BOARD OF HIGHER EDUCATION
REQUEST FOR COMMITTEE AND BOARD ACTION

COMMITTEE: Academic Affairs   **NO:**   AAC 19-25

COMMITTEE DATE: June 11, 2019

BOARD DATE: June 18, 2019

APPLICATION OF THE UNIVERSITY OF MASSACHUSETTS LOWELL TO AWARD THE BACHELOR OF SCIENCE IN ENGINEERING IN INDUSTRIAL ENGINEERING; THE MASTER OF SCIENCE IN ENGINEERING IN INDUSTRIAL ENGINEERING; AND THE DOCTOR OF PHILOSOPHY IN ENGINEERING IN INDUSTRIAL ENGINEERING

MOVED: The Board of Higher Education hereby approves the application of **University of Massachusetts Lowell** to award the **Bachelor of Science in Engineering in Industrial Engineering, the Master of Science in Engineering in Industrial Engineering, and the Doctor of Philosophy in Engineering in Industrial Engineering**

Upon graduating the first class for this program, the University shall submit to the Board a status report addressing its success in reaching program goals as stated in the application and in the areas of enrollment, curriculum, faculty resources, and program effectiveness.

VOTED: Motion approved by AAC 06/11/2019; Motion adopted by the BHE 06/18/2019

Authority: Massachusetts General Laws Chapter 15A, Section 9(b)

Contact: Winifred M. Hagan, Ed.D., Associate Commissioner for Academic Affairs and Student Success

INTENT AND MISSION

The mission of the University of Massachusetts Lowell (UML) is to enhance the intellectual, personal and cultural development of students through excellent, affordable educational programs. The University seeks to support the development of sustainable technologies and communities through teaching, research, scholarship and engagement. The proposed programs are designed to meet the needs of the MA economy in advanced manufacturing and automation. By drawing on expertise in engineering, sciences, business and health sciences, it is intended that the proposed degrees are aligned to provide an affordable pathway in Industrial Engineering (IE). UML intends that the programs be concerned with the design, improvement and installation of integrated systems of people, materials, information, equipment and energy, consistent with the definition of IE. The field draws upon specialized knowledge and skill in the mathematical, physical, and social sciences together with the principles and methods of engineering analysis and design, to specify, predict, and evaluate the results obtained from such systems. UML intends that the proposed programs will complement current mechanical engineering (ME) offerings, as they focus primarily on design and the IE programs are intended to focus on manufacturing, with an emphasis on automation. UML intends that the proposed programs will focus on manufacturing by building on a foundation of science and engineering with advanced coursework in automation and control, the manufacturing process, ergonomics, analytics and operations management. UML further intends that undergraduate students will be required to take a two-semester capstone sequence in which student teams solve problems proposed by industrial partners.

The degrees have been designed for graduates to enter the workforce in manufacturing with a design and implementation perspective or with a control and managerial perspective. Advanced degrees are intended to provide research opportunities in these areas. The bachelor's program is designed such that students may simultaneously pursue minors in robotics or production and operations management. The bachelor's program is also intended to facilitate advanced study in engineering or professional degree pursuits such as business or law. The graduate-level programs are designed, as are other programs in the Francis College of Engineering, to include a core set of courses and electives from approved subsets of courses within manufacturing and automation; analytics and operations; healthcare systems engineering; and ergonomics and safety.

The proposed program has obtained all necessary governance approvals on campus and was unanimously approved by the University of Massachusetts Board of Trustees on April 3, 2019. The required letter of intent was circulated on December 13, 2018.

NEED AND DEMAND

National and State Labor Market Outlook

UML reports that the Bureau of Labor Statistics (BLS) identifies IE as a fundamental degree for work in consulting, manufacturing, and research and development; that IE talent is increasingly being sought to improve healthcare delivery; and that IE graduates are sought for industries that plan to establish or

grow manufacturing in the United States. UML also reports that BLS market analyses project jobs for IE degree candidates to grow modestly in New England (2.3% over the next decade) and more aggressively across the country (5.7%). Looming retirements and a tightening labor market suggest the number of new positions expected to be ~1000 annually in New England with national expectations nearer ~45,000 annually. UML also reported that according to a recent study by Deloitte and The Manufacturing Institute, manufacturing industries face the need for 3.4 million workers, with an expected shortage of 2 million workers, over the next decade. The shortage is attributed to impending retirements coupled with a shortage of workers with science, technology, engineering and mathematic skills. UML pointes to MA as having a validated, critical workforce need for operators, technicians, and engineers in manufacturing, who service a wide variety of industries. Despite the projected need for nearly 1000 IEs annually in the region, New England graduated only 175 BS in IE in 2016. This includes Northeastern (66 graduates), UMass Amherst (23), WPI (20), Rhode Island (18) and New Haven (12). UML further reports a lack of graduate degree programs in this discipline, citing the need for additional graduates to support growing manufacturing and healthcare economies.

The labor market for industrial engineers in the Commonwealth and region is projected to remain stable between 2014 and 2024, growing at a rate of 0.9 and 2.3 percent, respectively. Accounting for retirements, Massachusetts expects to need 560 new industrial engineers each year, significantly higher than the annual in-state cohort of industrial engineering graduates (117 in 2016).

Expected industrial engineering job openings according to regions over time.[1]

	Massachusetts	New England	Nation
Baseline Year Employment	18,270	35,470	608,600
10-Year Projected Employment	18,430	36,290	643,300
Growth Rate	0.9%	2.3%	5.7%
Total Annual Openings	560	1140	45,000

UML's recent analysis of job postings taken from Indeed.com revealed 216 jobs listed when searching for "industrial engineer" within 25 miles of Lowell. Job titles included automation engineer, safety engineer, manufacturing engineer, quality engineer, and application engineer. The hiring firms included New Balance, Vicor Corporation, Rudolph Technologies, BAE Systems, Raytheon, General Electric, Schneider Electric, Thermo Fisher Scientific, M/A COM, and Analog Devices. Based on this job posting scan, UML suggests that graduates of the proposed industrial engineering programs would likely find employment opportunities within the immediate area, noting that eight out of ten of the companies sponsor senior design projects with the Francis College of Engineering.

Student Demand

UML gaged student demand for the proposed program by reviewing interest in the UML Mechanical Engineering (ME) programs. UML received almost 800 applications for the undergraduate ME program in FY18. UML built the proposed BSIE program from an ME foundation to capture this interest. UML

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[1] "Long Term Occupational Projections." Projections Central. *http://www.projectionscentral.com/Projections/LongTerm* Retrieved Spring semester 2019

UML Note: State and region occupational employment projections correspond to 2014 to 2024 projections. National projections correspond to 2016 to 2026.

also found that between 2012 and 2016, bachelor's degree completions in industrial engineering grew at annualized rates of 15.4 percent in Massachusetts and 16.2 percent in New England. Comparatively, bachelor's degree completion in all fields of study increased by only 2.5 percent annually in the region, indicating To UML that student interest in industrial engineering has increased in New England.

OVERVIEW OF PROPOSED PROGRAM

The proposed degrees in Industrial Engineering (BS MS and PhD) are planned to be offered through the Department of Mechanical Engineering at UML. It is anticipated that program directors at both the undergraduate and graduate level will be assigned to oversee the daily operations of the programs, including recruiting and advising. UML plans that program directors will report to the Chair of Mechanical Engineering, who reports to the Dean of Engineering.

Duplication

UML reports that the number of job openings for industrial engineers is expected to outpace the supply of graduates. This is attributed by UML to the relatively low number and small size programs in New England as depicted in the table below.

Institution	Graduates (2016)	Miles from Lowell	State	Delivery Mode	Tuition (MA students)
Northeastern Univ.	66	36.7	MA	Campus	$46,720
UMass Amherst	23	77.6	MA	Campus	$15,787
WPI	20	41.7	MA	Campus	$49,668
Univ. of Rhode Island	18	99.5	RI	Campus	$13,792
Univ. of New Haven	12	145	CT	Campus	$38,170

ACADEMIC AND RELATED MATTERS

Admission

UML plans that IE programs will have entrance requirements similar to other programs in the Francis College of Engineering. Admission to the College for baccalaureate, first-year students requires an application consisting of high school GPA and SAT or ACT scores.

UML plans to pursue dual enrollment and early college opportunities similar to other engineering programs in the College. For example, UML plans that the proposed baccalaureate program will pursue dual enrollment within the Introduction to Industrial Engineering course with its' partner secondary schools, which currently include Lowell and Littleton High Schools as well as dual enrollment within Manufacturing Laboratory courses that are applicable to the IE program.

In general, UML freshman applicants are evaluated using standards determined by both the Massachusetts Department of Higher Education and the university. UML Admissions counselors are sensitive to the factors that may result in accomplished students having a lower-than-expected GPA or SAT score. The applications of students who don't meet the standards, but for whom UMass Lowell otherwise seems like a good match, are reviewed individually. Applicants have the No Test Option to

decide whether to have standardized test scores used in the admissions process. UML suggests that applicants applying under the No Test Option should have a GPA of 3.25 or higher and evidence of outstanding academic success throughout high school. Academic requirements for admission include four courses in English and Mathematics including algebra I & II and geometry or trigonometry, precalculus or calculus comparable coursework. While three courses in Science are required, applicant to engineering programs are strongly encouraged to take four courses of science in high school. Two courses in social sciences, foreign language and electives are also generally required.

In addition, UML provides several non-traditional admissions pathways to students including the Middlesex Community College Connections program, MassTransfer, and Navitas UMass Lowell, which is an independently administered pathway to admission for international students who do not meet the standard admissions requirements.

Admission criteria for the Industrial Engineering MS and PhD programs follow those for other graduate Engineering programs. Specifically, applicants must have a minimum of a BS in Industrial Engineering, or a closely related field, with a minimum grade point average of 3.0 and a min GPA of 3.25 in science and engineering courses. Applicants with a MS in Industrial Engineering, or a closely related field, must have a minimum graduate GPA of 3.25. For other degrees in engineering or science, additional coursework may be necessary to meet prerequisite requirements. Completion of the Graduate Record Exam (GRE) is required. While there is no minimum score requirement, UML expects that admissions will be competitive. Completion of the TOEFL Exam is required for international students, except as exempted by Graduate Admissions rules. The program requires a TOEFL score of at least 550 (paper-based) or 213 (computer-based).

Program Enrollment

	Year 1			Year 2			Year 3			Year 4		
	BS	MS	PhD	BS	MS	PhD	BS	MS	PhD	BS	MS	PhD
New Full-Time	20	5	2	40	10	2	60	10	2	60	10	2
Continuing Full-Time	0	0	0	20	5	2	60	10	4	120	10	6
New Part-Time	0	10	1	0	10	1	0	10	1	0	10	1
Continuing Part-Time	0	0	0	0	10	1	0	20	2	0	30	3
Totals:	20	15	3	60	35	6	120	50	9	180	60	12

Curriculum (Attachment A)

The proposed BSIE curriculum expects to use the existing courses offered by the Departments of Mechanical Engineering, Electrical and Computer Engineering, and Biomedical Engineering in the Francis College of Engineering. In addition, engineering and science courses are planned to draw from existing courses offered by the Kennedy College of Sciences; and existing operations management courses offered by the Manning School of Business. A total of 15 new courses (highlighted in the

curriculum outline forms) and one laboratory are envisioned for IE undergraduates and graduate students. UML expects that these courses will focus on manufacturing and automation and build upon coursework in Mechanical, Electrical and Computer Engineering. A systems-level perspective is planned with traditional industrial engineering courses in modeling and data analysis, ergonomics and human factors, and systems design.

The proposed MSIE and PhDIE proposals build off a core set of courses in automation and control, operations research and ergonomics. It is planned that the existing courses in other UML colleges on campus will supply the options in each track including, manufacturing and automation; analytics and operations; healthcare systems engineering; and ergonomics and safety.

UML further plans that the Francis College of Engineering will seek accreditation from ABET for the BSIE degree. An application for review is expected to be submitted in 2023. Once accredited, UML graduates will be eligible to start the process of attaining a Professional Engineer (PE) license. The preliminary exam is generally taken after the completion of the bachelor's degree.

Internships and Field Studies

The proposed BSIE program includes a 2-course Capstone sequence wherein students work in multi-disciplinary teams and apply their engineering problem solving skills on open-ended, real-world projects. Projects may include members from other departments and colleges. This course has an emphasis on team work, communication, report writing, oral presentations, project definition and project planning. The Capstone courses define a sequence of problem identification, solution proposal and design, in the initial course (4019) followed by development and implementation in the second course (4020). While these courses take place with UML industrial partners, they are separate from the professional co-op program.

The professional co-op program is open to all engineering students. The program follows three phases: Professional Development Seminar, in which students develop professional and interpersonal skills while securing a co-op position; Industry Experience, in which students complete a work assignment at an employer for 3 or 6 months; and Co-op Assessment Course, in which students reflect on their experience and integrate it into their educational experience on-campus. In total, students receive 3 credits for this experience, in addition to any pay received from the employer segment. These credits may be used as technical electives in the BSIE program. In order to support this increasingly popular option for students, required courses will be offered each semester and during the summer.

RESOURCES AND BUDGET

Budget (Attachment B)

In UML's analysis, which included the use of external sources of market information, enrollments at competitive universities, and internal demand estimates for the ME program, led to projections of student revenues at the undergraduate and graduate levels. Expenses were determined by faculty and staff support, with additional support for new labs and equipment requested in year three. It is planned that faculty and teaching assistants will be added over time, calibrating program costs with revenues realized from enrollments. UML plans that if enrollments are softer than expected, the hiring processes can be slowed.

Faculty and Administration (Attachment C)

UML anticipates that initially the proposed programs will draw upon existing faculty in Francis College of Engineering, as well as the other colleges. It is expected that administrative and departmental support will derive from increased annual funding for the Mechanical Engineering Department. Two directors will provide administrative oversight for the programs, with support from an administrative assistant. Finally, a co-op advisor is planned to be added to facilitate co-op and internship experiences for the students.

Over time UML plans that a core of tenure-track IE faculty will be hired to teach, advise, and develop research programs with graduate students. It is expected that new tenure-track faculty will have doctoral degrees in IE or related fields. Two non-tenure track doctoral-level faculty lines are planned to teach undergraduate and graduate courses, and not have research responsibilities. UML proposes that additional faculty resources are expected for assistant teaching in other departments in the Francis College to meet the increased demand from the new students. These include assignments in electrical and computer engineering (1), mechanical engineering (1) and production and operations management (1). Hiring qualifications are planned to follow those of tenure-track faculty. Seven teaching assistants are planned to be assigned to the new programs in order to support the undergraduate program and facilitate the recruiting of graduate students.

In addition to these new hires, it is expected that current faculty in the Departments of Mechanical Engineering, Electrical and Computer Engineering, Biomedical Engineering, and Operations and Information Systems will contribute to the core offerings in the curriculum. It is also planned that a technician with an MSIE will be hired after new laboratories are ready for operation.

Facilities, Library and Information Technologies

UML plans that the Francis College of Engineering will house the proposed programs, including existing laboratories to begin (Lawrence Lin Makerspace, Manufacturing, Microprocessors, and Biomedical Engineering) with an increase in expenses to include office and lab supplies. In addition, the proposed program expects to develop new laboratories including manufacturing automation, ergonomics and human factors laboratory support. UML included details regarding the function and content of all laboratories within the full proposal.

Affiliations and Partnerships

UML referenced its' existing articulation agreements with nearly all community colleges in Massachusetts. It is expected that these will be extended to include Industrial Engineering as a transfer option to the proposed BSIE program. UML plans that an advisory board will be developed with alumni and industrial partner representatives. This is expected to help lead the BSIE program through the ABET accreditation process, as well as facilitate student placements and provide valuable input to the programs as they grow. UML further plans to open the professional co-op option to BSIE students.

PROGRAM EFFECTIVENESS

Goal	Measurable Objective	Strategy for Achievement	Timetable
Program Enrollment	High-quality Enrollees	Focused recruiting at high schools. Targeted outreach. Summer camps.	3-6 months before admission, then ongoing.
	Diverse Enrollees	Focused recruiting at high schools. Targeted outreach.	3-6 months before admission, then ongoing.
	Strong Enrollments	Recruiting at local and regional high schools and community colleges. Recruiting fairs. Open houses. Website.	3-6 months before admission, then ongoing.
Student Achievement	High Placement Rates	Establishing industrial advisory board; Establish professional co-op program	First year of program, then ongoing.
	High Retention Rates	Quality faculty; administrative support	First year of program, then ongoing.
	High Graduation Rates	Quality faculty; administrative support	First year of program, then ongoing.
Program Recognition	High-quality Faculty	Laboratory and equipment support;	Recruiting faculty in early years of program.
	ABET Accreditation	Quality faculty; administrative support; teaching lab support	Seek after first graduating class, then ongoing.
	National Ranking	Quality faculty; Research lab support	Annually.

EXTERNAL REVIEW AND INSTITUTIONAL RESPONSE

The proposed programs were reviewed by Abhi Deshmukh, Ph.D., James J. Solberg Head and Professor of Industrial Engineering at Purdue University in West Lafayette IN, Larry Hettinger, Ph.D., Consultant and former principal research scientist at Liberty Mutual Research Institute for Safety in Hopkinton MA, and Yuri Ivanov, Ph.D., Innovation Scientist in the Chief Technology Office at Rethink Robotics[2] in Cambridge MA

The reviewers found that the proposed programs are designed to meet a significant need for talent in manufacturing and service industries. They indicated that the emphasis on automated system design and analysis are warranted for the future economic outlook of Massachusetts and beyond. The team also noted that the skills students will learn should be applicable to both the design and the implementation of any system. The reviewers recommended changes to strengthen both the undergraduate and graduate curricula to strengthen student learning and ensure full preparation for the

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[2] Rethink Robotics was acquired by another company and no longer has a Boston-area office. Linked-In shows Dr. Ivanov is now at Amazon Robotics in North Reading MA.

workforce. The team also identified budget areas UML should consider during the launch period of the programs, including investments in automation and support for lab experiments in ergonomics and human factors. UML fully responded by adjusting the proposal accordingly, prior to submitting it for approvals.

STAFF ANALYSIS AND RECOMMENDATION

Staff thoroughly reviewed all documentation submitted by **University of Massachusetts Lowell** and the external reviewers. Staff recommendation is for approval of the proposed **Bachelor of Science in Engineering in Industrial Engineering, the Master of Science in Engineering in Industrial Engineering and the Doctor of Philosophy in Engineering in Industrial Engineering.**

ATTACHMENT A: CURRICULUM[3]

Undergraduate Program Curriculum Outline

Major Required (Core) Courses (# Total courses required = 22)		
Course Number	Course Title	Credit Hours
IENG.1xxx	Introduction to Industrial Engineering	2
IENG.3xxx	Manufacturing Processes	3
IENG.3xxx	Deterministic Modeling and Analysis	3
IENG.3xxx	Stochastic Modeling and Analysis	3
IENG.4xxx	Automation and Control	3
IENG.4xxx	Manufacturing Systems Automation	3
IENG.4xxx	Manufacturing Systems Automation Laboratory I	1
IENG.4xxx	Human Machine Systems Design	3
BMEN.4300	Occupational Ergonomics	3
EECE.2160	Application Programming	3
EECE.2650	Logic Design	3
EECE.3170	Microprocessor Systems Design	3
ENGN.2050	Statics	3
ENGN.2060	Strength of Materials	3
ENGN.2070	Dynamics	3
ENGN.4019	Capstone Design Proposal	3
ENGN.4020	Capstone Design Project	3
MECH.2010	Computer Aided Design	2

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[3] *Highlighted courses denote those that are new at UML*

MECH.2020	Manufacturing Laboratory	2
MECH.2960	Materials Science for Engineers	3
POMS.3010	Operations Management	3
POMS.4050	Predictive Data Analytics	3
	Sub Total Core Credits	61

Elective Courses (# Total courses required = 3)		
Course Number	Course Title	Credit Hours
IENG.5xxx	Advanced Deterministic Modeling and Analysis	3
IENG.5xxx	Advanced Stochastic Modeling and Analysis	3
IENG.5xxx	Industrial Automation	3
IENG.5xxx	Manufacturing Systems	3
IENG.5xxx	Advanced Manufacturing Processes	3
IENG.5xxx	Facilities Planning & Material Handling	3
IENG.5xxx	Simulation	3
IENG.5xxx	Advanced Human Machine Systems Design	3
EECE.4800/5320	Microprocessor Systems Design II and Embedded Sys	3
MECH.4530	Mechatronics	3
MECH.5300	Autonomous Robotic Systems	3
MECH.5315	Modern Control Systems	3
MECH.5740	Design for Reliability	3
MECH.5750	Industrial Design of Experiments	3
MECH.5760	Engineering Project Management	3
MECH.5790	Robotics	3
MECH.5180	Signal Processing Tech	3
MECH.5230	Structural Health Monitoring	3
MECH.5300	Autonomous Robotic Systems	3
BMEN.4310	Occupational Biomechanics	3
BMEN.4400	Occupational Safety Engineering	3
PLAS.5370	Business Law for Engineers	3
PLAS.5900	Survey of Intellectual Property	3
MGMT.3010	Organizational Behavior	3
POMS.4010	Logistics and Transportation	3
POMS.4040	Quality Control	3

POMS.4020	Global Supply Chain Management	3
POMS.4030	Service Management	3
MIST.3030	Database Management Systems	3
MIST.3040	Data Communications and Networks	3
MIST.3050	Business Applications Development	3
MIST.4020	Systems Analysis and Design	3
MIST.4080	Enterprise Systems Management	3
	Sub Total Elective Credits	9
Distribution of General Education Requirements Attach List of General Education Offerings (Course Numbers, Titles, and Credits)		# of Credits
Arts and Humanities, including Literature and Foreign Languages		15
Mathematics and the Natural and Physical Sciences		33
Social Sciences		9
Sub Total General Education Credits		57
Curriculum Summary		
Total number of courses required for the degree	44	
Total credit hours required for degree	127	
Prerequisite or Other Additional Requirements: None.		

General Education Requirements (# Total courses required = 20)		
Course Number	Course Title	Credit Hours
ENGL.1010	College Writing, I	3
ENGL.1020	College Writing II	3
PHIL.3340	Engineering and Ethics	3
	Arts and Humanities General Education Elective	3
	Arts and Humanities General Education Elective	3
ECON.2010	Economics I	3
	Social Sciences General Education Elective	3
	Social Sciences General Education Elective	3
CHEM.1210	Chemistry I	3
CHEM.1230	Chemistry I Lab	1
MATH.1310	Calculus I	4
MATH.1320	Calculus II	4

MATH.2210	Linear Algebra I	3
MATH.2310	Calculus III	4
MATH.2360	Engineering Differential Equations	3
MATH.3860	Probability and Statistics, I	3
PHYS.1410	Physics I	3
PHYS.1410L	Physics I Lab	1
PHYS.2450	Physical Properties of Matter	3
PHYS.2450L	Physics III Lab	1
	Sub Total Elective Credits	57

Appendix B

Graduate Program Curriculum Outlines

MSIE Program Curriculum Outline

Major Required (Core) Courses (Total courses required = 4)		
Course Number	Course Title	Credit Hours
IENG.5xxx	Advanced Deterministic Modeling & Analysis	3
IENG.5xxx	Advanced Stochastic Modeling & Analysis	3
IENG.5xxx	Industrial Automation	3
PUBH.5311	Occupational Biomechanics	3
	Subtotal # Core Credits Required	12
Concentration Course Choices (Total courses required = 6) (attach list as needed)		
IENG.5xxx	Manufacturing Systems	3
IENG.5xxx	Advanced Manufacturing Processes	3
IENG.5xxx	Facilities Planning & Material Handling	3
IENG.5xxx	Simulation	3
IENG.5xxx	Advanced Human-Machine Systems Design	3
PUBH.5300	Ergonomics and Work	3
PUBH.5320	Occupational Biomechanics Lab	3
PUBH.5400	Occupational Safety Engineering	3
PUBH.6381	Methods of Work Analysis	3
PUBH.6321	Advanced Biomechanics	3

EECE.5510	Advanced Robotics and Automation	3
EECE.5520	Microprocessor Systems II	3
EECE.5560	Robotics	3
ENGY.5340	Fundamentals of Nuclear Security and Safeguards	3
ENGY.5160	Radiation Shielding and Protection	3
MECH.5180	Signal Processing Tech	3
MECH.5230	Structural Health Monitoring	3
MECH.5300	Autonomous Robotic Systems	3
MECH.5315	Modern Control Systems	3
MECH.5540	Dynamic Systems and Controls	3
MECH.5710	Quality Engineering	3
MECH.5740	Design for Reliability	3
MECH.5750	Industrial Design of Experiments	3
MECH.5790	Robotics	3
MECH.6690	Fracture Mechanics	3
MATH.5910	Linear Statistics Modeling and Regression	3
MIST.6030	Database Management	3
MIST.6060	Business Intelligence and Data Mining	3
MIST.6150	Data Engineering for Business Analytics	3
MIST.6140	Social and Economic Networks	3
MIST.6160	Advanced Data Mining	3
POMS.6120	Statistics for Predictive Analytics	3
POMS.6220	Decision Analytics	3
POMS.6240	Analytical Decision-Making Tools	3
POMS.6210	Advanced Statistics for Business Analytics	3
POMS.6010	Operations Management	3
PLAS.5450	Lean Manufacturing	3
PUBH.5021	Health Policy and Management	3
PUBH.5060	Quantitative Methods in Health Management	3
PUBH.5100	Fundamentals of Occupational Health	3
PUBH.5110	Health Care Finance	3
PUBH.5120	Operations Analysis for Quality Improvement	3
PUBH.5140	Healthcare Management	3

PUBH.5210	Introduction to Industrial Hygiene	3
PUBH.5230	Introduction to Ergonomics	3
PUBH.5250	Industrial Hygiene and Ergonomics	3
PUBH.5420	Human Factors	3
PUBH.6590	Cleaner Production	3
	Subtotal # Concentration Credits Required	18

Curriculum Summary	
Total number of courses required for the degree	10
Total credit hours required for degree	30

Prerequisite or Other Additional Requirements:
The MSE in Industrial Engineering requires the completion of all core courses and at least four courses from one area of specialization (Courses are divided into the following areas: Manufacturing and Automation; Analytics and Operations; Healthcare Systems Engineering; Ergonomics and Safety). A total of 30 credits are required, with at least 21 from Engineering. A thesis option (9 credits) reduces the number of courses required in one specialization area to two.

PhD Program Curriculum Outline

Major Required (Core) Courses (Total courses required = 5)		
Course Number	Course Title	Credit Hours
IENG.5xxx	Advanced Deterministic Modeling & Analysis	3
IENG.5xxx	Advanced Stochastic Modeling & Analysis	3
IENG.5xxx	Industrial Automation	3
PUBH.5311	Occupational Biomechanics	3
IENG.7xxx	Doctoral Dissertation Industrial Engineering	21
	Sub-Total # Core Credits Required	33
Concentration Course Choices (Total courses required = 10) (attach list as needed)		
IENG.5xxx	Manufacturing Systems	3
IENG.5xxx	Advanced Manufacturing Processes	3
IENG.5xxx	Facilities Planning & Material Handling	3
IENG.5xxx	Simulation	3
IENG.5xxx	Advanced Human-Machine Systems Design	
PUBH.5300	Ergonomics and Work	3
PUBH.5320	Occupational Biomechanics Lab	3

PUBH.5400	Occupational Safety Engineering	3
PUBH.6381	Methods of Work Analysis	3
PUBH.6321	Advanced Biomechanics	3
EECE.5510	Advanced Robotics and Automation	3
EECE.5520	Microprocessor Systems II	3
EECE.5560	Robotics	3
ENGY.5340	Fundamentals of Nuclear Security and Safeguards	3
ENGY.5160	Radiation Shielding and Protection	3
MECH.5180	Signal Processing Tech	3
MECH.5230	Structural Health Monitoring	3
MECH.5300	Autonomous Robotic Systems	3
MECH.5315	Modern Control Systems	3
MECH.5540	Dynamic Systems and Controls	3
MECH.5710	Quality Engineering	3
MECH.5740	Design for Reliability	3
MECH.5750	Industrial Design of Experiments	3
MECH.5790	Robotics	3
MECH.6690	Fracture Mechanics	3
MATH.5910	Linear Statistics Modeling and Regression	3
MIST.6030	Database Management	3
MIST.6060	Business Intelligence and Data Mining	3
MIST.6150	Data Engineering for Business Analytics	3
MIST.6140	Social and Economic Networks	3
MIST.6160	Advanced Data Mining	3
POMS.6120	Statistics for Predictive Analytics	3
POMS.6220	Decision Analytics	3
POMS.6240	Analytical Decision-Making Tools	3
POMS.6210	Advanced Statistics for Business Analytics	3
POMS.6010	Operations Management	3
PLAS.5450	Lean Manufacturing	3
PUBH.5021	Health Policy and Management	3
PUBH.5060	Quantitative Methods in Health Management	3
PUBH.5100	Fundamentals of Occupational Health	3

PUBH.5110	Health Care Finance	3
PUBH.5120	Operations Analysis for Quality Improvement	3
PUBH.5140	Healthcare Management	3
PUBH.5420	Human Factors	3
PUBH.5510	Work Environmental Policy	3
PUBH.5750	Epidemiology and Biostatistics	3
PUBH.6590	Cleaner Production	3
	Subtotal # Concentration Credits Required	30

Curriculum Summary	
Total number of courses required for the degree	15
Total credit hours required for degree	63

Prerequisite or Other Additional Requirements:
A total of 63 credit hours of graduate level courses are required for the PhDIE degree. The PhDIE degree must involve a traditional research-based dissertation, plus:
- A minimum of 30 approved credit hours of graduate-level engineering courses beyond the bachelor's degree, including the MSE in Industrial Engineering core courses.
- A minimum of 21 credit hours of doctoral dissertation.
- The balance of the remaining 12 credits can be a mix of graduate-level engineering and science, including associated PHYS, CHEM, POMS, PUBH, and MATH courses and dissertation credits at the discretion of the department, faculty advisor and dissertation committee.
- At least two semesters of the 0-credit research seminar MECH.5010

In addition to these 63 semester hours of approved graduate courses and thesis:
- The student must have a minimum grade point average of 3.25 in order to graduate.
- The student is required to take and pass the doctoral qualifying examination.

ATTACHMENT B: BUDGET

REVENUE ESTIMATES

UNDERGRADUATE ESTIMATES	Year 1 2019		Year 2 2020		Year 3 2021		Year 4 2022		Year 5 2023	
Full-Time Tuition Rate: In-State	14710		14710		14710		14710		14710	
Full-Time Tuition Rate: Out-State	32357		32357		32357		32357		32357	
Mandatory Fees per Student (In-state)	1420		1420		1420		1420		1420	
Mandatory Fees per Student (out-state)	1420		1420		1420		1420		1420	
FTE # of New Students: In-State	18		36		54		54		54	
FTE # of New Students: Out-State	2		4		6		6		6	
# of In-State FTE Students transferring in from the institution's existing programs		2		4		7		10		10
# of Out-State FTE Students transferring in from the institution's existing programs		0		1		1		2		2
GRADUATE ESTIMATES										
Full-Time Tuition Rate: In-State	14590		14590		14590		14590		14590	
Full-Time Tuition Rate: Out-State	26370		26370		26370		26370		26370	
Mandatory Fees per Student (In-state)	470		470		470		470		470	
Mandatory Fees per Student (out-state)	470		470		470		470		470	
FTE # of Total Students: In-State	8.7		22.3		31.0		34.7		35.0	
FTE # of Total Students: Out-State	2		4		6		8		8	

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	Newly Generated Revenue	Revenue from existing programs	Newly Generated Revenue	Revenue from existing programs	Newly Generated Revenue	Revenue from existing programs	Newly Generated Revenue	Revenue from existing programs	Newly Generated Revenue	Revenue from existing programs
# of In-State FTE Students transferring in from the institution's existing programs	0		0		0		0		0	
# of Out-State FTE Students transferring in from the institution's existing programs	0		0		0		0		0	

Tuition and Fees	Newly Generated Revenue	Revenue from existing programs	Newly Generated Revenue	Revenue from existing programs	Newly Generated Revenue	Revenue from existing programs	Newly Generated Revenue	Revenue from existing programs	Newly Generated Revenue	Revenue from existing programs
First Year Students										
Tuition										
In-State	$264,780	$29,420	$529,560	$58,840	$794,340	$102,970	$794,340	$147,100	$794,340	$147,100
Out-of-State	$64,714	$0	$129,428	$32,357	$194,142	$32,357	$194,142	$64,714	$194,142	$64,714
Mandatory Fees	$28,400	$2,840	$56,800	$7,100	$85,200	$11,360	$85,200	$17,040	$85,200	$17,040
Second Year Students										
Tuition										
In-State			$264,780	$29,420	$529,560	$58,840	$794,340	$102,970	$794,340	$147,100
Out-of-State			$64,714	$0	$129,428	$32,357	$194,142	$32,357	$194,142	$64,714
Mandatory Fees			$28,400	$2,840	$56,800	$7,100	$85,200	$11,360	$85,200	$17,040
Third Year Students										
Tuition										
In-State					$264,780	$29,420	$529,560	$58,840	$794,340	$102,970
Out-of-State					$64,714	$0	$129,428	$32,357	$194,142	$32,357
Mandatory Fees					$28,400	$2,840	$56,800	$7,100	$85,200	$11,36

	Col1	Col2	Col3	Col4	Col5	Col6	Col7	Col8	Col9	Col10
										0
Fourth Year Students										
Tuition										
In-State							$264,780	$29,420	$529,560	$58,840
Out-of-State							$64,714	$0	$129,428	$32,357
Mandatory Fees							$28,400	$2,840	$56,800	$7,100
Graduate Students										
Tuition										
In-State	$126,447	$0	$325,843	$0	$452,290	$0	$505,787	$0	$510,650	$0
Out-of-State	$52,740	$0	$105,480	$0	$158,220	$0	$210,960	$0	$210,960	$0
Mandatory Fees	$5,013	$0	$12,377	$0	$17,390	$0	$20,053	$0	$20,210	$0
Gross Tuition and Fees	$542,094	$32,260	$1,517,382	$130,557	$2,775,264	$277,244	$3,957,846	$506,098	$4,678,654	$702,692
Grants	$0	$0	$0	$0	$200,000	$0	$400,000	$0	$500,000	$0
Contracts	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Campus budget allocation	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
					Fundraising for Lab					
Other Revenues	$0	$0	$0	$0	$500,000	$0	$0	$0	$0	$0
Total	$542,094	$32,260	$1,517,382	$130,557	$3,475,264	$277,244	$4,357,846	$506,098	$5,178,654	$702,692

EXPENDITURE ESTIMATES

	Year 1 2019		Year 2 2020		Year 3 2021		Year 4 2022		Year 5 2023	
	New Expenditures required for Program	Expenditures from current resources	New Expenditures required for Program	Expenditures from current resources	New Expenditures required for Program	Expenditures from current resources	New Expenditures required for Program	Expenditures from current resources	New Expenditures required for Program	Expenditures from current resources
Personnel Services										
Faculty	$160,000	$0	$510,000	$0	$802,000	$0	$899,000	$0	$997,000	$0
Administrators	$24,000	$0	$24,000	$0	$24,000	$0	$24,000	$0	$24,000	$0
Support Staff	$120,000	$0	$120,000	$0	$200,000	$0	$200,000	$0	$200,000	$0
Other (Faculty Startup Costs)	$0	$0	$500,000	$0	$500,000	$0	$250,000	$0	$250,000	$0
Fringe Benefits 37%	$112,480	$0	$241,980	$0	$379,620	$0	$415,510	$0	$451,770	$0
Total Personnel	**$416,480**	**$0**	**$1,395,980**	**$0**	**$1,905,620**	**$0**	**$1,788,510**	**$0**	**$1,922,770**	**$0**
Operating Expenses										
Supplies	$30,000	$0	$30,000	$0	$30,000	$0	$30,000	$0	$30,000	$0
Library Resources	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Marketing/Promotional Expenses	$15,000	$0	$10,000	$0	$5,000	$0	$0	$0	$0	$0
Laboratory Expenses	$10,000	$0	$20,000	$0	$30,000	$0	$40,000	$0	$40,000	$0
General Administrative Overhead	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000

Other (specify)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total Operating Expenses	**$65,000**	**$10,000**	**$70,000**	**$10,000**	**$75,000**	**$10,000**	**$80,000**	**$10,000**	**$80,000**	**$10,000**
Net Student Assistance										
Assistantships	$94,000	$0	$141,000	$0	$235,000	$0	$329,000	$0	$329,000	$0
Fellowships	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Stipends/Scholarships	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total Student Assistance	**$94,000**	**$0**	**$141,000**	**$0**	**$235,000**	**$0**	**$329,000**	**$0**	**$329,000**	**$0**
Capital										
Facilities / Campus recharges	$0	$0	$0	$0	$500,000	$0	$0	$0	$0	$0
Equipment	$0	$0	$0	$0	$450,000	$0	$0	$0	$0	$0
Other	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total Capital	**$0**	**$0**	**$0**	**$0**	**$950,000**	**$0**	**$0**	**$0**	**$0**	**$0**
Total Expenditures	**$575,480**	**$10,000**	**$1,606,980**	**$10,000**	**$3,165,620**	**$10,000**	**$2,197,510**	**$10,000**	**$2,331,770**	**$10,000**

BUDGET SUMMARY OF NEW PROGRAM ONLY

	Year 1	Year 2	Year 3	Year 4	Year 5
	2020	2021	2022	2023	2024
Total of newly generated revenue	**$574,354**	**$1,647,939**	**$3,752,508**	**$4,863,944**	**$5,881,346**
Total of additional resources required for program	**$585,480**	**$1,616,980**	**$3,175,620**	**$2,207,510**	**$2,341,770**
Excess/ (Deficiency)	**($11,126)**	**$30,959**	**$576,888**	**$2,656,434**	**$3,539,576**

ATTACHMENT C: FACULTY

Name of faculty member	Ten-ured Y/N	(C) indicates core course (OL) course currently taught online	# of sect-ions	Division or College of Employment	Full- or Part-time in Program	Full- or part- time other department /program	Sites where individual will teach program courses
Amirkhizi, Ali Ph.D. in Mechanical Engineering Assistant Professor	N	• Strengths of Materials (C) • Materials Science (C)	(1)	Engineering	Full-Time	ME Dept.	• Main Campus
Buchholz, Bryan Ph.D. in Biomedical Engineering Professor	Y	• Ergonomics (C) • Occupational Biomechanics (C)	(1) (1)	Engineering	Full-Time	BME Dept.	• Main Campus
Chen, Yao Ph.D. in Operations Management Professor	Y	• Operations Management (C) • Quality Control	(1) (1)	Business	Full-Time	OIS Dept.	• Main Campus
Chigan, Tricia Ph.D. in Computer Engineering Associate Professor	Y	• Logic Design (C)	(1)	Engineering	Full-Time	EECE Dept.	• Main Campus
Deokar, Amit Ph.D. in Mgmt Information Systems Assistant Professor	N	• Predictive Data Analytics (C) • Quality Control	(1) (1)	Business	Full-Time	OIS Dept.	• Main Campus

Geiger, Michael Ph.D. in Computer Engineering Assistant Teaching Professor	N	• Applications Programming (C)	(3)	Engineering	Full-Time	EECE Dept.	• Main Campus
Hansen, Chris Ph.D. in Mechanical Engineering Associate Professor	Y	• Strengths of Materials (C) • Materials Science (C)	(1)	Engineering	Full-Time	ME Dept.	• Main Campus
Luo, Yan Ph.D. in Computer Engineering Professor	Y	• Microprocessor System Design (C)	(1)	Engineering	Full-Time	EECE Dept.	• Main Campus
Motiwalla, L. Ph.D. in Business Administration Professor	Y	• Information Systems	(1)	Business	Full-Time	OIS Dept.	• Main Campus
Oztekin, Asil Ph.D. in Industrial Engineering and Mgmt Associate Professor	Y	• Predictive Data Analytics (C)	(1)	Business	Full-Time	OIS Dept.	• Main Campus
Palma, John Ph.D. in Electrical Engineering Assistant Teaching Professor	N	• Capstone Senior Design (C)	(2)	Engineering	Full-Time	EECE Dept.	• Main Campus
Papagiannopoulu, Dimitra Ph.D. in Computer Engineering	N	• Microprocessor System Design (C)	(1)	Engineering	Full-Time	EECE Dept.	• Main Campus

Assistant Professor							
Parkin, Robert Ph.D. in Mechanical Engineering Professor	Y	• Robotics	(1) (1)	Engineering	Full-Time	ME Dept.	• Main Campus
Percival, J. Ph.D. in Management Science Professor	Y	• Predictive Analytics (C)	(1)	Business	Full-Time	OIS Dept.	• Main Campus
Punnett, Laura Sc.D. in Public Health Professor	Y	• Ergonomics (C) • Occupational Biomechanics (C)	(1) (1)	Engineering	Full-Time	BME Dept.	• Main Campus
Shina, Sammy Ph.D. in Mechanical Engineering Professor	Y	• Quality Engineering • Engineering Project Management • Design of Experiments	(1) (1) (1)	Engineering	Full-Time	ME Dept.	• Main Campus
Sloan, Thomas Ph.D. in Management Science Associate Professor	N	• Operations Management (C) • Logistics and Transportation	(1) (1)	Business	Full-Time	OIS Dept.	• Main Campus
Sullivan, Dan Ph.D. in Mechanical Engineering Associate Teaching	N	• Computer Aided Design (C) • Statics (C)	(3) (1)	Engineering	Full-Time	ME Dept.	• Main Campus

Professor		• Dynamics (C)	(1)				
Sundberg, Glenn Ph.D. in Mechanical Engineering Associate Professor	Y	• Manufacturing Lab (C) • Manufacturing Processes (C)	(3) (3)	Engineering	Full- Time	ME Dept.	• Main Campus
Tang, Jianxin Ph.D. in Electrical Engineering Assistant Teaching Professor	N	• Logic Design (C)	(1)	Engineering	Full- Time	EECE Dept.	• Main Campus
Thomas, Walter Ph.D. in Energy Engineering Assistant Teaching Professor	N	• Statics (C) • Dynamics (C)	(1) (1)	Engineering	Full- Time	ME Dept.	• Main Campus
Thompson, Larry Ph.D. in Mechanical Engineering Assistant Teaching Professor	N	• Manufacturing Lab (C) • Manufacturing Processes (C)	(1) (1)	Engineering	Full- Time	ME Dept.	• Main Campus