LAWRENCE TECHNOLOGICAL UNIVERSITY

COLLEGE OF ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

MASTER OF SCIENCE IN MECHATRONIC SYSTEMS ENGINEERING (MSMSE)

Major focus

- Autonomous and Conventional Vehicle Mechatronic Systems Engineering
- Industrial Robotics Engineering

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INTRDUCTION

The Master of Science in Mechatronic Systems Engineering (MSMSE) program provides engineers with advanced scientific and engineering knowledge in an emerging high technology field – Mechatronic Systems Engineering.
Degrees in Mechatronics are very popular engineering degrees in many universities and colleges in Europe and Asia. Lawrence Technological University is proud to offer a unique MSMSE program in Michigan, and to further promote the MSMSE program in the United States of America.
As an interdisciplinary, high-technology field in engineering of controllable mechanical systems, the MSMSE program synergizes the knowledge outcome by integrating specific areas of:

- Mechanical Engineering
- Electrical and Computer Engineering
- Mathematics and Computer Science

MSMSE Graduates will:

1. Learn principles in mechanical system design for mechatronic systems
2. Develop strong analytical and application skills in analytical and adaptive dynamics of mechatronic systems
3. Provide expert knowledge in the areas of logic design of mechatronic systems, the classical and modern intelligent/robust control algorithm development, and designing mechanical systems with conjunction with their control systems
4. Develop analytical skills in the optimization of mechatronic systems
5. Learn principles of designing and be capable in the implementation of control algorithms in hardware – mechatronic systems.

MSMSE Graduates will be capable to apply their knowledge in various branches of the industry:

- Automotive and Truck Engineering
- Farm Tractor and Earthmoving Machine Engineering
- Military Vehicle Applications
- Autonomous/Unmanned Vehicle Engineering
- Robotics Engineering and Manufacturing
- Defense Systems Engineering
- Aerospace
- Biomedical Engineering
- Climate Control Systems Engineering
- Material Processing
- Machine Test Systems Engineering
- Communication Systems and Media
- Big and small business companies in countless fields of human activities

CURRICULUM

Students work close with the MSMSE Program Director on developing their own course- time schedule to better accomplish the course program within the optimal time-frame.

MSMSE pre-core courses are designed to help students with not sufficient academic backgrounds to be allowed to enroll in some of the MSMSE core courses. A decision on taking maximum two pre-courses is made by the MSMSE Program Director based on student transcripts and personal discussion.

MSMSE Pre-Core Courses (maximum 2 courses):

N	Course Title
1	EME4603 Introduction to Mechanics (non-ME)
2	EME4613 Introduction to Thermal Systems (non-ME)
3	EME3213 Introduction to Mechatronics
4	EEE4513 Control Systems (non-EE)
5	EEE2123 Circuits and Electronics (non-EE)
6	EEE3153 Electrical Machines and Controls (non-EE)

MSMSE Required Core Courses:

N	Course Title
1	MSE6113 Analytical and Adaptive Dynamics in Mechatronic Systems
2	MSE6123 Mechanical Design of Mechatronic Systems/Robots
3	MSE5133 Modern Control in Mechatronic Systems
4	MSE6143 Adaptive Control in Mechatronic Systems
5	MSE6153 Optimization in Mechatronic Systems
6	MCS5563 Intelligent Control
7	MSE6173 Mechatronic Systems Implementation – I
8	MSE6183 Mechatronic Systems Implementation – II

MSMSE Elective Courses (two required)*

N	Course Title
1	MSE6213 Stability in Mechatronic Systems
2	MSE6223 Algorithmic Synthesis of Complex Mechatronic Systems
3	MSE6233 Special Topics in Mechatronic Systems Engineering
4	MSE6243 Graduate Directed Study
5	MSE6253 Thesis – I
6	MSE6263 Thesis – II
7	MSE6273 Mechatronic Manufacturing Systems
8	MSE6283 Autonomous Wheel Power Management Systems
9	MSE7283 Robust Mechatronic Systems
10	EME6623 Automotive Control Systems – I
11	EME7623 Automotive Control Systems – II
12	MCS5503 Intelligent Systems
13	MCS6513 Advanced Topics in Intelligent Systems
14	EEE5294 Advanced Microprocessors
15	EEE 5533 Digital Control Systems
16	EEE5653 Digital Signal Processing

*** - some courses may have prerequisites listed in LTU Catalog**

TRANSFER PROCEDURE

For students transferring from other graduate programs into LTU MSMSE program, the following guidelines will be implemented:

1. No more than six (6) graduate semester credit hours may be transferred, and these must be from accredited MS programs.

2. A form with a request for courses for the current/coming semester must be filled in and submitted at the time of application.

3. A minimum grade of 3.00 must have been achieved in the transfer courses.

4. Courses must be completed within five years after the program was started.

ADMISSIONS REQUIREMENTS

Candidates applying for admission to the MSMSE program are required to have met the following criteria:

- Hold a Bachelor of Science degree in Mechanical Engineering, Electrical and Computer Engineering, or an equivalent degree from an ABET-accredited college or university.
- Hold a Bachelor of Science in Mathematics and Computer Science, or an equivalent degree from an accredited college or university, and 3-5 years experience working in a Mechatronic engineering field may apply.
- Provide official transcripts of all completed college work.
- Have a minimum undergraduate overall GPA of 3.00.
- Submit a completed graduate application form.
- Submit three letters of recommendation, including one from a corporate supervisor and one from a professor in the students' undergraduate program, if you graduated within the last three years.

The MSMSE Program Director and the MSMSE Program Engineering Committee, if necessary, may evaluate and consider applicants, who do not meet all conditions for regular admission, for conditional admission.

Applicants will be notified of their status within two weeks of completion of the minimum required hours. Conditional students are granted regular status after maintaining a minimum 3.00 GPA in three consecutive graduate-level courses. Applicants must satisfy all prerequisite requirements before they can be granted official graduate status. The MSMSE Program Director will decide prerequisite requirements. Applications to the MSMSE program may be submitted at any time of the year, for matriculation during any future semester.

COURSE DESCRIPTIONS

MSE6113 Analytical and Adaptive Dynamics in Mechatronic Systems
Prerequisites: EME4603 or equivalents or approval of program director.
Introduction to mechatronic systems engineering: mechanical, electrical and electronics components. Analytical and adaptive dynamics as the basis for the control algorithm development and a mechatronic system design. Advanced topics in analytical and adaptive dynamics are presented in the course including direct and inverse dynamic problems, stability of mechatronic systems, others.
Lecture: 3 hours.

MSE6123 Mechanical Design of Mechatronic Systems/Robots
Prerequisites: EME4603 or equivalents or approval of program director.
Course presents specifics in mechanical design of mechatronic systems with concentration on robots. Topics include requirements to mechanical systems as components of mechatronic systems and design methods. Position, kinematical and dynamic force analysis of robot manipulators is given for both rigid and non-rigid designs. Vibrations are analyzed and optimized in robot manipulators. Critical design components presented in conjunction with the motion requirements.
Lecture: 2.5 hours. Labs: 0.5 hour.

MSE5133 Modern Control in Mechatronic Systems
Prerequisites: EEE3153 or EEE4513 or approval of program director.
The course presents dynamic processes and characteristics of mechatronic system components with emphasis on the structure of feedback control theory and practice. Stability of linear feedback systems is given in details. Robust and digital control systems are also parts of the course.
Lecture: 2 hours. Labs: 1hour.

MSE6143 Adaptive Control in Mechatronic Systems
Prerequisite: MSE5113 Modern Control in Mechatronic Systems and graduate standing.
The course presents an analytical study in adaptive control for advanced applications. Various approaches are considered including gain scheduling controller modeling, model reference control (high-gain scheme), model reference adaptive control (parallel scheme), self-tuning regulators, and direct and indirect control. Linear and non-linear dynamic systems are the course subject.
Lecture: 2.5 hours. Labs: 0.5 hours.

MSE6153 Optimization in Mechatronic Systems
Prerequisite: MSE5113 Modern Control in Mechatronic Systems and graduate standing.
The course gives classical and numerical methods of optimization in depth that is followed by applications of controller optimization. Optimal controlling is presented for single-criterion and multi-criteria systems. Virtual implementation of optimal control is a part of the course.
Lecture 2 hours. Labs: 1 hour.

MCS5563 Intelligent Control
Prerequisites: MSE5133 Modern Control in Mechatronic Systems.
Artificial intelligent techniques applied to system control of mechatronic systems. Topics covered include: expert systems, fuzzy logic, neural networks, evolutionary computing, and hybrid systems.
Lecture 2 hours. Labs: 1 hour.

MSE6173 Mechatronic Systems Implementation - I
Prerequisite: Graduate standing.
This course integrates the knowledge that students have gained in all other courses and covers the theory and real design of mechatronic systems. All components of mechatronic systems are presented in a way of analytical study. At the end of the course students will be able to design a mechatronic system. This ability they supply with practical work on mechatronic system design.
Lecture: 2 hours. Labs: 1 hour.

MSE6183 Mechatronic Systems Implementation - II
Co-requisite: MSE6173 Mechatronic Systems Implementation - I, and graduate standing.
This lecture, lab, and project-oriented course is an addition to the first course on Mechatronic Systems Implementation. All lectures and laboratories cover major topics from the theory showing real world applications. Project topics are oriented on designing actual mechatronic systems.
Lecture: 2 hours. Labs: 1 hour.

MCS5503 Intelligent Systems
Prerequisite: MCS235
Introduction to artificial intelligence and computational intelligence. Problem solving by searching . Optimization methods. Knowledge representation and reasoning. Machine learning. Multi-agent systems. Pattern recognition. Introduction to artificial neural networks. Fuzzy logic.
Lecture: 3 hrs. 3 hours credit.

MCS6513 Advanced Topics in Intelligent Systems
Prerequisite: MCS5503
Advanced topics in artificial intelligence and computational intelligence. Advanced evolutionary computation. Advanced neural networks. Advanced fuzzy logic systems. Introduction to neuro-fuzzy systems and soft computing. Practical applications of computational intelligence to wireless devices, web programming, robotics and data mining.
Lecture: 3 hrs. 3 hours credit.

EEE5264 Advanced Microprocessors
Prerequisite: Graduate standing, or permission of department chair.
Design and applications microcomputers. Topics include: 16 bit versus 32 bit processor organization, controller design, I/O port interfacing, memory structure, addressing methods, keyboard and display interface, and hardware arithmetic functions. Design and interface considerations for peripheral ad interrupt devices
Lecture: 4 hrs. 4 hours credit.

EEE5533 Digital Control Systems
Prerequisite: Graduate standing, or permission of department chair.
Discrete time mathematics, Z-transforms, sampling rates, zero and first-order hold, time delays, system stability, continuous and discrete time systems, interfacing, computer control implementation concepts, state space realization.
Lecture: 4 hrs. 4 hour credit

EEE5654 Digital Signal Processing
Prerequisite: Graduate standing or permission of department chair
Sampling theory and sampling hardware. Z transform. Architecture of VLSI digital signal processors. Design and implementation of real time polynomial, Fir, IIR, and adaptive filters. Spectral analysis with FFT. Design of DSP application in communication and digital control.
Lecture: 4 hrs. 4 hours credit.

MSE6213 Stability in Mechatronic Systems
Prerequisite: Graduate standing
Theory of stability of mechanical systems is given in depth and in connection with the stability of electrical/electronic components for real world applications in mechatronics.
Lecture: 3 hours.

MSE6223 Algorithmic Synthesis of Complex Mechatronic Systems
Prerequisite: Graduate standing.
Some specific issues in the theory and application of adaptive and optimal control systems are presented in the course: synthesis of control lows, choice of weight coefficients for control quality, quasi-optimal systems. All procedures are given in the form of algorithms.
Lecture: 3 hours.

MSE6233 Special Topics in Mechatronic Systems Engineering
Prerequisite: Consent of MSMSE Program Director.
The course covers a specialized or a new topic in the Mechatronic Systems Engineering field that is not covered by other courses. There should be faculty and student interest.
Lecture: 3 hours.

MSE6243 Graduate Directed Study
Prerequisite: Consent of MSMSE Program Director.
This is an in-depth study of a Mechatronic System Engineering topic with a written report to the course instructor and program director. The proposed study application must be submitted and approved by the program director prior to election of the course.
Lecture:3 hours.

MSE6253 Thesis - I
Prerequisite: Graduate standing and approval of the MSMSE Engineering Committee.
First of a two-course sequence required to fulfill the thesis option. Students work in collaboration with a faculty advisor and, optionally, an industrial advisor. Students meet regularly with their advisors. Upon completion of both courses, students write a thesis and make a verbal presentation of their findings. Students also submit a research paper to a research reviewable journal or to a research conference with pee review.
Lecture: 3 hours.

MSE6263 Thesis - II
Pre-requisite or co-requisite: EMM6253 Thesis - I, and approval of the MSMSE Engineering Committee.
Second of a two-course sequence required to fulfill the thesis option. Students work in collaboration with a faculty advisor and, optionally, an industrial advisor. Students meet regularly with their advisors. Upon completion of both courses, students write a thesis and make a verbal presentation of their findings. Students also submit a research paper to a research reviewable journal or to a research conference with pee review.
Lecture: 3 hours.

MSE6273 Mechatronic Manufacturing Systems
Prerequisite: Graduate standing
The course presents characteristics and designs of mechatronic manufacturing systems including high volume production systems. Automated flow lines and automated assembly lines are discussed. Technology for programming robots and flexible manufacturing systems is given for various applications based on discrete and adaptive controls.
Lecture: 2.5hours. Labs: 0.5 hours.

MSE 6283 Autonomous Wheel Power Management Systems
Prerequisite: Graduate standing
This course covers wheel power management systems that autonomously control power distribution among the drive wheels of multi-wheel drive ground vehicles. The systems include various configurations with torque/power vectoring devices and individual wheel control, limited slip differentials and hydraulically controlled differentials, electronically-locking differentials, and positive engagement of the wheels. Autonomous wheel power management systems integrated with other vehicle autonomous systems are also presented in the course.
Students will be lectured on mechanical design for mechatronic systems, methods for developing control algorithms based on inverse dynamics principles, and PLD implementation. Methods for experimental study of wheel power management systems and vehicles are also considered. Students will exercise analytical skills and gain hands-on experience though workshops, innovative homework, and labs using the 4x4 vehicle chassis dynamometer and system setups.
Lecture: 2.5hours. Labs: 0.5 hours.

MSE7283 Robust Mechatronic Systems
Prerequisite: Graduate standing
The course covers advanced topics in robust control including fundamentals of theory, and also detailed fuzzy logic in control system design. Neuro-control is presented by artificial neural networks and by adaptive control based on neural network modeling.
Lecture: 3 hours.

EME6623 Automotive Control Systems – I
Concurrent Prerequisite: EME5433
Principles of contemporary analog control systems for automotive vehicle systems, including the fundamentals of analog control using Laplace Transforms. Analysis and design of analog control systems using modern control systems hardware and software. Topics include open loop and closed loop control, system performance and system design in the time and frequency domains, root locus, and Bode analysis/synthesis. Application of numerical methods, system modeling and simulation, and control software. Hands-on introduction to Matlab®, Simulink®, and dSPACE® software and hardware. Project based course with example applications to control systems in vehicle dynamics, steering, suspension, engine, transmission, driveline and other vehicle systems. LTU 4WD vehicle chassis dynamometer for vehicle controls is included. This is Course-1 in a (2) course series
Lecture: 2.5 hrs. Lab: 1 hr.

EME7623 Automotive Control Systems – II

Prerequisite: EME6623

Project based course focusing on the development of modern control systems for complex automotive vehicle systems. Emphasis on sampled data and digital control systems. This is Course –2 in a (2) course series culminating in student completion of an independent automotive controls systems project. Brief review of analog control systems, discussion of hardware-in the-loop concepts, and an introduction to sampled data systems and digital controls, including z-transforms. Control system project selection will be in the areas of vehicle dynamics, steering, suspension, engine, transmission, driveline, or any other vehicle system of special interest to the student. Modern simulation, modeling and control system software such as Matlab®, Simulink®, Stateflow®, dSPACE® software and hardware used for project implementation. Use of the LTU 4WD vehicle chassis dynamometer for vehicle controls is included.

Lecture: 2 hrs. Lab: 1 hr

INDUSTRY ADVISORY BOARD

The MSMSE Industry Advisory Board is composed of engineers and executives and other professionals working in the Industry and professional societies. Members of the Board are selected because of their knowledge of business practices, their experience working with engineers, and in the case of alumni, their special knowledge of the culture of Lawrence Technological University. The Industry Advisory Board fully supported the proposed program.

Aisin World Corporation of America

Chrysler LLC

Daimler AG

dSPACE, Inc.

Eaton Corporation

Ford Motor Company

General Motors Corporation

Johnson Controls, Inc.

Kistler Instrument Corporation

KUKA Robotics Corporation

MSC.Software Corporation

National Instruments Corporation

Opal-RT Technologies Inc.

Robert Bosch Corporation

Robotic Industries Association

Siemens VDO

The Math Works

The Timken Corporation

Toyota Technical Center, U.S.A., Inc.

U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC)

Vector CANtech, Inc.