025

☑	Course Offered ☑ Indefinitely ☐ One term only	**RO USE ONLY** Date Received: Date Completed: Completed By:

	CURRENT LISTING	**REQUESTED LISTING**
☐	Dept (Home): Industrial & Operations Engin Subject: IOE Catalog: 435	Dept (Home): Industrial & Operations Engin Subject: IOE Catalog: 435
☐	☑ Course is Cross-Listed with Other Departments Department / Subject / Catalog Number Robotics - ROB - 435	☑ Course is Cross-Listed with Other Departments Department / Subject / Catalog Number Robotics - ROB - 435
☐	Course Title (full title) Quantifying Human Motion Through Wearable Sensors	Course Title (full title) Quantifying Human Motion Through Wearable Sensors
☐	Abbreviated Title (20 char) Quant Hum Mot	Abbreviated Title (20 char) Quant Hum Mot
☑	Course Description (Please limit to 80 words and attach separate sheet if necessary) Hands-on introduction to inertial measurement units (IMUs) for measuring human motion strategies. Includes random processes, autocorrelation, cross-correlation, Fourier transforms, orientation representations, reference frames, and filters (low-pass, high-pass filters, Kalman). These concepts are applied to estimating biomechanical measures (e.g., body joint angles, torso posture, phases of gait, positions) and selecting metrics to support decision making reliant on human movement.	
☑	Full Term Credit Hours Undergraduate Min: 3 Graduate Min: Undergraduate Max: 3 Graduate Max:	Half Term Credit Hours Undergraduate Min: Graduate Min: Undergraduate Max: Graduate Max:
☑	Course Credit Type Undergraduate Student	
☐	Repeatability ☐ Course is Repeatable for Credit Maximum number of repeatable credits:	☐ Course is Y graded ☐ Can be taken more than once in the same term

Subject: Industrial & Operations Engin Catalog: 435

☐

Grading Basis
- ☑ Graded (A – E)
- ☐ Credit/No Credit
- ☐ Satisfactory/Unsatisfactory
- ☐ Pass/Fail
- ☐ Business Administration

Grading
- ☐ Not for Credit
- ☐ Not for Degree Credit
- ☐ Degree Credit Only

Add Consent
- ☐ Department Consent
- ☐ Instructor Consent
- ☑ No Consent

Drop Consent
- ☐ Department Consent
- ☐ Instructor Consent
- ☑ No Consent

	CURRENT LISTING	REQUESTED LISTING
☐	Advisory Prerequisite (254 char)	Advisory Prerequisite (254 char)
☑	Enforced Prerequisite (254 char) (ROB 101 OR MATH 214) AND IOE 265 AND (IOE 333 OR ROB 204) C- or above or graduate standing. Minimum grade requirement:	Enforced Prerequisite (254 char) (ROB 101 OR MATH 214) AND IOE 265 AND (IOE 333 OR ROB 204) C- or above. Minimum grade requirement:
☐	Credit Exclusions	Credit Exclusions

☐

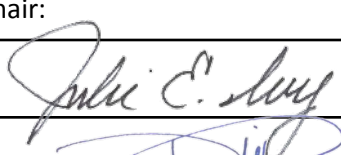
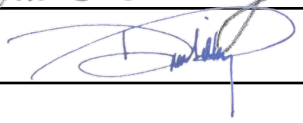
Course Components / Graded Component
- ☑ Lecture / ☑
- ☐ Seminar / ☐
- ☐ Recitation / ☐
- ☐ Lab / ☐
- ☐ Discussion / ☐
- ☐ Independent Study / ☐

Terms Typically Offered
- ☐ Fall
- ☑ Winter
- ☐ Spring
- ☐ Summer
- ☐ Spring/Summer

Cognizant Faculty Member Name: Leia Stirling Cognizant Faculty Member Title: Associate Professor

SIGNATURES ARE REQUIRED FROM ALL DEPARTMENTS INVOLVED (Please Print AND Sign Name)

Contact Person: Leonora Lucaj Email: lucajl@umich.edu Phone: 734-764-3297

CoE Curriculum Committee Representative:		Print: Yavuz Bozer	Date: 01/25/24
CoE Curriculum Committee Chair:		Print:	Date:
Home Department Chair:		Print: Julie Ivy	Date: 01/25/24
Cross-Listed Department Chair:		Print: Dawn Tilbury	Date: 01/29/2024
Cross-Listed Department Chair:		Print:	Date:
Cross-Listed Department Chair:		Print:	Date:

DEPARTMENTAL/COLLEGE USE ONLY

Current:	Requested:
Course Description Hands-on introduction to inertial measurement units (IMUs) for measuring human motion. Includes random processes, autocorrelation, cross-correlation, Fourier transforms, orientation representations, reference frames, and filters (low-pass, high-pass, Kalman). These concepts are applied to estimating biomechanical measures (e.g., body angles, gait phases, positions) and selecting metrics to support decision making.	Course Description Hands-on introduction to inertial measurement units (IMUs) for measuring human motion strategies. Includes random processes, autocorrelation, cross-correlation, Fourier transforms, orientation representations, reference frames, and filters (low-pass, high-pass filters, Kalman). These concepts are applied to estimating biomechanical measures (e.g., body joint angles, torso posture, phases of gait, positions) and selecting metrics to support decision making reliant on human movement.
Class Length Full term	Class Length Full term
Contact hours (lecture): 3	Contact hours (lecture): 3
Contact hours (recitation)	Contact hours (recitation)
Contact hours (lab)	Contact hours (lab)

Additional Info:

Submitted by:
Home dept

Describe how this course fits with the degree requirements:
This is part of the IOE Tech Electives, in Group C.

Special resources of facilities required for this course:

Supporting statement:
This course is getting a graduate level version/number so we are restricting this class to undergrads. The instructor would also like to slightly update the course description.

1210 LSA Building
500 S. State Street
Ann Arbor, MI 48109-1382
Phone: 734.763.2113
Fax: 734.936.3148
ro.curriculum@umich.edu
ro.umich.edu

Course Approval Request Form

Office of the Registrar, University of Michigan

☑ **CHECK APPROPRIATE BOXES FOR ALL CHANGES**

Action Requested
- ☑ New Course
- ☐ Modification of Existing Course
- ☐ Deletion of Existing Course

Date of Submission: 2023-12-22
Effective Term: Winter 2025

☑	Course Offered ☑ Indefinitely ☐ One term only	**RO USE ONLY** Date Received: Date Completed: Completed By:

	CURRENT LISTING			**REQUESTED LISTING**		
☑	Dept (Home): Subject: Catalog:			Dept (Home): Industrial & Operations Engin Subject: IOE Catalog: 535		
☑	☐ Course is Cross-Listed with Other Departments			☑ Course is Cross-Listed with Other Departments		
	Department	Subject	Catalog Number	Department	Subject	Catalog Number
				Robotics - ROB - 535		
☑	Course Title (full title)			Course Title (full title) Quantifying Human Motion Through Wearable Sensors		
☑	Abbreviated Title (20 char)			Abbreviated Title (20 char) Quant Hum Mot		
☑	Course Description (Please limit to 80 words and attach separate sheet if necessary) Hands-on introduction to inertial measurement units (IMUs) for measuring human motion strategies. Includes random processes, autocorrelation, cross-correlation, Fourier transforms, orientation representations, reference frames, and filters (low-pass, high-pass filters, Kalman). These concepts are applied to estimating biomechanical measures (e.g., body joint angles, torso posture, phases of gait, positions) and selecting metrics to support decision making reliant on human movement. Graduate credit includes additional synergistic research components.					
☑	Full Term Credit Hours Undergraduate Min: Undergraduate Max:	Graduate Min: 3 Graduate Max: 3		Half Term Credit Hours Undergraduate Min: Undergraduate Max:	Graduate Min: Graduate Max:	
☑	Course Credit Type Rackham Graduate Student, Non Rackham Graduate Student					
☐	Repeatability ☐ Course is Repeatable for Credit Maximum number of repeatable credits:			☐ Course is Y graded ☐ Can be taken more than once in the same term		

Subject:	Catalog:

☑	Grading Basis ☑ Graded (A – E) ☐ Credit/No Credit ☐ Satisfactory/Unsatisfactory ☐ Pass/Fail ☐ Business Administration Grading ☐ Not for Credit ☐ Not for Degree Credit ☐ Degree Credit Only	Add Consent ☐ Department Consent ☐ Instructor Consent ☑ No Consent	Drop Consent ☐ Department Consent ☐ Instructor Consent ☑ No Consent

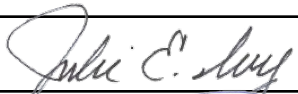
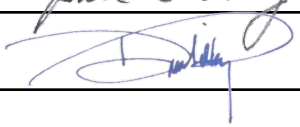
	CURRENT LISTING	**REQUESTED LISTING**
☐	Advisory Prerequisite (254 char)	Advisory Prerequisite (254 char)
☐	Enforced Prerequisite (254 char) Minimum grade requirement:	Enforced Prerequisite (254 char) Minimum grade requirement:
☐	Credit Exclusions	Credit Exclusions

☑	Course Components ☑ Lecture ☐ Seminar ☐ Recitation ☐ Lab ☐ Discussion ☐ Independent Study	Graded Component ☑ ☐ ☐ ☐ ☐ ☐	Terms Typically Offered ☐ Fall ☑ Winter ☐ Spring ☐ Summer ☐ Spring/Summer

Cognizant Faculty Member Name: Leia Stirling	Cognizant Faculty Member Title: Associate Professor

SIGNATURES ARE REQUIRED FROM ALL DEPARTMENTS INVOLVED (Please Print AND Sign Name)

Contact Person: Leonora Lucaj Email: lucajl@umich.edu Phone: 734-764-3297

CoE Curriculum Committee Representative:		Print: Yavuz Bozer	Date: 01/25/24
CoE Curriculum Committee Chair:		Print:	Date:
Home Department Chair:		Print: Julie Ivy	Date: 01/25/24
Cross-Listed Department Chair:		Print: Dawn Tilbury	Date: 01/29/2024
Cross-Listed Department Chair:		Print:	Date:
Cross-Listed Department Chair:		Print:	Date:

DEPARTMENTAL/COLLEGE USE ONLY

Current:	Requested:
Course Description	Course Description Hands-on introduction to inertial measurement units (IMUs) for measuring human motion strategies. Includes random processes, autocorrelation, cross-correlation, Fourier transforms, orientation representations, reference frames, and filters (low-pass, high-pass filters, Kalman). These concepts are applied to estimating biomechanical measures (e.g., body joint angles, torso posture, phases of gait, positions) and selecting metrics to support decision making reliant on human movement. Graduate credit includes additional synergistic research components.
Class Length	Class Length Full term
Contact hours (lecture):	Contact hours (lecture): 3
Contact hours (recitation)	Contact hours (recitation)
Contact hours (lab)	Contact hours (lab)

Additional Info:

Submitted by:
Home dept

Describe how this course fits with the degree requirements:
This is a 500 level elective for grad student curriculum.

Special resources of facilities required for this course:

Supporting statement:
See attached document.

Supporting Statement

Course Number Selection: IOE 535 was proposed since the course could have the same number scheme as the undergraduate version (IOE 435). The proposed course aligns with the Ergonomics themed courses.

Course Justification: The original IOE 491 one course justification is provided as an Appendix to this Statement. In brief, this course does not overlap with current IOE courses and expands student's ability to perform ergonomic assessments. From a Robotics perspective, this course will build on their signal processing and filtering skills with applications to quantifying human performance, which will support assessments of human-robot interactions. This course has attracted students from IOE, Robotics, Mechanical Engineering, Computer Science, and Kinesiology during the first two offerings. The graduate version supports course credit requirements for the Masters program, which has a requirement for number of 500 level IOE courses. The graduate version will include additional synergistic research activities with each assignment. These activities include additional mathematical proofs, computational modeling, and scholarly literature review.

Syllabus from offerings: The syllabus from the two initial offerings and from the proposed permanent course are included as attachments with this submission.

Teaching evaluation results: A summary of the teaching evaluation information is provided in the table below.

Item	**WN2020**	**FA2022**
Students Enrolled	27 students	28 students
Number Completing Evaluation	11 students	15 students
Overall this was an excellent course	4.4 (Median)	4.4 (Median)
Overall, Leia Stirling was an excellent Teacher	4.9 (Median)	4.9 (Median)

Required Course Status: This course will not be required and will be eligible as a 500 level IOE course for the IOE Master's degree program.

Prerequisites: The course is listed to have (ROB 101 OR MATH 214) AND IOE 265 AND (IOE 333 OR ROB 204) or graduate standing.

Timing: The form proposes to teach the course in the Winter term. I am open to determining if the course should be Fall term based on the IOE and Robotics department elective needs.

IOE 435/ROB 435/IOE535: Quantifying Human Motion Through Wearable Sensors
Winter 2025

Faculty	Professor Leia Stirling (she/her/hers)	leias@umich.edu Industrial & Operations Engineering G634 IOE Building 734-647-6828 (office) Office hours: TBD or by appointment
GSI	TBD	

Course Meetings	This course meets two times each week: TBD
Pre-requisites	**(**MATH 214 OR ROB 101), IOE 265, (IOE 333 OR ROB 204), graduate standing, and/or permission of instructor
Course Web Site	The course Canvas site will contain the following items, among others: • Announcements • Weekly calendar • Lecture slides and recordings • Links to assignments • Required and supplementary reading • Link to Piazza discussion board

Catalog Description

Quantifying Human Motion Through Wearable Sensors

Hands-on introduction to inertial measurement units (IMUs) for measuring human motion strategies. Includes random processes, autocorrelation, cross-correlation, Fourier transforms, orientation representations, reference frames, and filters (low-pass, high-pass filters, Kalman). These concepts are applied to estimating biomechanical measures (e.g., body joint angles, torso posture, phases of gait, positions) and selecting metrics to support decision making reliant on human movement. Graduate credit includes additional synergistic research components. (*3 credits*)

Course Objectives

This course will integrate engineering concepts to the measurement of human motion strategies. Specifically, the objectives of the course are to:

1. Provide a set of tools for measuring human motion using wearable sensors.
2. Provide methods for defining metrics of human motion strategy for task-specific decision making.

Course Outcomes

Upon completion of this course, you should be able to:

1. Describe the phases of gait.
2. Express the relationship between position, velocity, and acceleration for fixed and moving reference frames using state space notation.
3. Describe the relationship between a Fourier Transform of a signal and the time domain of the signal, including how a low and high pass filter affects these signals.
4. Calculate descriptors of random processes (e.g., autocorrelation, cross-correlation between two signals, Nyquist Frequency) and describe their importance.
5. Describe the similarities and differences between Euler angles, Direction Cosine Matrices, and quaternions, and convert between these rotational representations.
6. Calculate a velocity and position from an acceleration signal, implementing a zero-velocity update in estimates of position.
7. Describe and implement the Kalman filter loop, including the form of the dynamics model and observation model in state space form for estimating IMU orientation, and the measures that are necessary to iterate an estimate.
8. Describe methods for aligning IMUs to biomechanical reference frames.
9. Use an IMU to estimate biomechanical measures (e.g., joint angles, torso posture, phases of gait).
10. Identify and describe ethical considerations for human monitoring.
11. Give examples of tools used for work analysis and apply these tools to biomechanics performance to define relevant metrics for a specified task.

Textbook

There is no required textbook for this course. Reading materials from a variety of sources will be made available on Canvas.

Tentative Schedule (based on WN 24 dates)

Date	Lecture	Topic	Reading	Assignments
Jan 10	1	Course introduction		
Jan 15	--	**No Class**		
Jan 17	2	Human movement	Chapter excerpts from Perry and Burnfield	HW1 assigned
Jan 22	3	Reference frame representations	Diebel (2006)	
Jan 24	4	Reference frame representations		HW 1 due, HW2 assigned
Jan 29	5	Equations of Motion		
Jan 31	6	Random Processes and Fourier Transforms		

Feb 5	7	Random Processes and Fourier Transforms		HW 2 due, HW 3 assigned
Feb 7	8	Filters		
Feb 12	9	Filters		
Feb 14	10	Kalman Filters	Welch and Bishop (2006)	HW 3 due, HW4 assigned
Feb 19	11	Kalman Filters		
Feb 21	12	Extended Kalman Filter for IMU Orientation		HW 4 due, HW5 assigned
Feb 26	--	**No Class**		
Feb 28	--	**No Class**		
March 4	13	Extended Kalman Filter for IMU Orientation		
March 6	14	Personal Dead Reckoning	Ojeda and Borenstein (2007)	
March 11	15	IMU Alignment	Vitali (2020)	HW 5 due, HW 6 assigned
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March 18	17	Estimating joint angles and torso orientation	Shlens (2014)	HW 6 due, HW 7 assigned
March 20	18	Estimating joint angles and torso orientation		
March 25	19	Defining metrics of performance		
March 27	20	Defining metrics of performance		HW 7 due, HW 8 assigned
April 1	21	Reliability and Validity of Metrics		
April 3	22	In-class workshop for final project		
April 8	23	Human monitoring ethics		HW 8 due
April 10	24	In-class workshop and peer review		
April 15	25	Exploration of muscle activity wearable sensors		
April 17	26	Final Project Presentations		Final presentations due
April 22	27	Final Project Presentations		

Grading

The grading scheme for undergraduate and graduate students is the same. Each assignment is worth 10% of the grade, with the final project worth 20% of the final grade. Within each assignment, graduate students will have an additional submission responsibility related to the course material to build additional depth of understanding of the domain.

Item	Points
Assignments	80
Final Project	20
Total Points	**100**

Assignments

Students may discuss the assignments together, but each student must do their own work and turn in their own assignment. Assignments are due at the beginning of class. Late assignments will only be accepted with permission from the instructor.

Use of Generative AI

Generative AI (Artificial Intelligence) is now widely available to produce text, images, and other media. Our goal as a community of learners is to explore and understand how these tools may be used to augment human performance. However, keep the following three principles in mind: (1) An AI cannot pass this course; (2) AI contributions must be attributed and true; (3) The use of AI resources must be open and documented.

1. *An AI cannot pass this course.* Our goal in assigning grades is to assess *your* learning. Any deliverable that does not demonstrate learning (for instance, because it appears to be entirely or largely produced by an AI tool) is therefore not eligible for a grade. The teaching team will produce AI-generated sample solutions in order to establish a baseline, which you are expected to surpass. In addition, success in this course will rely on your ability to understand the content and expectations of this course, which any AI tool will not have access to.
2. *AI contributions must be attributed and true*. You are taking full responsibility for AI-generated materials as if you had produced them yourself. AI tools are known to generate false information and fake citations and to plagiarize material. Therefore, you must verify all information and ensure that you are citing any information or ideas to their ultimate sources.
3. *The use of AI resources must be open and documented.* Include an explanatory appendix that, for each and every unique usage of an AI tool, states the name of the tool used, the prompts given to it, and the output.

Failure to document your use of AI tools, as well as any plagiarism that results, even inadvertently, from the use of AI tools (such as quotations or information that are not properly attributed) constitutes academic misconduct, and may be referred to the Honor Council.

You can find more information about using generative AI and access a secure AI tool provided by UM at https://genai.umich.edu/guidance/students

Exams

There are no exams for this class. Your assignments and final projects provide the course assessments.

Final Project

Students will be placed in groups of 3 – 4 people. Students should identify a concept from class that can be applied to an area of mutual interest within the team and related to measuring human motion. Teams must provide a proposed topic by the date stated in the schedule. For the project, your team will either (1) develop a public engagement activity or (2) perform a study. Final projects include a written and oral component and will be described in more detail during the term.

Diversity, Equity, and Inclusion

At U-M Industrial and Operations Engineering (IOE), we value all people and are committed to promoting diversity, equity and inclusion (DEI) in its fullest form for everyone in our community and beyond. We advance scientific and mathematical methods and develop engineering technologies to help solve human-centered local and global challenges; meaning we impact people, processes, and systems through generating and analyzing data across a range of applications. Not only does incorporating DEI principles make our solutions more powerful, applicable, and ethical, promoting and fostering DEI is a core value of the IOE community and leadership. At U-M IOE we view DEI as interwoven with our research, teaching and community involvement.

I consider this classroom to be a place where you will be treated with respect, and I welcome individuals of all ages, backgrounds, beliefs, ethnicities, genders, gender identities, gender expressions, national origins, religious affiliations, sexual orientations, ability – and other visible and nonvisible differences. All members of this class are expected to contribute to a respectful, welcoming and inclusive environment for every other member of the class.

I am dedicated to helping each of you achieve all that you can in this class. I may, either in lecture or smaller interactions, accidentally use language that creates offense or discomfort. Should I do this, please contact me and help me understand and avoid making the same mistake again.

Academic integrity

The College of Engineering Honor Code is a statement of ethical standards by which the faculty and students of the College of engineering conduct themselves. Both undergraduate and graduate students are bound by the provisions of the Honor Code; ignorance of it is no excuse to infringe upon it. You are expected to read and abide by the Honor Code:

http://elc.engin.umich.edu/wp-content/uploads/sites/19/2019/03/Honor-Code-Pamphlet-2018.pdf

Accommodations

The University of Michigan is committed to providing equal opportunity for participation in all programs, services and activities. Request for accommodations by persons with disabilities may be made by contacting the Services for Students with Disabilities (SSD) Office located at G664 Haven Hall. The SSD phone number is 734-763-3000 and webpage is http://ssd.umich.edu/. Once your eligibility for an accommodation has been determined you will be issued a verified individual services accommodation (VISA) form. Please present this form to me at the beginning of the term, or at least two weeks prior to the need for the accommodation (test, project, etc…). Any information you provide is private and confidential and will be treated as such.

Student well-being

Students may experience stressors that can impact both their academic experience and their personal well-being. These may include academic pressure and challenges associated with relationships, mental health, alcohol or other drugs, identities, finances, etc. If you are experiencing concerns, seeking help is a courageous thing to do for yourself and those who care about you. If the source of your stressors is academic, please contact me so that we can find solutions together. For personal concerns, U-M offers many resources, some of which are listed at Resources for Student Well-being on the Well-being for U-M Students website. You can also search for additional resources on that website.

Reporting Concerns and Misconduct

The Department of Industrial and Operations Engineering is dedicated to providing an environment that is inclusive, supportive, and respectful. If we fall short, we want to hear from you. Use our website to learn about ways to report concerns or misconduct anonymously, confidentially, or formally, and know that you will be heard, you will be taken seriously, and the U-M IOE community will stand behind you.

https://sites.google.com/umich.edu/report-concerns-and-misconduct/

The Department of Robotics strives for a community built on respect and integrity. Actions against those values do not only hurt our community members, but weaken our community and what we can achieve as a whole. While reporting misconduct is up to those who encounter it, we hope everyone feels comfortable pointing out instances of wrongdoing, without fear of retaliation. Know that the Robotics community will stand behind you, whatever your decision. If you encounter behavior or misconduct that does not follow Robotics values or University of Michigan policies, or are unsure if you have experienced such behavior, there are many resources and contacts available for you. Use our website to learn about ways to report concerns or misconduct.

https://robotics.umich.edu/academics/current-students/reporting-concerns-and-misconduct/

Title IX Statement & Resources

Violence and harassment based on sex and gender are civil rights offenses subject to the same kinds of accountability and the same kinds of support applied to offenses against other protected categories such as race, national origin, etc. If you or someone you know has been harassed or assaulted, you can find the appropriate resources here:

- Sexual Assault and Prevention Center (SAPAC) 24-hour confidential crisis line 734-936-3333, sapac.umich.edu

- Counseling and Psychological Services (CAPS) 734-764-8312, caps.umich.edu
- University of Michigan Police (DPSS) 734-763-1131 (or 911 for emergency), dpss.umich.edu
- Office of Student Conflict Resolution 724-936-6308, oscr.umich.edu

Appendix: Original Course Justification Statement

IOE 491: Quantifying Human Motion Through Wearable Sensors

Prof. Leia Stirling
Proposed September 2019

Why is this course needed?

There is a growing interest to use wearable technology to assess human performance outside a laboratory environment. These measures in operationally relevant locations (e.g., in outdoor environments, hospitals, factories, warehouses) permits understanding of task strategies and work processes, as well as musculoskeletal risk factors. Commercial wearable sensors include fitness trackers and smart watches, which can provide information to users on their heart rates, step counts, and GPS localization. Statista[1] estimates the global revenue for wearable sensors was valued at $26.43 billion U.S. Dollars in 2018 and is expected to grow to $73.27 billion U.S. Dollars by 2022. In 2018, there were an estimated 174.26 million units of wearable devices shipped worldwide. Haghi et al.[2] summarize the opportunities for wearable sensors for healthcare monitoring, while Seshadri et al.[3] provide a review of using wearable sensing for monitoring athletes. Wearables are also starting to be used in workplace environments for monitoring physical fatigue[4] and optimizing warehouse tasks.[5] The IOE department has strength in Ergonomics and a course in wearable sensors as related to human motion would support educational outcomes and prepare students for integrating wearable motion sensors in a variety of operational domains.

The use of wearable technology for measuring human motion has several complexities that must be considered, including how estimations of position and posture are affected by signal noise and sensor placement. The course will focus on using Inertial Measurement Units (IMUs), which contain tri-axial accelerometers, gyroscopes, and magnetometers. To use these sensors, the course will provide learning objectives to build the skill-set needed to work with the measured signals in a biomechanically relevant manner. Topic areas will include:

- Cognitive Task Analysis: Techniques and methods for understanding the important decision making factors for a task. These methods will be related to defining metrics of motor performance.
- Probability and Statistics: Random processes, autocorrelation, cross-correlation, power spectral density, Nyquist Frequency

[1] https://www.statista.com/statistics/610447/wearable-device-revenue-worldwide/
[2] M. Haghi, K. Thurow, I. Habil, R. Stoll, and M. Habil, "Wearable Devices in Medical Internet of Things," *Heal. Informatics Res.*, vol. 23, no. 1, pp. 4–15, 2017.
[3] D. R. Seshadri, R. T. Li, J. E. Voos, J. R. Rowbottom, C. M. Alfes, C. A. Zorman, and C. K. Drummond, "Wearable sensors for monitoring the internal and external workload of the athlete," npj Digit. Med., vol. 2, no. 1, 2019.
[4] Z. Sedighi Maman, M. A. Alamdar Yazdi, L. A. Cavuoto, and F. M. Megahed, "A data-driven approach to modeling physical fatigue in the workplace using wearable sensors," *Appl. Ergon.*, 2017.
[5] A. Diete, T. Sztyler, L. Weiland, and H. Stuckenschmidt, "Exploring a multi-sensor picking process in the future warehouse," *UbiComp 2016 Adjun. - Proc. 2016 ACM Int. Jt. Conf. Pervasive Ubiquitous Comput.*, pp. 1755–1758, 2016.

- Dynamics: Fourier transforms, reference frames, orientation representations, equations of motion
- IMU analysis: Direct estimation, drift correction, filters (low-pass, high-pass, Kalman)
- Biomechanics applications: Aligning IMUs to body reference frames, estimating body joint angles, estimating torso postures, detecting phases of gait

Pre-requisites for this course will be MATH 215, IOE 265, IOE 333, and/or permission of instructor. These topics will be presented in a manner that is approachable to students that have not had any dynamics or controls courses.

In context with the ABET requirements, this course will map to the criteria as follows:

(a) an ability to apply knowledge of mathematics, science, and engineering. The course provides learning objectives aligned with applying mathematical methods to biomechanics problems.

(b) an ability to design and conduct experiments, as well as to analyze and interpret data. Assignments within the course include the collection of data from wearable sensors and the interpretation of these data.

(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability. The course will provide students with a realistic understanding of the applicability of sensors for specific biomechanics problems. The course will include ethical considerations when using human data, as well as considerations of how the sensors can be used to inform health and safety.

(d) an ability to function on multidisciplinary teams. The course will not explicitly focus on multidisciplinary teams, but will present techniques that space engineering disciplines that are integrated to use wearable sensors.

(e) an ability to identify, formulate, and solve engineering problems. The course provides open-ended problems that require students to formulate a solution and test the solution in an engineering context, specifically related to biomechanics.

(f) an understanding of professional and ethical responsibility. The course includes a lecture on the ethics of using personal human data.

(g) an ability to communicate effectively. The course includes final project presentations that will provide an opportunity for oral communication skills, as well as problem sets that require written communication.

(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context. We do not specifically focus on global, economic, or environmental questions explicitly. The course will consider education related to societal concerns of health monitoring and ethics of data monitoring.

(i) *a recognition of the need for, and an ability to engage in life-long learning*. The final project in the course requires the use of methods in the class to develop an outreach activity. As part of the course, students will also receive a lecture on outreach and education planning to support their final project development.

(j) *a knowledge of contemporary issues.* As highlighted, wearable sensors are a growing market with many opportunities for students.

(k) *an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.* The course includes techniques from several core engineering disciplines that will be integrated by students in the context of wearable sensors.

How does this course improve the undergraduate curriculum?
The course will introduce IOE students to key concepts in dynamics and signal processing in the context of biomechanics applications. The course will build the students theoretical understanding of wearable sensors, as well as demonstrate how these methods are applied to biomechanics. The course provides continued experiences in communication, and will apply engineering ethical questions for consideration in the context of human motion sensing.

How does the course meet the needs of our students and society?
This course provides a foundation for students to use new technologies that are being integrated across industry and government to aid in operational decision making. It is important that our students not use these technologies as black boxes, but understand the limitations and benefits of these systems. This understanding will lead to more informed decision making.

Supporting Statement

Course Number Selection: IOE 535 was proposed since the course could have the same number scheme as the undergraduate version (IOE 435). The proposed course aligns with the Ergonomics themed courses.

Course Justification: The original IOE 491 one course justification is provided as an Appendix to this Statement. In brief, this course does not overlap with current IOE courses and expands student's ability to perform ergonomic assessments. From a Robotics perspective, this course will build on their signal processing and filtering skills with applications to quantifying human performance, which will support assessments of human-robot interactions. This course has attracted students from IOE, Robotics, Mechanical Engineering, Computer Science, and Kinesiology during the first two offerings. The graduate version supports course credit requirements for the Masters program, which has a requirement for number of 500 level IOE courses. The graduate version will include additional synergistic research activities with each assignment. These activities include additional mathematical proofs, computational modeling, and scholarly literature review.

Syllabus from offerings: The syllabus from the two initial offerings and from the proposed permanent course are included as attachments with this submission.

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Item	**WN2020**	**FA2022**
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Number Completing Evaluation	11 students	15 students
Overall this was an excellent course	4.4 (Median)	4.4 (Median)
Overall, Leia Stirling was an excellent Teacher	4.9 (Median)	4.9 (Median)

Required Course Status: This course will not be required and will be eligible as a 500 level IOE course for the IOE Master's degree program.

Prerequisites: The course is listed to have (ROB 101 OR MATH 214) AND IOE 265 AND (IOE 333 OR ROB 204) or graduate standing.

Timing: The form proposes to teach the course in the Winter term. I am open to determining if the course should be Fall term based on the IOE and Robotics department elective needs.

IOE 435/ROB 435/IOE535: Quantifying Human Motion Through Wearable Sensors
Winter 2025

Faculty	Professor Leia Stirling (she/her/hers)	leias@umich.edu Industrial & Operations Engineering G634 IOE Building 734-647-6828 (office) Office hours: TBD or by appointment
GSI	TBD	

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Catalog Description

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This course will integrate engineering concepts to the measurement of human motion strategies. Specifically, the objectives of the course are to:

1. Provide a set of tools for measuring human motion using wearable sensors.
2. Provide methods for defining metrics of human motion strategy for task-specific decision making.

Course Outcomes

Upon completion of this course, you should be able to:

1. Describe the phases of gait.
2. Express the relationship between position, velocity, and acceleration for fixed and moving reference frames using state space notation.
3. Describe the relationship between a Fourier Transform of a signal and the time domain of the signal, including how a low and high pass filter affects these signals.
4. Calculate descriptors of random processes (e.g., autocorrelation, cross-correlation between two signals, Nyquist Frequency) and describe their importance.
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6. Calculate a velocity and position from an acceleration signal, implementing a zero-velocity update in estimates of position.
7. Describe and implement the Kalman filter loop, including the form of the dynamics model and observation model in state space form for estimating IMU orientation, and the measures that are necessary to iterate an estimate.
8. Describe methods for aligning IMUs to biomechanical reference frames.
9. Use an IMU to estimate biomechanical measures (e.g., joint angles, torso posture, phases of gait).
10. Identify and describe ethical considerations for human monitoring.
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Use of Generative AI

Generative AI (Artificial Intelligence) is now widely available to produce text, images, and other media. Our goal as a community of learners is to explore and understand how these tools may be used to augment human performance. However, keep the following three principles in mind: (1) An AI cannot pass this course; (2) AI contributions must be attributed and true; (3) The use of AI resources must be open and documented.

1. *An AI cannot pass this course.* Our goal in assigning grades is to assess *your* learning. Any deliverable that does not demonstrate learning (for instance, because it appears to be entirely or largely produced by an AI tool) is therefore not eligible for a grade. The teaching team will produce AI-generated sample solutions in order to establish a baseline, which you are expected to surpass. In addition, success in this course will rely on your ability to understand the content and expectations of this course, which any AI tool will not have access to.
2. *AI contributions must be attributed and true*. You are taking full responsibility for AI-generated materials as if you had produced them yourself. AI tools are known to generate false information and fake citations and to plagiarize material. Therefore, you must verify all information and ensure that you are citing any information or ideas to their ultimate sources.
3. *The use of AI resources must be open and documented.* Include an explanatory appendix that, for each and every unique usage of an AI tool, states the name of the tool used, the prompts given to it, and the output.

Failure to document your use of AI tools, as well as any plagiarism that results, even inadvertently, from the use of AI tools (such as quotations or information that are not properly attributed) constitutes academic misconduct, and may be referred to the Honor Council.

You can find more information about using generative AI and access a secure AI tool provided by UM at https://genai.umich.edu/guidance/students

Exams

There are no exams for this class. Your assignments and final projects provide the course assessments.

Final Project

Students will be placed in groups of 3 – 4 people. Students should identify a concept from class that can be applied to an area of mutual interest within the team and related to measuring human motion. Teams must provide a proposed topic by the date stated in the schedule. For the project, your team will either (1) develop a public engagement activity or (2) perform a study. Final projects include a written and oral component and will be described in more detail during the term.

Diversity, Equity, and Inclusion

At U-M Industrial and Operations Engineering (IOE), we value all people and are committed to promoting diversity, equity and inclusion (DEI) in its fullest form for everyone in our community and beyond. We advance scientific and mathematical methods and develop engineering technologies to help solve human-centered local and global challenges; meaning we impact people, processes, and systems through generating and analyzing data across a range of applications. Not only does incorporating DEI principles make our solutions more powerful, applicable, and ethical, promoting and fostering DEI is a core value of the IOE community and leadership. At U-M IOE we view DEI as interwoven with our research, teaching and community involvement.

I consider this classroom to be a place where you will be treated with respect, and I welcome individuals of all ages, backgrounds, beliefs, ethnicities, genders, gender identities, gender expressions, national origins, religious affiliations, sexual orientations, ability – and other visible and nonvisible differences. All members of this class are expected to contribute to a respectful, welcoming and inclusive environment for every other member of the class.

I am dedicated to helping each of you achieve all that you can in this class. I may, either in lecture or smaller interactions, accidentally use language that creates offense or discomfort. Should I do this, please contact me and help me understand and avoid making the same mistake again.

Academic integrity

The College of Engineering Honor Code is a statement of ethical standards by which the faculty and students of the College of engineering conduct themselves. Both undergraduate and graduate students are bound by the provisions of the Honor Code; ignorance of it is no excuse to infringe upon it. You are expected to read and abide by the Honor Code:

http://elc.engin.umich.edu/wp-content/uploads/sites/19/2019/03/Honor-Code-Pamphlet-2018.pdf

Accommodations

The University of Michigan is committed to providing equal opportunity for participation in all programs, services and activities. Request for accommodations by persons with disabilities may be made by contacting the Services for Students with Disabilities (SSD) Office located at G664 Haven Hall. The SSD phone number is 734-763-3000 and webpage is http://ssd.umich.edu/. Once your eligibility for an accommodation has been determined you will be issued a verified individual services accommodation (VISA) form. Please present this form to me at the beginning of the term, or at least two weeks prior to the need for the accommodation (test, project, etc…). Any information you provide is private and confidential and will be treated as such.

Student well-being

Students may experience stressors that can impact both their academic experience and their personal well-being. These may include academic pressure and challenges associated with relationships, mental health, alcohol or other drugs, identities, finances, etc. If you are experiencing concerns, seeking help is a courageous thing to do for yourself and those who care about you. If the source of your stressors is academic, please contact me so that we can find solutions together. For personal concerns, U-M offers many resources, some of which are listed at Resources for Student Well-being on the Well-being for U-M Students website. You can also search for additional resources on that website.

Reporting Concerns and Misconduct

The Department of Industrial and Operations Engineering is dedicated to providing an environment that is inclusive, supportive, and respectful. If we fall short, we want to hear from you. Use our website to learn about ways to report concerns or misconduct anonymously, confidentially, or formally, and know that you will be heard, you will be taken seriously, and the U-M IOE community will stand behind you.

https://sites.google.com/umich.edu/report-concerns-and-misconduct/

The Department of Robotics strives for a community built on respect and integrity. Actions against those values do not only hurt our community members, but weaken our community and what we can achieve as a whole. While reporting misconduct is up to those who encounter it, we hope everyone feels comfortable pointing out instances of wrongdoing, without fear of retaliation. Know that the Robotics community will stand behind you, whatever your decision. If you encounter behavior or misconduct that does not follow Robotics values or University of Michigan policies, or are unsure if you have experienced such behavior, there are many resources and contacts available for you. Use our website to learn about ways to report concerns or misconduct.

https://robotics.umich.edu/academics/current-students/reporting-concerns-and-misconduct/

Title IX Statement & Resources

Violence and harassment based on sex and gender are civil rights offenses subject to the same kinds of accountability and the same kinds of support applied to offenses against other protected categories such as race, national origin, etc. If you or someone you know has been harassed or assaulted, you can find the appropriate resources here:

- Sexual Assault and Prevention Center (SAPAC) 24-hour confidential crisis line 734-936-3333, sapac.umich.edu

- Counseling and Psychological Services (CAPS) 734-764-8312, caps.umich.edu
- University of Michigan Police (DPSS) 734-763-1131 (or 911 for emergency), dpss.umich.edu
- Office of Student Conflict Resolution 724-936-6308, oscr.umich.edu

Appendix: Original Course Justification Statement

IOE 491: Quantifying Human Motion Through Wearable Sensors

Prof. Leia Stirling
Proposed September 2019

Why is this course needed?

There is a growing interest to use wearable technology to assess human performance outside a laboratory environment. These measures in operationally relevant locations (e.g., in outdoor environments, hospitals, factories, warehouses) permits understanding of task strategies and work processes, as well as musculoskeletal risk factors. Commercial wearable sensors include fitness trackers and smart watches, which can provide information to users on their heart rates, step counts, and GPS localization. Statista[1] estimates the global revenue for wearable sensors was valued at $26.43 billion U.S. Dollars in 2018 and is expected to grow to $73.27 billion U.S. Dollars by 2022. In 2018, there were an estimated 174.26 million units of wearable devices shipped worldwide. Haghi et al.[2] summarize the opportunities for wearable sensors for healthcare monitoring, while Seshadri et al.[3] provide a review of using wearable sensing for monitoring athletes. Wearables are also starting to be used in workplace environments for monitoring physical fatigue[4] and optimizing warehouse tasks.[5] The IOE department has strength in Ergonomics and a course in wearable sensors as related to human motion would support educational outcomes and prepare students for integrating wearable motion sensors in a variety of operational domains.

The use of wearable technology for measuring human motion has several complexities that must be considered, including how estimations of position and posture are affected by signal noise and sensor placement. The course will focus on using Inertial Measurement Units (IMUs), which contain tri-axial accelerometers, gyroscopes, and magnetometers. To use these sensors, the course will provide learning objectives to build the skill-set needed to work with the measured signals in a biomechanically relevant manner. Topic areas will include:

- Cognitive Task Analysis: Techniques and methods for understanding the important decision making factors for a task. These methods will be related to defining metrics of motor performance.
- Probability and Statistics: Random processes, autocorrelation, cross-correlation, power spectral density, Nyquist Frequency

[1] https://www.statista.com/statistics/610447/wearable-device-revenue-worldwide/
[2] M. Haghi, K. Thurow, I. Habil, R. Stoll, and M. Habil, "Wearable Devices in Medical Internet of Things," *Heal. Informatics Res.*, vol. 23, no. 1, pp. 4–15, 2017.
[3] D. R. Seshadri, R. T. Li, J. E. Voos, J. R. Rowbottom, C. M. Alfes, C. A. Zorman, and C. K. Drummond, "Wearable sensors for monitoring the internal and external workload of the athlete," npj Digit. Med., vol. 2, no. 1, 2019.
[4] Z. Sedighi Maman, M. A. Alamdar Yazdi, L. A. Cavuoto, and F. M. Megahed, "A data-driven approach to modeling physical fatigue in the workplace using wearable sensors," *Appl. Ergon.*, 2017.
[5] A. Diete, T. Sztyler, L. Weiland, and H. Stuckenschmidt, "Exploring a multi-sensor picking process in the future warehouse," *UbiComp 2016 Adjun. - Proc. 2016 ACM Int. Jt. Conf. Pervasive Ubiquitous Comput.*, pp. 1755–1758, 2016.

- Dynamics: Fourier transforms, reference frames, orientation representations, equations of motion
- IMU analysis: Direct estimation, drift correction, filters (low-pass, high-pass, Kalman)
- Biomechanics applications: Aligning IMUs to body reference frames, estimating body joint angles, estimating torso postures, detecting phases of gait

Pre-requisites for this course will be MATH 215, IOE 265, IOE 333, and/or permission of instructor. These topics will be presented in a manner that is approachable to students that have not had any dynamics or controls courses.

In context with the ABET requirements, this course will map to the criteria as follows:

(a) an ability to apply knowledge of mathematics, science, and engineering. The course provides learning objectives aligned with applying mathematical methods to biomechanics problems.

(b) an ability to design and conduct experiments, as well as to analyze and interpret data. Assignments within the course include the collection of data from wearable sensors and the interpretation of these data.

(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability. The course will provide students with a realistic understanding of the applicability of sensors for specific biomechanics problems. The course will include ethical considerations when using human data, as well as considerations of how the sensors can be used to inform health and safety.

(d) an ability to function on multidisciplinary teams. The course will not explicitly focus on multidisciplinary teams, but will present techniques that space engineering disciplines that are integrated to use wearable sensors.

(e) an ability to identify, formulate, and solve engineering problems. The course provides open-ended problems that require students to formulate a solution and test the solution in an engineering context, specifically related to biomechanics.

(f) an understanding of professional and ethical responsibility. The course includes a lecture on the ethics of using personal human data.

(g) an ability to communicate effectively. The course includes final project presentations that will provide an opportunity for oral communication skills, as well as problem sets that require written communication.

(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context. We do not specifically focus on global, economic, or environmental questions explicitly. The course will consider education related to societal concerns of health monitoring and ethics of data monitoring.

(i) *a recognition of the need for, and an ability to engage in life-long learning*. The final project in the course requires the use of methods in the class to develop an outreach activity. As part of the course, students will also receive a lecture on outreach and education planning to support their final project development.

(j) *a knowledge of contemporary issues.* As highlighted, wearable sensors are a growing market with many opportunities for students.

(k) *an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.* The course includes techniques from several core engineering disciplines that will be integrated by students in the context of wearable sensors.

How does this course improve the undergraduate curriculum?
The course will introduce IOE students to key concepts in dynamics and signal processing in the context of biomechanics applications. The course will build the students theoretical understanding of wearable sensors, as well as demonstrate how these methods are applied to biomechanics. The course provides continued experiences in communication, and will apply engineering ethical questions for consideration in the context of human motion sensing.

How does the course meet the needs of our students and society?
This course provides a foundation for students to use new technologies that are being integrated across industry and government to aid in operational decision making. It is important that our students not use these technologies as black boxes, but understand the limitations and benefits of these systems. This understanding will lead to more informed decision making.

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Course Approval Request Form

Office of the Registrar, University of Michigan

☑ **CHECK APPROPRIATE BOXES FOR ALL CHANGES**

Action Requested
- ☑ New Course
- ☐ Modification of Existing Course
- ☐ Deletion of Existing Course

Date of Submission: 2024-02-01
Effective Term: Fall 2024

☑	Course Offered ☑ Indefinitely ☐ One term only	**RO USE ONLY** Date Received: Date Completed: Completed By:

	CURRENT LISTING	**REQUESTED LISTING**
☑	Dept (Home): Subject: Catalog:	Dept (Home): Robotics Subject: ROB Catalog: 298
☐	☐ Course is Cross-Listed with Other Departments Department / Subject / Catalog Number	☐ Course is Cross-Listed with Other Departments Department / Subject / Catalog Number
☑	Course Title (full title)	Course Title (full title) Special Topics in Robotics
☑	Abbreviated Title (20 char)	Abbreviated Title (20 char) Spec Topics Robotics
☑	Course Description (Please limit to 80 words and attach separate sheet if necessary) Topics of current interest in Robotics.	
☑	Full Term Credit Hours Undergraduate Min: 1 Graduate Min: Undergraduate Max: 8 Graduate Max:	Half Term Credit Hours Undergraduate Min: Graduate Min: Undergraduate Max: Graduate Max:
☑	Course Credit Type Undergraduate Student	
☑	Repeatability ☑ Course is Repeatable for Credit Maximum number of repeatable credits: 99	☐ Course is Y graded ☑ Can be taken more than once in the same term

Subject: Catalog:

☑	Grading Basis ☑ Graded (A – E) ☐ Credit/No Credit ☐ Satisfactory/Unsatisfactory ☐ Pass/Fail ☐ Business Administration Grading ☐ Not for Credit ☐ Not for Degree Credit ☐ Degree Credit Only	Add Consent ☐ Department Consent ☐ Instructor Consent ☑ No Consent	Drop Consent ☐ Department Consent ☐ Instructor Consent ☑ No Consent

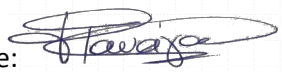
	CURRENT LISTING	REQUESTED LISTING
☐	Advisory Prerequisite (254 char)	Advisory Prerequisite (254 char)
☐	Enforced Prerequisite (254 char) Minimum grade requirement:	Enforced Prerequisite (254 char) Minimum grade requirement:
☐	Credit Exclusions	Credit Exclusions

☑	Course Components ☑ Lecture ☐ Seminar ☑ Recitation ☑ Lab ☑ Discussion ☐ Independent Study	Graded Component ☑ ☐ ☐ ☐ ☐ ☐	Terms Typically Offered ☑ Fall ☑ Winter ☑ Spring ☑ Summer ☑ Spring/Summer

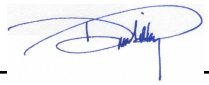
Cognizant Faculty Member Name: Jessy Grizzle Cognizant Faculty Member Title: Professor

SIGNATURES ARE REQUIRED FROM ALL DEPARTMENTS INVOLVED (Please Print AND Sign Name)

Contact Person: Kayla Dombrowski Email: kakelle@umich.edu Phone: 734-936-7999

CoE Curriculum Committee Representative:  Print: Dimitra Panagou Date: 1/26/2024

CoE Curriculum Committee Chair: Print: Date:

Home Department Chair:  Print: Dawn Tilbury Date: 1/31/24

Cross-Listed Department Chair: Print: Date:

Cross-Listed Department Chair: Print: Date:

Cross-Listed Department Chair: Print: Date:

DEPARTMENTAL/COLLEGE USE ONLY

Current:	Requested:
Course Description	Course Description Topics of current interest in Robotics.
Class Length	Class Length Full term
Contact hours (lecture):	Contact hours (lecture): 1 - 8
Contact hours (recitation)	Contact hours (recitation) 1 - 8
Contact hours (lab)	Contact hours (lab) 1 - 8

Additional Info:

Submitted by:
Home dept

Describe how this course fits with the degree requirements:

Special resources of facilities required for this course:

Supporting statement:
This request to establish this undergraduate special topics course in Robotics (298) is to allow us to develop courses that will be accessible to all students in the College. Following CoE tradition, we would like to offer courses twice as special topics before considering an application for an official number. Note, that the course content could vary, depending on the instructor. Special Topics courses will abide by the CoE Assignment of Credit Hour Policy for each course component.

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Course Approval Request Form

Office of the Registrar, University of Michigan

☑ **CHECK APPROPRIATE BOXES FOR ALL CHANGES**

Action Requested
- ☐ New Course
- ☑ Modification of Existing Course
- ☐ Deletion of Existing Course

Date of Submission: 2024-02-01
Effective Term: Fall 2024

☑	Course Offered ☑ Indefinitely ☐ One term only	**RO USE ONLY** Date Received: Date Completed: Completed By:

	CURRENT LISTING	**REQUESTED LISTING**
☐	Dept (Home): Robotics Subject: ROB Catalog: 311	Dept (Home): Robotics Subject: ROB Catalog: 311
☐	☐ Course is Cross-Listed with Other Departments Department / Subject / Catalog Number	☐ Course is Cross-Listed with Other Departments Department / Subject / Catalog Number
☐	Course Title (full title) How to Build Robots and Make Them Move	Course Title (full title) How to Build Robots and Make Them Move
☐	Abbreviated Title (20 char) How to Make Robots	Abbreviated Title (20 char) How to Make Robots
☑	Course Description (Please limit to 80 words and attach separate sheet if necessary) Introduces the fundamentals of mechanical design, control, fabrication, actuation, instrumentation, and computer interfaces required to realize robotic systems. Students will learn to analyze/simulate rigid body kinematics, kinetics, and dynamics, as well as assess the impedance properties of their designs. 'Hands-on' skills will be emphasized in addition to theoretical concepts.	
☐	Full Term Credit Hours Undergraduate Min: 4 Graduate Min: Undergraduate Max: 4 Graduate Max:	Half Term Credit Hours Undergraduate Min: Graduate Min: Undergraduate Max: Graduate Max:
☐	Course Credit Type Undergraduate Student	
☐	Repeatability ☐ Course is Repeatable for Credit Maximum number of repeatable credits: 0	☐ Course is Y graded ☐ Can be taken more than once in the same term

Subject: Robotics Catalog: 311

☐

Grading Basis
- ☑ Graded (A – E)
- ☐ Credit/No Credit
- ☐ Satisfactory/Unsatisfactory
- ☐ Pass/Fail
- ☐ Business Administration

Grading
- ☐ Not for Credit
- ☐ Not for Degree Credit
- ☐ Degree Credit Only

Add Consent
- ☐ Department Consent
- ☐ Instructor Consent
- ☑ No Consent

Drop Consent
- ☐ Department Consent
- ☐ Instructor Consent
- ☑ No Consent

	CURRENT LISTING	REQUESTED LISTING
☑	Advisory Prerequisite (254 char) ME 240 and/or 360, ROB 310	Advisory Prerequisite (254 char) (EECS 215 or PHYSICS 240 or PHYSICS 260 or MECHENG 240 or BIOMEDE 231) and ROB 310
☐	Enforced Prerequisite (254 char) ROB 204 Minimum grade requirement: C-	Enforced Prerequisite (254 char) ROB 204 Minimum grade requirement: C-
☐	Credit Exclusions None	Credit Exclusions None

☐

Course Components

	Graded Component
☑ Lecture	☐
☐ Seminar	☐
☐ Recitation	☐
☑ Lab	☑
☐ Discussion	☐
☐ Independent Study	☐

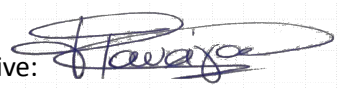
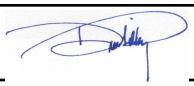
Terms Typically Offered
- ☑ Fall
- ☐ Winter
- ☐ Spring
- ☐ Summer
- ☐ Spring/Summer

Cognizant Faculty Member Name: Elliott Rouse

Cognizant Faculty Member Title: Associate Professor

SIGNATURES ARE REQUIRED FROM ALL DEPARTMENTS INVOLVED (Please Print AND Sign Name)

Contact Person: Kayla Dombrowski Email: kakelle@umich.edu Phone: 734-936-7999

CoE Curriculum Committee Representative:		Print: Dimitra Panagou	Date: 1/26/2024
CoE Curriculum Committee Chair:		Print:	Date:
Home Department Chair:		Print: Dawn Tilbury	Date: 1/31/24
Cross-Listed Department Chair:		Print:	Date:
Cross-Listed Department Chair:		Print:	Date:
Cross-Listed Department Chair:		Print:	Date:

DEPARTMENTAL/COLLEGE USE ONLY

Current:	**Requested:**
Course Description ROB311 introduces the fundamentals of mechanical design, control, fabrication, actuation, instrumentation, and computer interfaces required to realize robotic systems. Students will learn to analyze/simulate rigid body kinematics, kinetics, and dynamics, as well as assess the impedance properties of their designs. 'Hands-on' skills will be emphasized in addition to theoretical concepts.	Course Description Introduces the fundamentals of mechanical design, control, fabrication, actuation, instrumentation, and computer interfaces required to realize robotic systems. Students will learn to analyze/simulate rigid body kinematics, kinetics, and dynamics, as well as assess the impedance properties of their designs. 'Hands-on' skills will be emphasized in addition to theoretical concepts.
Class Length Full term	Class Length Full term
Contact hours (lecture):	Contact hours (lecture): **3**
Contact hours (recitation) 0	Contact hours (recitation)
Contact hours (lab) 3	Contact hours (lab) 2

Additional Info:

Submitted by:
Home dept

Describe how this course fits with the degree requirements:
The objective of Robotics 311 is to introduce emerging roboticists to the tools that enable rapid design, prototyping, and control of robotic systems; in addition, the overarching goal of the course is conveniently obtained from the course title: "How to build robots and make them move." The course material will be delivered in a lecture setting, with one lecture per week dedicated to group projects. The goal of the projects will be to showcase the lecture content (e.g. the sensing, acting, and reasoning sections of the lecture material).

The course is intended to combine theory and practice. The lecture components of the class will include theoretical contributions in modeling, Lagrangian & Newton-Euler dynamics, and control, while the practical components will focus on CAD, manufacturing, and electrical hardware. Robotics 311 is arranged in this way to show how the theoretical and practical combined can create opportunities greater than the sum of their parts. Following the completion of this course, students should be able to:

Recognize a challenge that could be solved with a robotic system
Design a robotic system to solve the challenge
Manufacturer the robotic system
Test the robotic system for completion of the task
Lecture components will be taught broadly (tools to solve broad problems), where more 'application-specific' questions will be addressed with individual groups / group projects.

Special resources of facilities required for this course:
If there are any additional special resources or facilities required for this course, enter them here.

Ideally, this course would have the ‘hands on’ lecture in the large lecture hall on the 1st floor FRB.

Supporting statement:
The change in enforced prerequisites is requested based on course feedback after offering this course twice. In order for students to get the most out of this course, they need to have seen modeling systems, differential equation representations, and how this relates to system response.

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Course Approval Request Form

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Action Requested
- ☐ New Course
- ☑ Modification of Existing Course
- ☐ Deletion of Existing Course

Date of Submission: 2024-01-26
Effective Term: Fall 2024

☑	Course Offered ☑ Indefinitely ☐ One term only	**RO USE ONLY** Date Received: Date Completed: Completed By:

	CURRENT LISTING	**REQUESTED LISTING**
☐	Dept (Home): Robotics Subject: ROB Catalog: 330	Dept (Home): Robotics Subject: ROB Catalog: 330
☐	☐ Course is Cross-Listed with Other Departments Department / Subject / Catalog Number	☐ Course is Cross-Listed with Other Departments Department / Subject / Catalog Number
☐	Course Title (full title) Localization, Mapping, and Navigation	Course Title (full title) Localization, Mapping, and Navigation
☐	Abbreviated Title (20 char) SLAM & Navigation	Abbreviated Title (20 char) SLAM & Navigation
☑	Course Description (Please limit to 80 words and attach separate sheet if necessary) Development of full-stack autonomous navigation and mapping for mobile robots. Topics include dead reckoning from odometry, sensor modeling of LIDAR and cameras, visual odometry, path planning, and simultaneous localization and mapping (SLAM).	
☐	Full Term Credit Hours Undergraduate Min: 4 Graduate Min: Undergraduate Max: 4 Graduate Max:	Half Term Credit Hours Undergraduate Min: Graduate Min: Undergraduate Max: Graduate Max:
☐	Course Credit Type Undergraduate Student	
☐	Repeatability ☐ Course is Repeatable for Credit Maximum number of repeatable credits: 0	☐ Course is Y graded ☐ Can be taken more than once in the same term

Subject: Robotics Catalog: 330

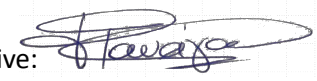
☐	Grading Basis ☑ Graded (A – E) ☐ Credit/No Credit ☐ Satisfactory/Unsatisfactory ☐ Pass/Fail ☐ Business Administration Grading ☐ Not for Credit ☐ Not for Degree Credit ☐ Degree Credit Only Add Consent ☐ Department Consent ☐ Instructor Consent ☑ No Consent Drop Consent ☐ Department Consent ☐ Instructor Consent ☑ No Consent

	CURRENT LISTING	**REQUESTED LISTING**
☐	Advisory Prerequisite (254 char) (IOE 265 or EECS 301) and (ME 240 or ME 360) and (Math 215 or Math 216)	Advisory Prerequisite (254 char) (IOE 265 or EECS 301) and (ME 240 or ME 360) and (Math 215 or Math 216)
☐	Enforced Prerequisite (254 char) ROB 204, EECS 280 Minimum grade requirement: C-	Enforced Prerequisite (254 char) ROB 204, EECS 280 Minimum grade requirement: C-
☐	Credit Exclusions	Credit Exclusions
☐	Course Components ☑ Lecture ☐ Seminar ☐ Recitation ☑ Lab ☐ Discussion ☐ Independent Study Graded Component ☑ ☐ ☐ ☐ ☐ ☐ Terms Typically Offered ☑ Fall ☐ Winter ☐ Spring ☐ Summer ☐ Spring/Summer	

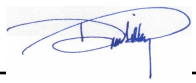
Cognizant Faculty Member Name: Katie Skinner Cognizant Faculty Member Title: Assistant Professor

SIGNATURES ARE REQUIRED FROM ALL DEPARTMENTS INVOLVED (Please Print AND Sign Name)

Contact Person: Kayla Dombrowski Email: kakelle@umich.edu Phone: 734-936-7999

CoE Curriculum Committee Representative:  Print: Dimitra Panagou Date: 1/26/2024

CoE Curriculum Committee Chair: Print: Date:

Home Department Chair:  Print: Dawn Tilbury Date: 1/31/24

Cross-Listed Department Chair: Print: Date:

Cross-Listed Department Chair: Print: Date:

Cross-Listed Department Chair: Print: Date:

DEPARTMENTAL/COLLEGE USE ONLY

Current:	Requested:
Course Description The development of full-stack autonomous navigation and semantic mapping for mobile robots. Topics include dead reckoning from odometry, sensor modeling of LIDAR and IMUs, simultaneous localization and mapping, semantic scene understanding, and an introduction to deep learning methods for convolutional feature learning and object detection.	Course Description Development of full-stack autonomous navigation and mapping for mobile robots. Topics include dead reckoning from odometry, sensor modeling of LIDAR and cameras, visual odometry, path planning, and simultaneous localization and mapping (SLAM).
Class Length Full term	Class Length Full term
Contact hours (lecture): 3	Contact hours (lecture): 3
Contact hours (recitation) 0	Contact hours (recitation) 0
Contact hours (lab) 2	Contact hours (lab) 2

Additional Info:

Submitted by:
Home dept

Describe how this course fits with the degree requirements:

Special resources of facilities required for this course:
Availability of a CAEN Lab and access to lab space for 2 hour weekly lab sessions.

Supporting statement:
This request is for modification to the topics for ROB 330: SLAM & Navigation. The following course topics will be removed: deep learning, semantic scene understanding, object detection, and convolutional neural networks. This change is being requested based on course feedback and due to new course development in the undergraduate program in Robotics. This content is now covered in a special topics course offered by the Robotics Department, ROB 498: Deep Learning for Robot Perception. Removing this content will provide more time to focus in depth on topics related to robot perception and navigation including visual odometry, visual SLAM, and camera-LiDAR projection. Additionally, new course content will be introduced for building skills in the Robot Operating System (ROS).

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ro.umich.edu

Course Approval Request Form

Office of the Registrar, University of Michigan

☑ **CHECK APPROPRIATE BOXES FOR ALL CHANGES**

Action Requested
- ☐ New Course
- ☑ Modification of Existing Course
- ☐ Deletion of Existing Course

Date of Submission: 2024-02-01
Effective Term: Fall 2024

☑	Course Offered ☑ Indefinitely ☐ One term only	**RO USE ONLY** Date Received: Date Completed: Completed By:

	CURRENT LISTING	**REQUESTED LISTING**
☐	Dept (Home): Robotics Subject: ROB Catalog: 498	Dept (Home): Robotics Subject: ROB Catalog: 498
☐	☐ Course is Cross-Listed with Other Departments Department / Subject / Catalog Number	☐ Course is Cross-Listed with Other Departments Department / Subject / Catalog Number
☐	Course Title (full title) Special Topics in Robotics	Course Title (full title) Special Topics in Robotics
☐	Abbreviated Title (20 char) Spec Topics Robotics	Abbreviated Title (20 char) Spec Topics Robotics
☐	Course Description (Please limit to 80 words and attach separate sheet if necessary) Topics of current interest in Robotics.	
☐	Full Term Credit Hours Undergraduate Min: 1 Graduate Min: 1 Undergraduate Max: 8 Graduate Max: 8	Half Term Credit Hours Undergraduate Min: Graduate Min: Undergraduate Max: Graduate Max:
☐	Course Credit Type Undergraduate Student, Rackham Graduate Student, Non-Rackham Graduate Student, Rackham Graduate Student with Additional Work	
☑	Repeatability ☑ Course is Repeatable for Credit Maximum number of repeatable credits: 99	☐ Course is Y graded ☑ Can be taken more than once in the same term

Subject: Robotics Catalog: 498

☐

Grading Basis
- ☑ Graded (A – E)
- ☐ Credit/No Credit
- ☐ Satisfactory/Unsatisfactory
- ☐ Pass/Fail
- ☐ Business Administration

Grading
- ☐ Not for Credit
- ☐ Not for Degree Credit
- ☐ Degree Credit Only

Add Consent
- ☐ Department Consent
- ☐ Instructor Consent
- ☑ No Consent

Drop Consent
- ☐ Department Consent
- ☐ Instructor Consent
- ☑ No Consent

	CURRENT LISTING	REQUESTED LISTING
☐	Advisory Prerequisite (254 char)	Advisory Prerequisite (254 char)
☐	Enforced Prerequisite (254 char) Minimum grade requirement:	Enforced Prerequisite (254 char) Minimum grade requirement:
☐	Credit Exclusions	Credit Exclusions

☑

Course Components / Graded Component
- ☑ Lecture — ☑
- ☐ Seminar — ☐
- ☑ Recitation — ☐
- ☑ Lab — ☐
- ☑ Discussion — ☐
- ☐ Independent Study — ☐

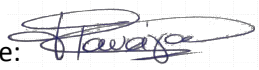
Terms Typically Offered
- ☑ Fall
- ☑ Winter
- ☑ Spring
- ☑ Summer
- ☑ Spring/Summer

Cognizant Faculty Member Name: Chad Jenkins

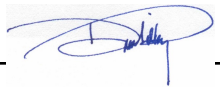
Cognizant Faculty Member Title: Professor

SIGNATURES ARE REQUIRED FROM ALL DEPARTMENTS INVOLVED (Please Print AND Sign Name)

Contact Person: Kayla Dombrowski Email: kakelle@umich.edu Phone: 734-936-7999

CoE Curriculum Committee Representative:  Print: Dimitra Panagou Date: 1/26/2024

CoE Curriculum Committee Chair: Print: Date:

Home Department Chair:  Print: Dawn Tilbury Date: 1/31/24

Cross-Listed Department Chair: Print: Date:

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DEPARTMENTAL/COLLEGE USE ONLY

Current:	Requested:
Course Description Topics of current interest in Robotics.	Course Description Topics of current interest in Robotics.
Class Length Full term	Class Length Full term
Contact hours (lecture):	Contact hours (lecture): 1 - 8
Contact hours (recitation)	Contact hours (recitation) 1 - 8
Contact hours (lab)	Contact hours (lab) 1 - 8

Additional Info:

Submitted by:
Home dept

Describe how this course fits with the degree requirements:

Special resources of facilities required for this course:

Supporting statement:
The Robotics Department is currently running all of our electives as special topic numbers. It is possible that students may exceed the current eight credit limit if they enroll in more than two of our electives. We would like to increase the amount of repeatability credits to avoid this issue. We are also striving to offer four credit electives that would include a discussion section, recitation, or lab. We would like to add these components at the course level. Special Topics courses will abide by the CoE Assignment of Credit Hour Policy for each course component.