NSF Mechatronics Education Innovation Workshop

Balance of Theory and Applied Work: Integration of Education and Research based on Collaboration with Industry

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Balance of Theory and Applied Work in Mechatronics Engineering Program is based on:

1. Integration of Education Process and Research Work
2. Collaboration with Industry

Master of Science in Mechatronic Systems Engineering Program at Lawrence Technological University – 2005

Mechatronics Thrust in BSME, MSME, and Ph.D. in Interdisciplinary Engineering Programs at the University of Alabama at Birmingham – 2012
What are the drivers behind an academic program design?

Engineering Workforce Development and Motivation of Research-Oriented Academic Program

- Up to 40% of engineering workforce in some engineering fields will retire during the next decade.

- Younger engineers should be quick learners and gain industry experience to keep leadership positions in engineering.

- In this regards, universities should establish innovative conditions for students to learn and gain experience in engineering practice both inside and outside the classroom.

- Such innovative conditions should make the diplomas “last longer” and make engineering experience “younger”, i.e., make the experience in many senses as a student attribute.
23 Companies

3M Corporation Research Laboratory
Aisin World Corporation of America
Chrysler LLC
Daimler AG
De-Sta-Co
dSPACE, Inc.
Eaton Corporation
Festo Corp.
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
SKF Corp.
The Math Works
Toyota Technical Center, U.S.A., Inc.
U.S. Army Tank Automotive R&D Engineering Center
Vector CANtech, Inc.
MASTER OF SCIENCE IN MECHATRONIC SYSTEMS ENGINEERING PROGRAM

Two Concentrations:
- Conventional/Unmanned Ground Vehicle Engineering
- Robotics

Established in 2005
# Program Curriculum

## MASTER OF SCIENCE IN MECHATRONIC SYSTEMS ENGINEERING PROGRAM

<table>
<thead>
<tr>
<th>Module</th>
<th>Core Course</th>
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<tbody>
<tr>
<td>1. Modelling and Mechanical Design</td>
<td>1. Analytical and Adaptive Dynamics in Mechatronic Systems</td>
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<td>2. Mechanical Design of Mechatronic Systems and Robots</td>
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<td>3. Engineering Analysis</td>
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<td>2. Control and Optimization</td>
<td>4. Modern Control in Mechatronic Systems</td>
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<td>5. Intelligent Control</td>
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<td>6. Optimization in Mechatronic Systems</td>
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<td>8. Implementation of Mechatronic Systems – II</td>
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Education - Research Integration

1. All the core-courses were built from scratch. It was easier to incorporate advanced *research-related matters* in the syllabi.

2. All core courses were developed as *analytically rigorous* and at the same time *product-oriented courses*.

3. There were two types of projects arranged in the program:
   (i) Research projects and
   (ii) Open-end engineering projects.

They were organized as either *course projects* or *projects outside the course curricular*. 
ANALYTICAL AND ADAPTIVE DYNAMICS IN MECHATRONIC SYSTEMS

Product-Oriented Course with Rigorous Math Content
MECHANICAL DESIGN OF MECHATRONIC SYSTEMS/ROBOTS

Autonomous/Conventional Vehicle and System Design

Industrial Robot Design

KUKA Robot: Car Sit Durability Test

Wheel-Leg Combination

Kistler Plate for Biomechanics
CONTROL COURSES

- Modern Control in Mechatronic Systems
- Optimization in Mechatronic Systems
- Intelligent Control
MECHATRONIC SYSTEMS IMPLEMENTATION

Dr. Konstantin Neiss, Daimler AG
Teaching Mechatronics Engineering in HEV

Dr. Thomas Gillespie, CarSim
Mr. David Thomas, TARDEC (Intelligent Systems)
Mr. John Wilson, National Instruments
Dr. Liu Qiao, 3M
Dr. Alexander Opeiko, Chrysler LLC
Dr. Süreyya Nejat Dogan, Daimler AG
Dr. Konstantin Neiss, Daimler AG
Dr. Andrzej Pawlak, Delphi ...

(18) Adjuncts and Lecturers from Industry
NATIONAL INSTRUMENTS

Jeannie Falcon  
John Wilson, Adjunct  
Becky Linton, Adjunct

42 contact hours of  
NI Hardware and Software in core courses:
  • Lectures  
  • Computer Workshops  
  • Labs  
  • Projects

One course = 45 contact hours

National Instruments had one “hidden/embedded” course in the MSMSE program
EXAMPLE OF COLLABORATION WITH INDUSTRY:
FESTO MECHATRONICS DAY ON CAMPUS

FESTO Mobile Mechatronics Lab
AUTONOMOUS WHEEL POWER MANAGEMENT SYSTEMS
“DUAL-PURPOSE” LABORATORY OF MECHATRONIC SYSTEMS
Built with Industry Support

• High-tech equipment that can be used for both research work and teaching graduate/undergraduate students

• Theory and principles of mechatronic systems engineering through rigorous analytical work and hands-on applications

• Equipment and infrastructure for fundamental and applied research

Equipment Cost: $710,000

2,140 sq. ft.
LABORATORY OF MECHATRONIC SYSTEMS

Open-end Engineering Projects

Equal-Weight Distribution on Wheels

Lift

Negative Damping in Robotic System

Hydraulic Power Steering System
VEHICLE SET UP FOR TIRE POWER BALANCE RESEARCH

- Kistler Instrument Piezoelectric Wheel Transducers and Control Unit
- National Instruments cRIO-9104
- Stress Analysis Services Laser
- Computer Control Unit
- Students: George Thomas, Jesse Paldan, Gerald Murphy
Student Research Committee
“Autonomous Vehicles and Robotic Systems”
Established at
Association for Unmanned Vehicle Systems International

(18) student research papers were published in Int. Conference Proceedings and Int. Journals in 2008 - 2012
University of Alabama at Birmingham

Mechatronics Thrust in BSME, MSME, and Ph.D. in Interdisciplinary Engineering

Applications: Vehicle and Robotics Engineering
# Mechatronics Thrust in BSME, MSME, and Ph.D. in Interdisciplinary Engineering

<table>
<thead>
<tr>
<th>Undergraduate and 5XX Courses</th>
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<tbody>
<tr>
<td>Introduction to Mechatronics</td>
<td>ME 360</td>
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<tr>
<td>Kinematics and Dynamics of Machines with ADAMS</td>
<td>ME 370</td>
</tr>
<tr>
<td>Vehicle Dynamics</td>
<td>ME 430/530</td>
</tr>
<tr>
<td>Mechanical Systems, Labs</td>
<td>ME 461</td>
</tr>
<tr>
<td>Introduction to Vehicle Drivetrain Systems Engineering</td>
<td>ME 490/590</td>
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<tr>
<td>Introduction to Hybrid and Electric Vehicle Engineering</td>
<td>ME 4XX/5XX</td>
</tr>
<tr>
<td>Energy Efficiency of Hybrid and Electric Vehicles, Labs</td>
<td>ME 4XX/5XX</td>
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<tr>
<td>Mechanical Design of Robots: Mechatronics Approach</td>
<td>ME 4XX/5XX</td>
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<th>Graduate Courses</th>
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<tbody>
<tr>
<td>Analytical and Adaptive Dynamics in Mechatronic Systems</td>
<td>ME 672/772</td>
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<tr>
<td>Dynamics and Mobility of Vehicles: Modeling and Simulation</td>
<td>ME 673/773</td>
</tr>
<tr>
<td>Autonomous Wheel Power Management Systems: Theory and Design</td>
<td>ME 674/774</td>
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Laboratory of Mechatronics Systems

Undergraduate students doing labs with NI myRIO donated by National Instruments

DC Motors

Sensors

Pendulum
Undergraduate Students taking Individual Study Courses and doing Undergraduate Research in the Lab

3-Wheel Robot Project

Robot Dynamics and Design
Unmanned Ground Vehicle with Individual Wheel Electric Drives
Publications of BSME, MSME and PhD Students
2013 – 2016

(31) Conference and Journal Papers

(2) Chapters in Book:
“Advanced Autonomous Vehicle Design for Severe Environments”,
Editors: V. V. Vantsevich and M. V. Blundell,
Balance of Theory and Applied Work in Mechatronics Engineering Program is based on:

1. Integration of Education Process and Research Work
   • Courses are analytically rigorous and at the same time product-oriented
   • Research work organized as
     (i) Research projects and
     (ii) Open-end engineering projects
   • Projects: course projects or projects outside the course curricular.

2. Collaboration with Industry:
   • Curriculum and Course Development
   • Building Advanced Laboratories
   • Adjunct and Guest Lecturers from Industry
THANK YOU

Q&A