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ILLINOIS
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Proposal to the Senate Educational Policy Committee

PROPOSAL TITLE: Establish a Major in Mechanical Engineering in the College of Engineering for the degree of Master of Engineering.

SPONSOR: Professor Anthony Jacobi, 333-4108, a-jacobi@illinois.edu

COLLEGE CONTACT: William G. Buttlar, Associate Dean, Office of Graduate and Professional Engineering Programs, College of Engineering, 333-5966, buttlar@illinois.edu.

BRIEF DESCRIPTION: This proposal seeks to establish a major in Mechanical Engineering for the degree of Master of Engineering (MEng). The purpose of the Master of Engineering in Mechanical Engineering (MEngME) is to serve students seeking a professional post-graduate degree and enhanced preparation for a career in Mechanical Engineering. The curriculum for the MEngME is organized as follows:

- The MEngME will reside in the Department of Mechanical Science and Engineering (MechSE) in the College of Engineering and will require a total of at least 32 hours of formal graded coursework.
- The MEngME degree will require at least 12 hours at the 500-level; 8 credit hours must be in the Mechanical Engineering (ME) or Theoretical and Applied Mechanics (TAM) rubrics.
- A minimum of 3 hours in a designated advanced math course will be required.
- A minimum of 4 hours in a designated professional development course will be required. This can be fulfilled through a capstone project.

JUSTIFICATION:

MechSE continually refocuses its research and teaching in areas of critical societal need. To address the needs of our students, our industrial partners, and the greater societal issues relevant to engineering practice, the MEngME program has been designed to offer students an accelerated, industry-oriented graduate degree. The MEngME provides more in-depth technical knowledge than can be covered in a traditional engineering B.S. degree in a format that can be completed in one year. The curriculum allows students to focus their coursework in areas that are most relevant to their professional career interests. Students who graduate from the program will have recognizable expertise, and these credentials will make it more likely that they will find opportunities to utilize their skills to address pressing societal and industry needs.

MechSE, the College of Engineering, and the University of Illinois are uniquely qualified to offer a leading program in this area. MechSE is currently home to numerous labs and research centers focusing on theoretical and experimental investigations of phenomena related to energy systems, materials behavior, combustion, micro- and nano-mechanical systems, controls and dynamics, thermodynamics, biomechanics, and much more. MechSE has state-of-the-art facilities and a significant number of faculty members with expertise in these areas, matched only by a few peer institutions around the world. These aspects will appeal to prospective students and industrial partners.

BUDGETARY AND STAFF IMPLICATIONS:

a. *Additional staff and dollars needed:* MEngME students will pay tuition. The College of Engineering (CoE) will use graduate tuition dollars returned to the CoE from the Office of the Provost Budget and Resource Planning to fund additional instructional resources needed (if any) to support the curriculum in Master of Engineering programs. Graduate tuition funds returned to the colleges from campus are considered state, recurring funds that may be used to fund faculty hires or support instruction in other ways. The CoE has developed a tuition distribution model for departments offering majors and/or concentrations within M.Eng (See Appendix A Tuition Distribution Model). Tuition funds returned to MechSE will be used to cover the costs to provide additional resources (if needed) to support faculty in teaching courses with increased enrollment due to MEngME students. If a clear need is demonstrated, faculty hires could be made subject to the usual college and campus approval process. The MEngME consists of existing courses already being taken by MechSE graduate students and does not require the development of any new courses.

b. *Internal reallocations (e.g., change in class size, teaching loads, student-faculty ratio, etc.):* The program should have minimal impact in terms of our existing curriculum, teaching loads, and student-faculty ratios. MechSE currently offers the possibility of a one-year accelerated MSME degree. The MEngME is a more appropriate degree program for students with an interest in a one-year master program. Since the department has already allocated resources to similar existing programs, the impact of the change will be minimal. The department will review and assess the MEngME program during the annual departmental review with the Dean of the College of Engineering to determine if internal resources should be reallocated if there is a need.

c. *Effect on course enrollment in other units and explanations of discussions with representatives of those departments:* As a result of the flexible nature of the program, there will be minimal impact on other units. With the exception of the 4 credit hour elective requirement which must be fulfilled outside of the major department for breadth, all degree requirements can be fulfilled within the major department. Thus, there will not be a significant impact on any other unit.

d. *Impact on the University Library:* Letter provided.

e. *Impact on computer use, laboratory use, equipment, etc.:* The program is designed to provide students with the necessary access to facilities without impacting the availability of the facilities to support ongoing research projects. To ensure the program has a minimal impact with regard to use of facilities, we will work with Directors of labs. These individuals may also be included in the steering committee

for the program. It is expected that lab sections, if needed, will be scheduled during the "off" hours of the facilities, including evenings or weekends.

DESIRED EFFECTIVE DATE: Fall 2014.

STATEMENT FOR PROGRAMS OF STUDY CATALOG: See Appendix B.

CLEARANCES:

Signatures:

_____	_____
Unit Representative:	Date:
_____	_____
College Representative:	Date:
_____	_____
Graduate College Representative:	Date:
_____	_____
Council on Teacher Education Representative:	Date:

Appendix A:
(Budgetary and Staff Implications)

New Degree Programs – Required Budgetary Implication Questions

1) How does the unit intend to financially support this program?

Students in the MEngME degree program will pay tuition. The College of Engineering has developed a tuition distribution model for units offering majors or concentration for the M.Eng. (see Tuition Distribution Model in this Appendix)

2) Will the unit need to seek campus or other external resources?

No.

3) If no new resources are required, how will the unit create capacity or surplus to appropriately resource this program? (What functions or programs will the unit no longer support?)

The MEngME consists of courses currently being taken by MechSE graduate students. No new courses are being developed for this degree program. Admissions, advising, and course enrollment will be managed by MechSE with existing staff. Tuition returned to MechSE from the College of Engineering will be used to provide additional resources required (if needed) to support instruction due to increased enrollment. Targeted enrollment for the first year is 30 students. This enrollment level would not cause a significant impact on the current resources.

4) Please provide a market analysis: What market indicators are driving this proposal? What type of employment outlook should these graduates expect? What resources will be required to assist students with job placement?

MechSE already administers one-year MSME programs that were established in Fall 2010. To date, 15 students have graduated from these one-year programs, and three students are currently enrolled. These programs are marketed toward students intending to work in industry, but are not as clearly delineated from existing research-oriented MS programs as the proposed MEngME degree will be. The proposed MEngME degree will reach a broader segment appealing to both prospective students and employers. MechSE's industrial contacts, including major employers of MechSE undergraduate alumni, have expressed an interest in a professional engineering degree. Depending on interest, MechSE may allow students to register for the MEngME program on part-time status to increase enrollment. Students in the MEngME program will have the resources of the College of Engineering Career Services office to assist with job placement.

5) If this is a proposed graduate program, please discuss the programs intended use of waivers. If the program is dependent on waivers, how will the unit compensate for lost tuition revenue?

Because the program has been approved as self-supporting, there will be no Graduate College or BOT waivers allowed for students in this program.

Tuition Distribution Model

Tuition returned to the College of Engineering (CoE) (net of campus overhead, currently 10% of total graduate tuition received) will be distributed as follows:

Tuition returned will be split 20% CoE and 80% MechSE.

Appendix B:

(Programs of Study)

Mechanical Science and Engineering

mechse.illinois.edu
Head of the Department: Placid M. Ferreira
Associate Head for Graduate Programs: Harley T. Johnson
168 Mechanical Engineering Building
1206 West Green Street
Urbana, IL 61801
(217) 244-3416
E-mail: mechse-grad@illinois.edu
Associate Head for Mechanics Programs: Kenneth Christensen
154 Mechanical Engineering Building
1206 West Green Street
Urbana, IL 61801
(217) 333-4388
E-mail: mechse-mechanics@illinois.edu

Major: Mechanical Engineering
Degrees Offered: MEngME, M.S., Ph.D.

Major: Theoretical and Applied Mechanics
Degrees Offered: M.S., Ph.D.

Off-Campus Program: Mechanical Engineering
Degree offered: M.S.

Joint Degree Program: Master of Science in Mechanical Engineering and Master of Business Administration
Degrees Offered: M.S. and M.B.A.

Medical Scholar Program: Doctor of Philosophy (Ph.D.) in Mechanical Engineering or Theoretical and Applied Mechanics and Doctor of Medicine (M.D.) through the Medical Scholars Program

Graduate Degree Programs

Building upon the longstanding strengths of programs in mechanical engineering and in mechanics, the Department of Mechanical Science and Engineering (MechSE) at the University of Illinois at Urbana-Champaign is taking a bold, new approach to research and education that will enable it to address some of the most pressing problems facing the nation and the world. A new paradigm in research is being created in the department by integrating basic sciences such as biology, chemistry, applied mathematics, and applied

physics with the traditional mechanical engineering and engineering mechanics disciplines of fluid mechanics-thermal science, solid mechanics-materials, and controls-dynamics. This integration is fostering new directions and discoveries in nanomechanics, nanomanufacturing, biomechanics and computational science and engineering.

The goal of all research in the department is to address critical societal problems in the areas of health, security-defense, energy-environment, manufacturing, and transportation. While the basic function of departmental research is generation of new knowledge, a growing number of projects are prompted by current needs of the State of Illinois and of the nation.

The department offers graduate programs leading to master's and doctoral degrees with exciting research opportunities as described in the Faculty Research Interests section below. Opportunity also exists for specializing in (i) computational science and engineering and (ii) energy and sustainability engineering within the department's graduate programs via the Computational Science and Engineering (CSE) Option and the Energy and Sustainability Engineering (EaSE) Option. The Medical Scholars Program permits highly qualified students to integrate the study of medicine with study for a graduate degree in a second discipline, including Mechanical Engineering and Theoretical and Applied Mechanics. The department is not accepting applications for the joint MBA program at this time.

Admission

An applicant for admission to the Department of Mechanical Science and Engineering must (1) be a graduate of an institution awarding a baccalaureate degree equivalent to that granted by the University of Illinois at Urbana-Champaign; (2) be adequately prepared for advanced study as demonstrated by his or her previous program of study and scholastic record; and (3) be recommended for admission by the Department of Mechanical Science and Engineering. A minimum grade point average of 3.25 (A = 4.00) for the last two years of undergraduate study is required and a 3.50 for any previous graduate work completed. Scores on the Graduate Record Examination (GRE) general test are required of all applicants. Based upon the previous preparation of the student, prerequisite courses may be specified by the advisor, but the credit may not be applied toward a degree.

All applicants whose native language is not English must submit a minimum TOEFL score of 103 (iBT), 257 (CBT), or 613 (PBT); or minimum International English Language Testing System (IELTS) academic exam scores of 7.0 overall and 6.0 in all subsections. Applicants may be exempt from the TOEFL if certain criteria are met. Full admission status is granted for those meeting the minimum requirements and having taken the TOEFL or IELTS since the scores required for admission to MechSE are above the minimum scores demonstrating an acceptable level of English language proficiency.

Students may apply to the Medical Scholars Program prior to beginning graduate school or while in the graduate program. Applicants to the Medical Scholars Program must meet

the admissions standards for and be accepted into both Mechanical Science and Engineering and the College of Medicine. An application to the Medical Scholars Program will also serve as the application to the Mechanical Science and Engineering graduate programs. Further information on this program is available by contacting the Medical Scholars Program, (125 Medical Sciences Building, 217-333-8146, mspo@illinois.edu).

Students interested in the joint M.S.M.E.-M.B.A. degree program must apply initially to the M.B.A. program. In the term in which 60 hours of the M.B.A. course work prescribed for the joint-degree program is expected to be completed, they become eligible to petition to transfer to the M.S.M.E. degree program and with MechSE approval, may be admitted under the joint M.S.M.E.-M.B.A. program code.

Degree Requirements

*For additional details and requirements refer to the department's graduate program requirements and the Graduate College Handbook.

Master of Engineering with a major in Mechanical Engineering

Requirements	
Credit Hours	**Hours**
Total Credit for the Degree	***32***
Course Work	32
ME or TAM course work	12-20
Applied math / computational science requirement - from approved list	3-4
Elective courses - chosen in consultation with advisor	4-8
Professional development Choice or combination of (a) graduate-level capstone project (e.g., ME 597 Independent Study), or (b) course in leadership, entrepreneurship, or other business-related course.	4-8
Other Requirements and Conditions (may overlap):	
A minimum of 4 elective hours must be completed outside of the major department.	
A minimum of 12 500-level credit hours applied toward the degree, 8 of which must be in ME or TAM.	
A maximum of 4 hours of independent study may be applied toward degree requirements.	
Elective course category may include a maximum of 4 hours of special topics credit	

Professional development category may include a maximum of 4 hours of special topics credit
The minimum program GPA is 3.0.

Master of Science, Mechanical Engineering

Requirements	Thesis Option	Non-thesis Option
Credit Hours	**Hours**	**Hours**
Total Credit for the Degree	***32***	***36***
Thesis Research – ME 599 (min-max applied toward the degree)	4-8	n/a
Course Work	24-28	36
MSE 492 (1 hour); credit does not apply toward the degree	0	0
ME 590 – registration (1 hour) every term while in residence; credit does not apply toward the degree	0	0
ME 597 or TAM 597	n/a	4
Elective courses – chosen in consultation with advisor (subject to Other Requirements and Conditions below)	24-28	36
Other Requirements and Conditions (may overlap):*		
A minimum of 8 ME or TAM credit hours with 4 at the 500 level.		
A minimum of 12 500-level credit hours applied toward the degree.		
For the thesis option, a maximum of 4 hours of ME 597 or TAM 597 (or other approved independent study) may be applied toward the elective course work requirement.		
No ME 599 credit may be applied toward the elective course work requirement.		
The minimum program GPA is 3.0.		
Departmental approval is required to pursue the non-thesis option.		

Master of Science, Theoretical and Applied Mechanics

Requirements	Thesis Option	Non-thesis Option
Credit Hours	**Hours**	**Hours**
Total Credit for the Degree	***32***	***36***
Thesis Research – TAM 599 (min-max applied toward the degree)	4-8	n/a
Course Work	24-28	36
TAM 500 – registration (1 hour) every term while in residence; credit does not apply toward the degree	0	0
Elective courses – chosen in consultation with advisor (subject to Other Requirements and Conditions below)	24-28	36
Other Requirements and Conditions (may overlap):*		
A minimum of 16 TAM credit hours, with 8 at the 500 level.		
A minimum of 12 500-level credit hours applied toward the degree.		
No TAM 599 credit may be applied toward the elective course work requirement.		
A maximum of 4 hours of TAM 597 or ME 597 (or other approved independent study) may be applied toward the elective course work requirement.		
The minimum program GPA is 3.0.		
Departmental approval is required to pursue the non-thesis option.		

A full-time student can usually complete the program requirements in one academic year of study. A student who has an assistantship can usually complete the requirements in one calendar year.

For more details of the degree requirements for all M.S. programs, visit the department's Graduate Program Web site.

Doctor of Philosophy, Mechanical Engineering

Requirements	Required Hours – Entering with approved M.S. or M.A. degree	Required Hours – Entering with approved B.S. or B.A. degree
Credit Hours	**Hours**	**Hours**
Total Credit for the Degree	***64***	***96***
Thesis Research – ME 599 (min-max applied toward the degree)	32	40
Course Work	32	56
MSE 492 (1 hour) if not taken while completing the Master's degree; credit does not apply toward the degree	0	0
ME 590 – registration (1 hour) every term while in residence; credit does not apply toward the degree	0	0
Advanced math requirement from an approved list	3-4	3-4
Elective courses – chosen in consultation with advisor (subject to Other Requirements and Conditions below)	28-29	52-53
Other Requirements and Conditions (may overlap):*		
Minimum 500-level credit hours applied toward the degree	16	24
Maximum hours of ME 597 or TAM 597 (or other approved independent study) which may be applied only toward the elective course work requirement	4	8
A maximum of 4 hours of ME 597 or TAM 597 (or other approved independent study) may be applied toward the elective course work requirement.		
No ME 599 credit may be applied toward the elective course work requirement.		

The minimum program GPA is 3.0.
Ph.D. exam and dissertation requirements: Qualifying exam Preliminary exam Final exam or dissertation defense Dissertation deposit
Continuous registration is required after the preliminary exam and until dissertation deposit, while on campus and during semester of final defense.

1. A student entering with a bachelor's degree has the option of a direct Ph.D. program. It does not award an M.S. degree.

For those students entering the program with a master's degree, qualifying examinations should be taken no later than the second calendar semester after initial enrollment. For students entering with a bachelor's degree under the direct Ph.D. program, qualifying examinations should be taken as early as possible, generally no later than the third semester.

A student entering with a bachelor's degree has the option of a direct Ph.D. program. Qualifying examinations should be taken as early as possible, generally no later than the third semester.

For the Ph.D. program, a preliminary examination is taken after the qualifying examination. A minimum of six months should elapse between the successful completion of the doctoral preliminary examination and the doctoral final examination (oral dissertation defense).

Doctor of Philosophy, Theoretical and Applied Mechanics

Requirements	**Hours**
Credit Hours	**Hours**
Total Credit for the Degree	***96***
Thesis Research – TAM 599 (min-max applied toward the degree)	32-64
Course Work	32
TAM 500 – registration (1 hour) every term while in residence; credit does not apply toward the degree	0
Elective courses beyond core and breadth – chosen in consultation with	0-32

advisor (subject to Other Requirements and Conditions below)	
Other Requirements and Conditions:*	
Credit for TAM 531 or 532, 541, 542, 551 or equivalent as evaluated by the Associate Head for Mechanics	
Credit for minimum of 16 hours of TAM breadth courses from a departmental list, or equivalent as evaluated by the Associate Head for Mechanics.	
A 25% or more teaching assistantship for at least one semester.	
The minimum program GPA is 3.0.	
Ph.D. exam and dissertation requirements: Qualifying exam Preliminary exam Final exam or dissertation defense Dissertation deposit	
Continuous registration is required after the preliminary exam and until thesis deposit, while on campus and during semester of final defense.	

Candidates for the Doctor of Philosophy degree are required to complete a minimum of 32 graduate hours of course work beyond the bachelor's degree with a minimum grade point average of 3.0. The course work must include 16 hours of core courses, or equivalent as evaluated by the Associate Head for Mechanics in applied mathematics, fluid mechanics, and solid mechanics taken at the University of Illinois at Urbana-Champaign or elsewhere. In addition, course work is required from each of the following major areas, totaling 16 hrs: 2 courses total from applied mathematics, fluid mechanics, and solid mechanics, 1 course in mechanics of materials, and at least 1 course in either computational mechanics or experimental mechanics.

Acceptance into the doctoral program requires good academic standing and successful completion of a Qualifying Examination, which is the defense of a scholarly work, such as a master's thesis. A student must also pass an oral preliminary examination based on the proposed thesis work.

For more details of the degree requirements for both Ph.D. programs, visit the department’s Graduate Program Web site.

Joint Degree Program

The joint M.B.A. program requires a total of 92 graduate hours of course work with 32 for the M.S. as prescribed above, plus 60 graduate hours for the M.B.A. degree, including 40 hours of M.B.A. core course work; and 20 hours of M.B.A. elective course work to

fulfill the requirements of a concentration. For the joint M.B.A. program, the degrees are awarded simultaneously after the requirements for both degrees have been met.

Off-Campus Programs

The department offers the M.S. in Mechanical Engineering with both a thesis and a non-thesis option as described above.

Medical Scholars Program

Students in the Medical Scholars program must meet the specific requirements for both the medical and graduate degrees. On average, students take eight years to complete both degrees. The first year of the combined program is typically spent meeting requirements of the Mechanical Engineering or Theoretical and Applied Mechanics graduate degree.

Graduate Teaching Experience

Although teaching is not a general Graduate College requirement, experience in teaching is considered an important part of the graduate experience in both the ME and TAM Ph.D. programs. The TAM Ph.D. requires that one semester of teaching assistantship be completed during the program.

Faculty Research Interests

A new paradigm in research is being created in the department by integrating basic sciences such as biology, chemistry, applied mathematics, and applied physics with the traditional mechanical engineering and engineering mechanics disciplines of fluid mechanics/thermal science, solid mechanics/materials and controls/dynamics. This integration is fostering new directions and discoveries in nanomechanics, nanomanufacturing, biomechanics and computational science and engineering.
The goal of all research in the department is to address critical societal problems in the areas of health, security/defense, energy/environment, manufacturing, and transportation. While the basic function of departmental research is generation of new knowledge, a growing number of projects are prompted by current needs of the state of Illinois and of the nation.

Faculty research interests include the following:

- **Biomechanics** – cell adhesion and motility, biological machines, bio-fluid mechanics, orthopedic biomechanics, musculoskeletal biomechanics, rehabilitation engineering, bone mechanics, composite biological nanomaterials, single-cell mechanics, synthetic biomaterials, failure mechanics of biomaterials, cytoskeletal biomechanics, mechanotransduction, bio-imaging of cytoskeletal structures and stress distribution in living cells, human motion analysis, human-machine systems.
- **Nanomechanics/nanomanufacturing** – micro/nano-fluidics, NEMS and MEMS, photonic metamaterials and devices, 3D micro/nanofabrication, process planning, programmable machines, nanotubes, nano-materials, electronic and photonic

materials, metal cutting, micro/meso-machining, agile fixturing, scanning probe microscopy, micro/nano heat and mass transfer, feature-based cost analysis, rapid prototyping, interface surface science and technology, tribology, magnetic storage, friction/vibration characterization, microscale transport, electrokinetic phenomena, nano-positioning, atomic force microscopy, nanoscale actuation and robotics.

- **Controls/dynamics** – autonomous networked vehicle control, nonlinear mechanical systems and phenomena, distributed-parameter systems, wavelet methods, stability theory, piecewise smooth dynamics, multi-body dynamics, control of multi-rate and asynchronous systems, equi-variant (symmetric) dynamical systems, control using methods of stochastic dynamics, experimental and analytical modal analysis, and control theory (non-linear, adaptive, robust, optimal, and distributed) with application to mechanical and electromechanical systems.
- **Fluid mechanics/thermal sciences** – bio-fluids, combustion, propulsion, energy systems and the environment, IC engines, gas turbines, laser diagnostics, energetic materials, combustion synthesis of materials, micro- and nano-scale heat transfer, kinetics of chemical processes, two-phase flow, liquid atomization and spray, air-conditioning and refrigeration systems, micro-fluidics, computational fluid dynamics, compressible flow, fluid-structure interactions, meshless methods, detonation, deflagration-to-detonation transition, shock propagation, reacting flows, internal ballistics of rockets and guns, continual eddies, turbulent boundary layers, turbulent wakes, stratified turbulence, turbulence simulation, instability modes, vortex dynamics, coating flows, flow separation, three-dimensional foams, direct numerical simulation, large-eddy simulation, and particle-image velocimetry.
- **Solid mechanics/materials** – bio-materials, composite biological nanomaterials, electronic and photonic materials, stochastic mechanics, mechanics and transport in random media, thermomechanics, composite materials, creep, fatigue, fracture, high-temperature material behavior, polymer processing, ceramic-matrix composites, thin films, deformation processes, crystal plasticity, micro-scale phenomena, non-linear dynamics, continuum mechanics, ferroelectric ceramics, shape-memory alloys, composite interfaces, woven laminates, electronic packaging, energetic materials, corn-based composites, orientable elastomers, thermoelasticity, dynamic plasticity, residual stresses, martensitic microstructure, surface crack growth, brittle-to-ductile transition, pure shear failure, shear-band measurements, damage evolution, creep resistance, hydrogen embrittlement, powder consolidation, solidification, strain-gradient plasticity, nanotubes, composite interfaces, continuum-atomistic coupling, surface waves, wave scattering, crack detection, vibration transport, diffuse waves, stochastic waves, reverberant ultrasound and casting processes.

Centers, Programs, and Institutes

The following research centers and programs are integral to the MechSE graduate program:

- Air Conditioning and Refrigeration Center (ACRC)
- Center for Intracellular Mechanics
- Center for Nanoscale Chemical-Electrical-Mechanical Manufacturing systems (Nano-CEMMS)
- Continuous Casting Consortium (CCC)
- Cooperative Networked Control of Dynamical Peer-to-Peer Vehicle Systems
- Fracture Control Program
- Manufacturing Research Center
- Midwest Structural Sciences Center
- The Center for Advanced Automotive Bio-Fuel Combustion Engines
- The Center for Process Simulation and Design
- The Center of Advanced Materials for Purification of Water with Systems (The WaterCAMPWS)
- The Global Enterprise for Micro-Mechanics and Molecular Medicine (GEM4)

To learn more about the research centers and programs within the MechSE department, please visit the department's research center Web site.

Facilities and Resources

Research facilities include laboratories for advanced automation, air conditioning and refrigeration, combustion, computer-integrated manufacturing, control systems, design for manufacturing, gas dynamics, heat transfer, high-temperature materials, human factors and simulation of human-machine interaction, human dynamics and controls, intracellular mechanics, cell and molecular mechanics, internal-combustion engines, laser diagnostics for combustion, opto-electronic materials, machining and machine tool systems, mechanical behavior of materials, metrology, micromachining, microtribodynamics, polymer and composite materials processing, propulsion, rapid prototyping, robotics, short-pulse laser-ablation technology, thermal processing of materials, thermal radiation, tribology, and vehicle dynamics. Special facilities include a micro-fabrication facility with its own clean room (Class 10 and 1000) for silicon and CMOS-based micro-fabrication, test facilities for refrigeration and air-conditioning systems and components, low- and high-speed wind tunnels, and laboratories for study of combustion, quantitative visualization, complete specimen-scale mechanical testing equipment including an environmental testing chamber, thermomechanical and multiaxial loading capabilities. The department has a machine shop staffed with skilled instrument makers.

Financial Aid

Financial assistance is available to students who are admitted and includes fellowships, research and teaching assistantships, and/or waivers of tuition and fees. Assistantship stipends vary with one's entry level into the program. All applicants, regardless of U.S.

citizenship, whose native language is not English and who wish to be considered for teaching assistantships must demonstrate spoken English language proficiency by achieving a minimum score of 50 on the Test of Spoken English (TSE), 24 on the speaking subsection of the TOEFL iBT, or 8 on the speaking subsection of the IELTS. For students who are unable to take the TSE, iBT, or IELTS, a minimum score of 4CP is required on the EPI test, offered on campus. All new teaching assistants are required to participate in the Graduate Academy for College Teaching conducted prior to the start of the semester.

Appendix C

(Approved courses for applied math / computational science requirement)

TAM 541
Mathematical Methods I
Credit: 4 hours.
Vector and tensor algebra and complex-variable methods; ordinary differential equations, qualitative questions of existence and uniqueness; analytic solution methods, numerical methods, power-series solution and special functions; eigenvalue problems, Green's functions, Laplace transforms, stability of solutions; engineering applications drawn from mechanics.

TAM 470
Computational Mechanics (same as CSE 450)
Credit: 3 OR 4 hours.
Modercomputational mechanics: mappings and iterative methods; stability; convergence; consistency; numerical and symbolic solutions of ordinary and partial differential equations; finite-difference methods; the finite-element method; spectral methods. Applications to problems in solid mechanics, fluid mechanics, and dynamics. Same asCSE 450. 3 undergraduate hours. 3 or 4 graduate hours.

ME 471
Finite Element Analysis (same as CSE 451)
Credit: 3 OR 4 hours.
The finite element method and its application to engineering problems: truss and frame structures, heat conduction, and linear elasticity; use of application software; overview of advanced topics such as structural dynamics, fluid flow, and nonlinear structural analysis.

CSE 510 (same as CS 555)
Numerical Methods for PDEs
Numerical techniques for initial and boundary value problems in partial differential equations. Finite difference and finite element discretization techniques, direct and iterative solution methods for discrete problems, and programming techniques and usage of software packages.

MATH 442
Intro Partial Diff Equations
Credit: 3 OR 4 hours.
Introduces partial differential equations, emphasizing the wave, diffusion and potential (Laplace) equations. Focuses on understanding the physical meaning and mathematical properties of solutions of partial differential equations. Includes fundamental solutions and transform methods for problems on the line, as well as separation of variables using orthogonal series for problems in regions with boundary. Covers convergence of Fourier series in detail.

4 hours of credit requires approval of the instructor and completion of additional work of substance

CS 450 (same as CSE 401, ECE 491, and MATH 450)
Numerical Analysis
Credit: 3 OR 4 hours.
Linear system solvers, optimization techniques, interpolation and approximation of functions, solving systems of nonlinear equations, eigenvalue problems, least squares, and quadrature; numerical handling of ordinary and partial differential equations.

MATH 487 (same as ECE 493)
Advanced Engineering Math
Credit: 3 OR 4 hours.
Complex linear algebra, inner product spaces, Fourier transforms and analysis of boundary value problems, Sturm-Liouville theory.

MATH 488
Math Methods in Engineering
Credit: 3 OR 4 hours.
Matrices, determinants, bounds and approximations to eigenvalues, introduction to linear operator theory and inner product spaces, orthogonal expansions, and Fourier transforms.

Appendix D

(Possible courses for professional development course*)

ENG 461 (same as TE 461)
Technology Entrepreneurship
Credit: 3 hours.
Critical factors affecting technology-based ventures: opportunity assessment; the entrepreneurial process; founders and team building; preparation of a business plan including market research, marketing and sales, finance, and manufacturing considerations.

ENG 465 (same as TE 465)
Business Technical Consulting
Credit: 4 hours.
Consulting process, problem definition, project management, technology commercialization, interpersonal skills, human resources management leadership, and followership. Consulting teams formed work directly with a real business client for twelve weeks on a project jointly defined by the client and team.

ENG 466 (same as TE 466)
High-Tech Venture Marketing
Credit: 1 OR 2 hours.
Cornerstone marketing concepts for innovators and engineers to enable analysis of products and technologies from a marketing perspective: engineering product development and adoption life cycle; objectives and strategies; marketing management; communication skills; sales process and tactics; special considerations for new high-tech engineering products and innovations.

ENG 565 (same as TE 565)
Technol Innovation & Strategy
Credit: 2 hours.
Concepts and frameworks for analyzing how firms can create, commercialize and capture value from technology-based products and services. Business, commercialization, and management aspects of technology. Emphasis on reasons that existing firms or startups which have successfully commercialized products or services fail to sustain their success as technology changes and evolves.

ENG 566 (same as TE 566)
Finance for Engineering Mgmt
Credit: 2 hours.
Cornerstone financial concepts for engineering management to enable analysis of engineering projects from a financial perspective: income statements; the balance sheet; cash flow statements; corporate organization; the time value of money; net present value; discounted cash flow analysis; portfolio theory.

IE 430
Economic Foundation of Quality Systems
Credit: 3 OR 4 hours.
Total quality systems for planning, developing, and manufacturing world-class products. Economic foundations of total quality. Product value, cost, pricing, environmental quality, activity-based costing, design for assembly, organization structure, lead time, innovation, Taguchi methods, simulation-based significance testing, Strategic Quality Deployment, statistical process control, and conjoint analysis.

IE 431
Quality Engineering
Credit: 3 hours.
Quality Engineering principles and the Six Sigma Define-Measure-Analyze-Improve-Control (DMAIC) process. Application of concepts and methods of statistical process control, designed experiments, and measurement systems analysis to cases of quality and productivity improvement; application of the fundamentals of quality engineering and the Six Sigma to areas of produce development, service enterprise, and manufacturing processes.

Other graduate-level leadership, entrepreneurship, or business-related course chosen in consultation with advisor

*Only required if student chooses to fulfill through a course in leadership, entrepreneurship, or other business-related course as opposed to a for-credit internship course (e.g., ME 598 Special Topics) or graduate-level/capstone design course (e.g., ME 597 Independent Study).