NSF Mechatronics Education Innovation Workshop

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

Vladimir V. Vantsevich, PhD, ScD, ASME Fellow

November 14 - 15, 2016

UAB SCHOOL OF ENGINEERING

NYU TANDON SCHOOL OF ENGINEERING

VREL
VEHICLE & ROBOTICS ENGINEERING LABORATORY

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*.

MSMSE PROGRAM INDUSTRY ADVISORY BOARD

23 Companies

3M Corporation Research Laboratory
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Chrysler LLC
Daimler AG
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dSPACE, Inc.
Eaton Corporation
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Opal-RT Technologies Inc.
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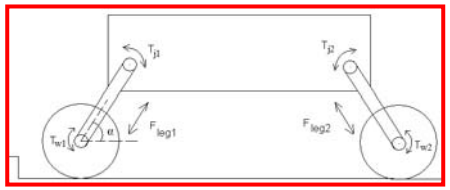
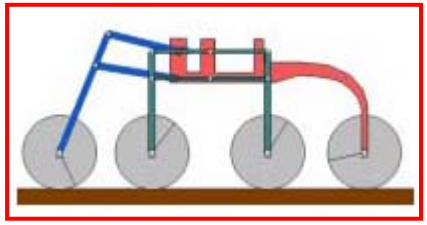
The Math Works
Toyota Technical Center, U.S.A., Inc.
U.S. Army Tank Automotive R&D Engineering Center
Vector CANtech, Inc.

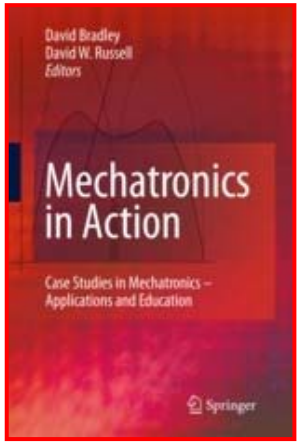
MASTER OF SCIENCE IN MECHATRONIC SYSTEMS ENGINEERING PROGRAM



Two Concentrations:

- Conventional/Unmanned Ground Vehicle Engineering
- Robotics





Established in 2005

Program Curriculum

MASTER OF SCIENCE IN MECHATRONIC SYSTEMS ENGINEERING PROGRAM

Module	Core Course
1. Modelling and Mechanical Design	1. Analytical and Adaptive Dynamics in Mechatronic Systems 2. Mechanical Design of Mechatronic Systems and Robots 3. Engineering Analysis
2. Control and Optimization	4. Modern Control in Mechatronic Systems 5. Intelligent Control 6. Optimization in Mechatronic Systems
3. Hardware Implementation	7. Implementation of Mechatronic Systems – I 8. Implementation of Mechatronic Systems – II

Education - Research Integration

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

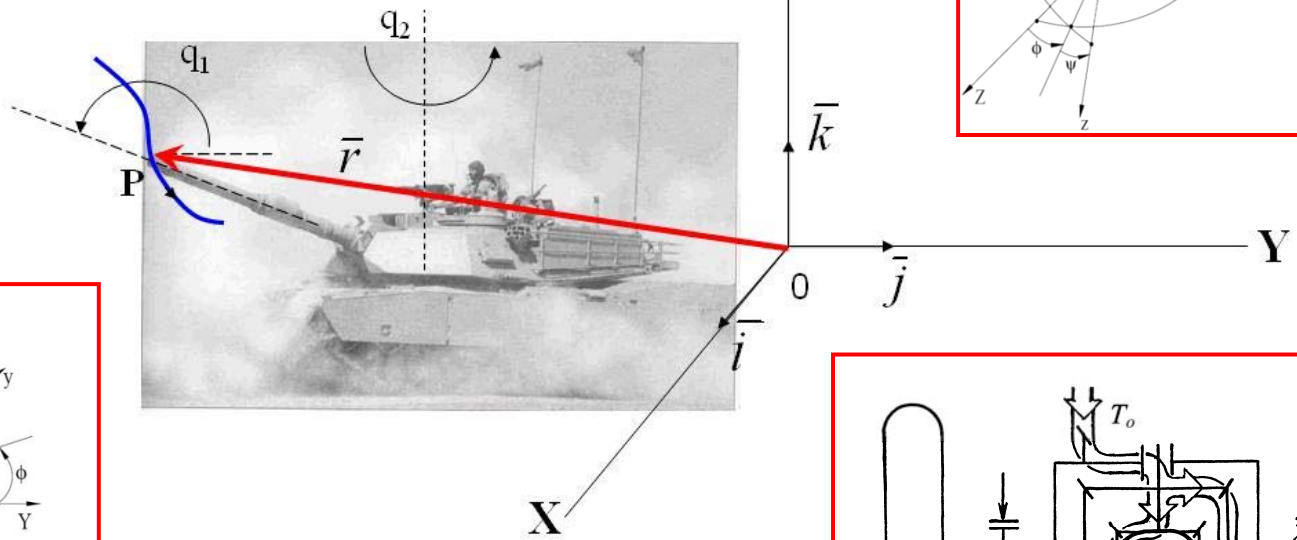
2. All core courses were developed as *analytically rigorous* and at the same time *product-oriented courses*.

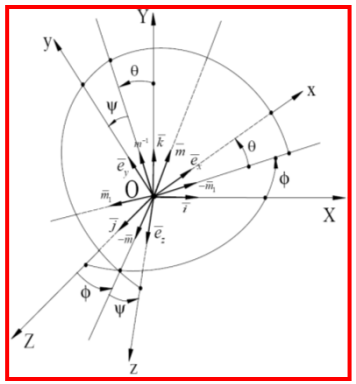
3. There were two types of projects arranged in the program:
   (i) Research projects and
   (ii) Open-end engineering projects.

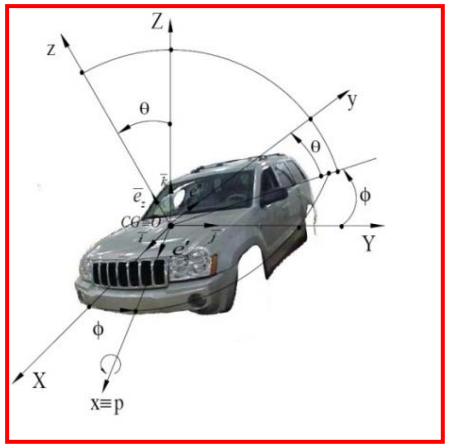
They were organized as either *course projects* or *projects outside the course curricular*.

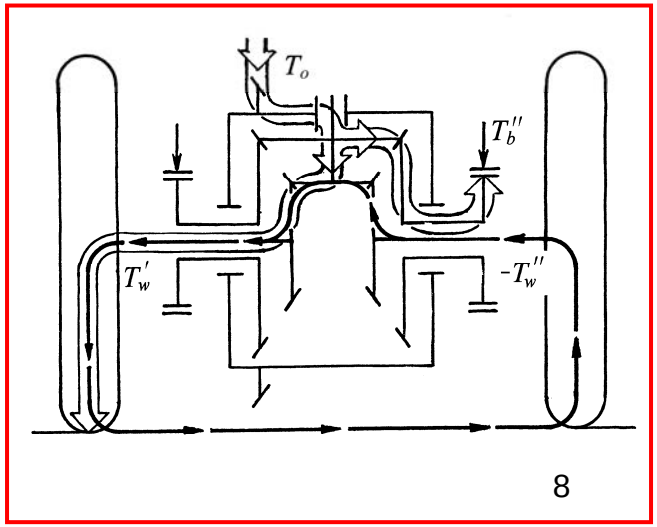
ANALYTICAL AND ADAPTIVE DYNAMICS IN MECHATRONIC SYSTEMS

Product-Oriented Course with Rigorous Math Content









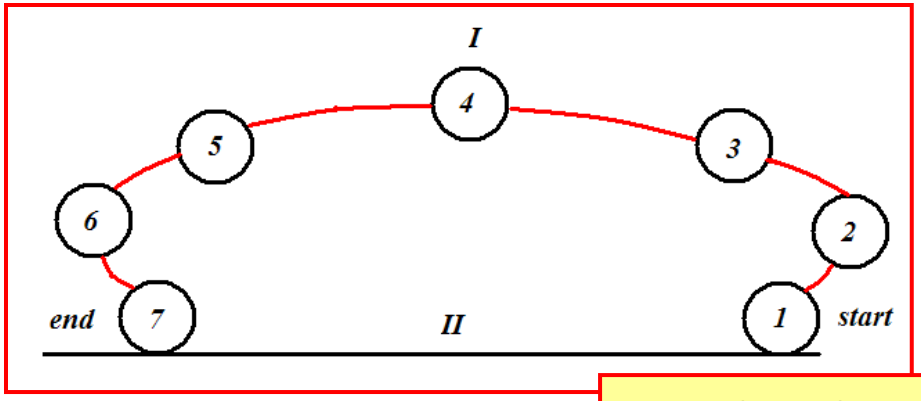
MECHANICAL DESIGN OF MECHATRONIC SYSTEMS/ROBOTS

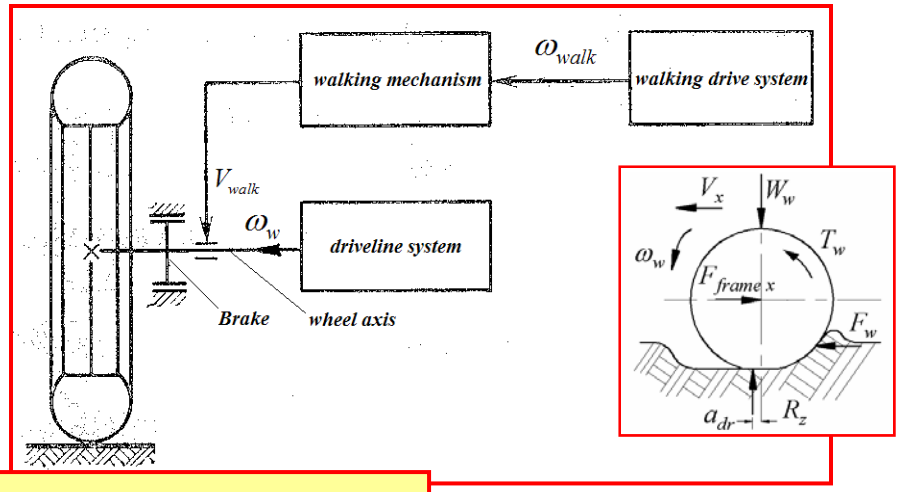
Autonomous/Conventional Vehicle and System Design

Industrial Robot Design

KUKA Robot: Car Sit Durability Test

Kistler Plate for Biomechanics

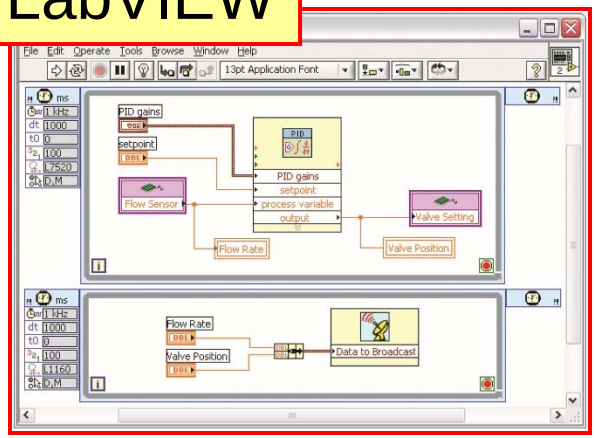




Wheel-Leg Combination

CONTROL COURSES

NI LabVIEW

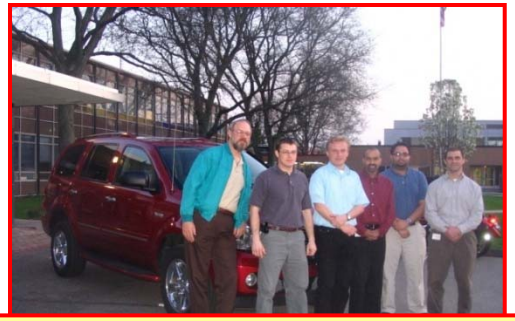


dSPACE

- Modern Control in Mechatronic Systems
- Optimization in Mechatronic Systems
- Intelligent Control

NI VeriStand

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

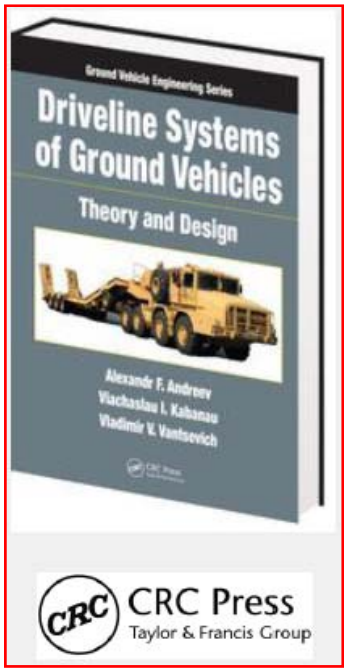
One course = 45 contact hours

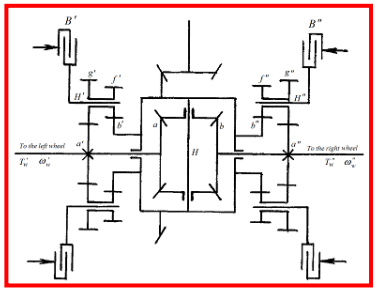
National Instruments had
one “hidden/embedded” course in
the MSMSE program

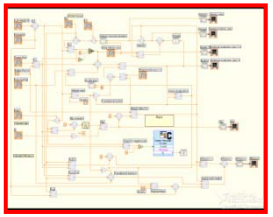
EXAMPLE OF COLLABORATION WITH INDUSTRY: FESTO MECHATRONICS DAY ON CAMPUS

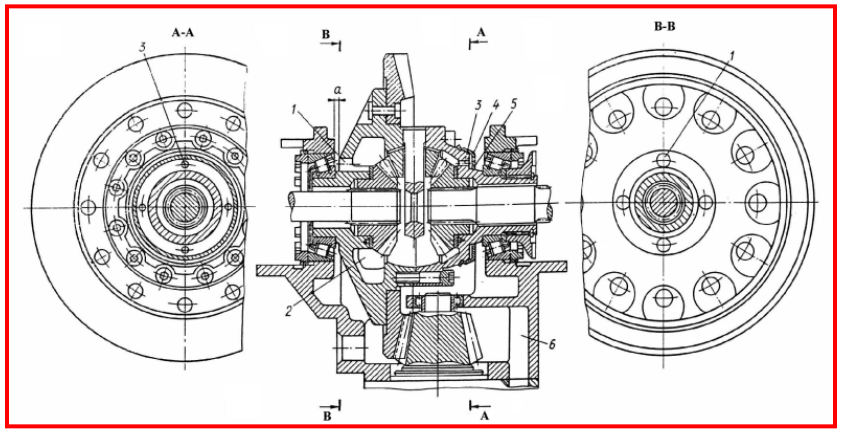
FESTO Mobile Mechatronics Lab

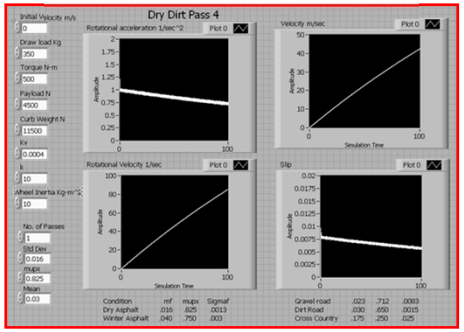
AUTONOMOUS WHEEL POWER MANAGEMENT SYSTEMS

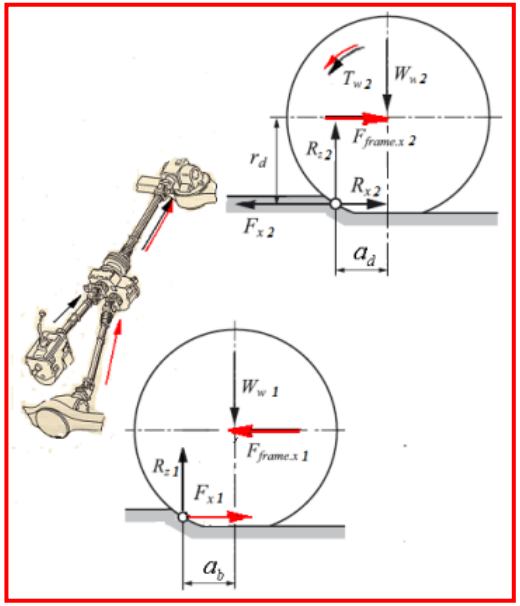


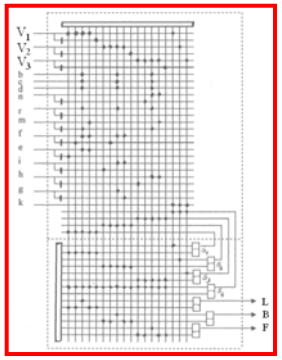








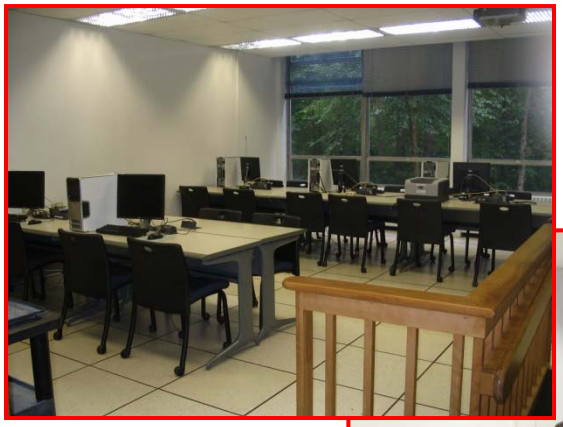




"DUAL-PURPOSE" LABORATORY OF MECHATRONIC SYSTEMS

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

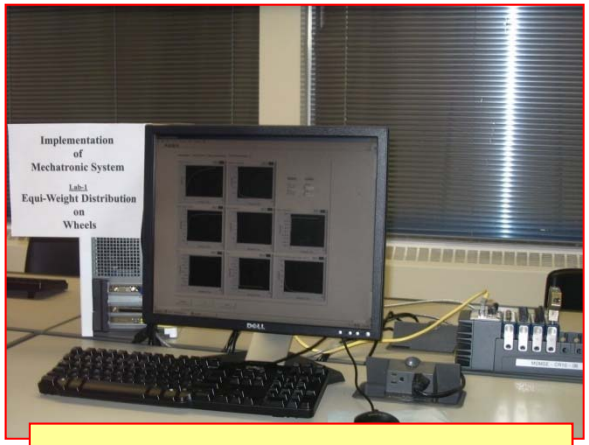


2,140 sq. ft.

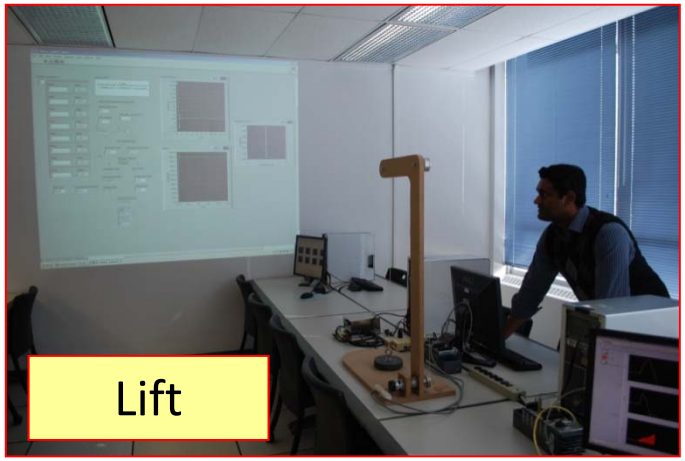
Equipment Cost: $710,000

LABORATORY OF MECHATRONIC SYSTEMS

Open-end Engineering Projects

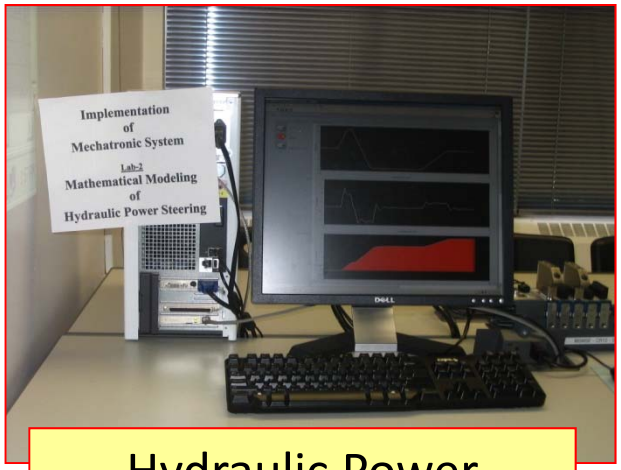


Equal-Weight Distribution on Wheels



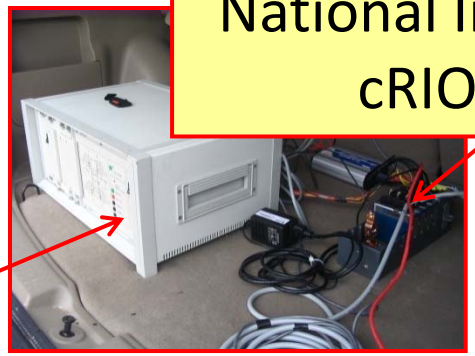
Lift

Negative Damping in Robotic System



Hydraulic Power Steering System

VEHICLE SET UP FOR TIRE POWER BALANCE RESEARCH



National Instruments cRIO-9104

Computer Control Unit

Kistler Instrument Piezoelectric Wheel Transducers and Control Unit

Stress Analysis Services Laser

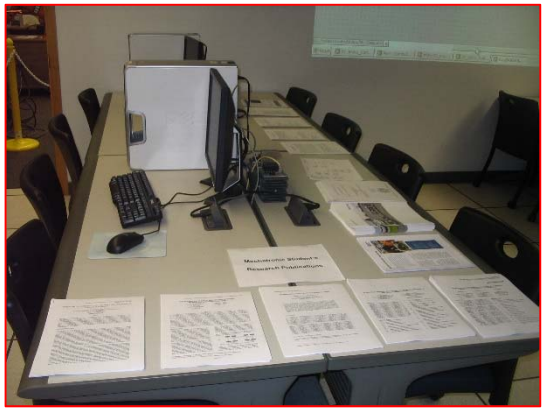
Students:
George Thomas
Jesse Paldan
Gerald Murphy

Student Research Committee

"Autonomous Vehicles and Robotic Systems"

Established at

Association for Unmanned Vehicle Systems International

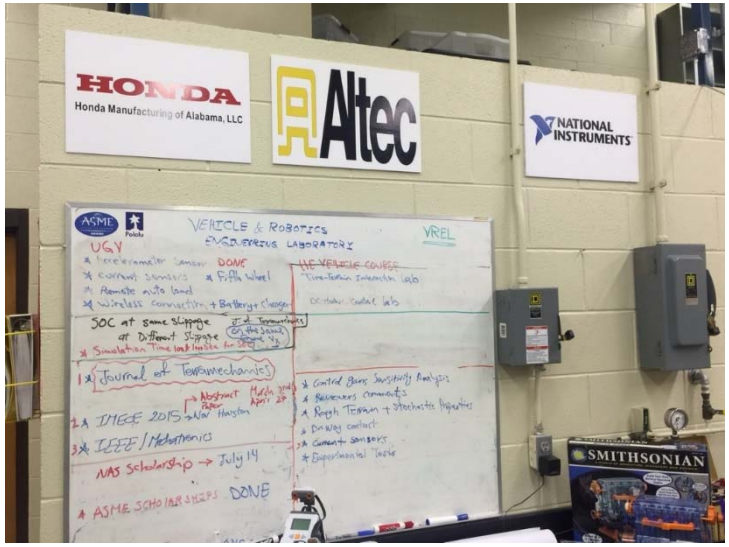


(18) student research papers were published in Int. Conference Proceedings and Int. Journals in 2008 - 2012

University of Alabama at Birmingham

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

Applications: Vehicle and Robotics Engineering

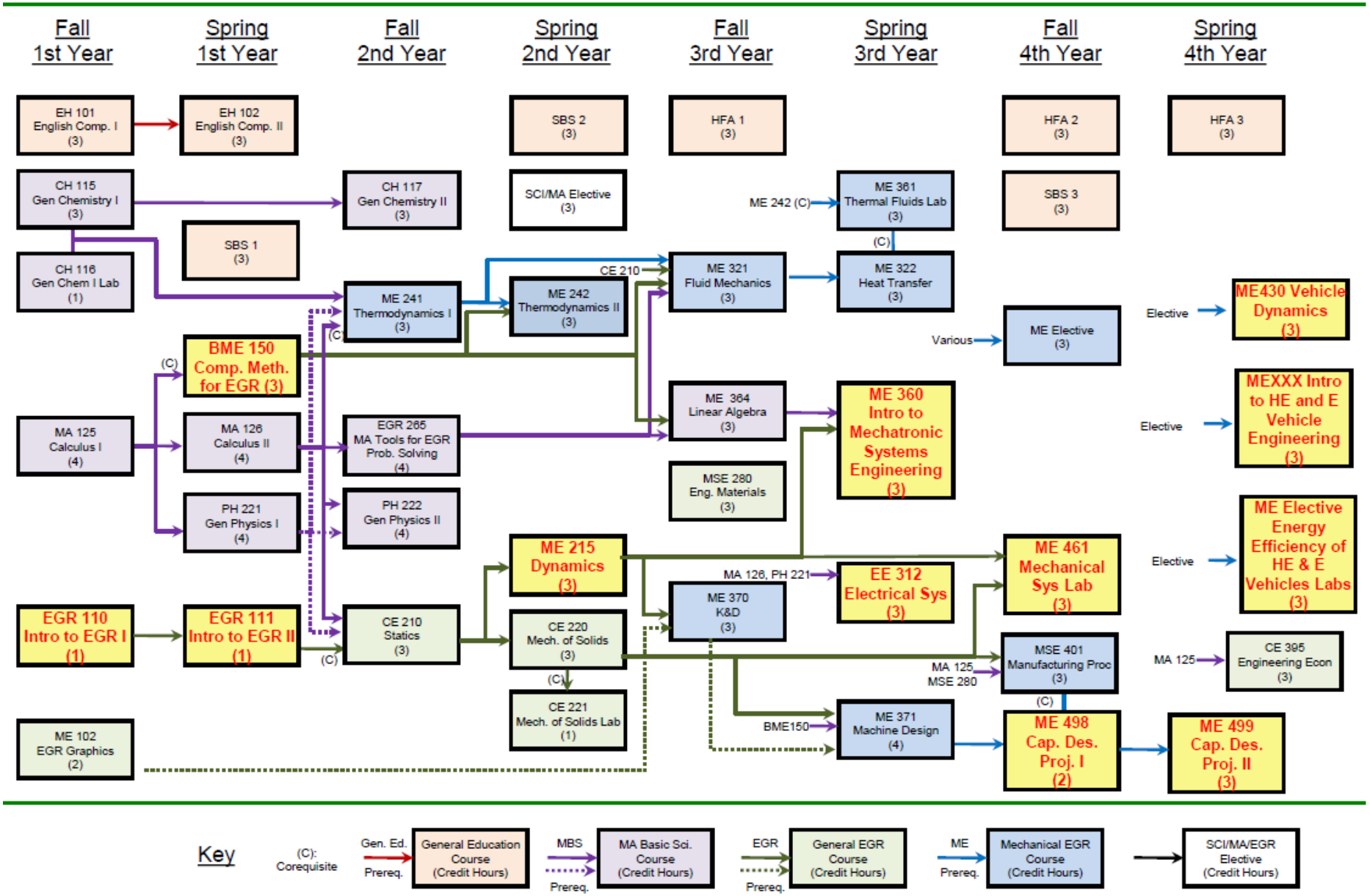


Mechatronics Thrust in
BSME, MSME, and Ph.D. in Interdisciplinary Engineering

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

B.S. Mechanical Engineering Prerequisite Flowchart

Curriculum for Discussion



Laboratory of Mechatronics Systems

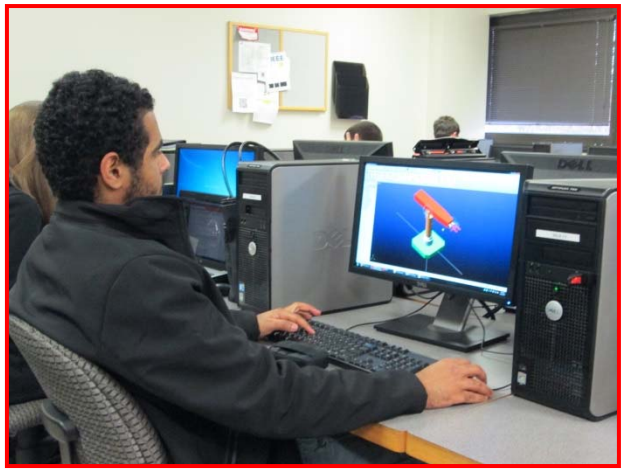
Undergraduate students doing labs with NI myRIO donated by National Instruments

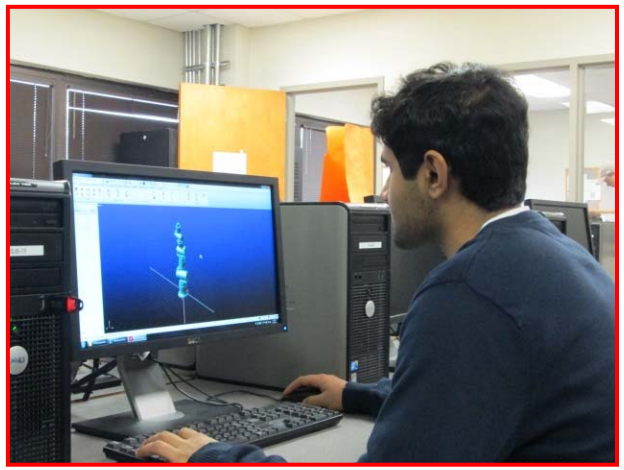
DC Motors

Sensors

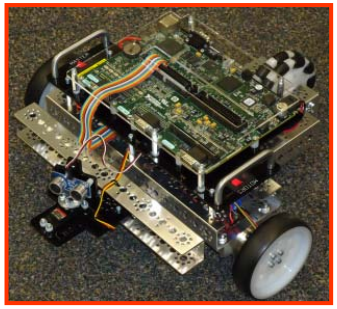
Pendulum

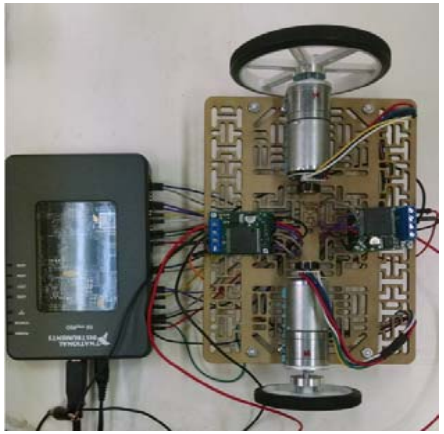
Undergraduate Students taking Individual Study Courses and doing Undergraduate Research in the Lab



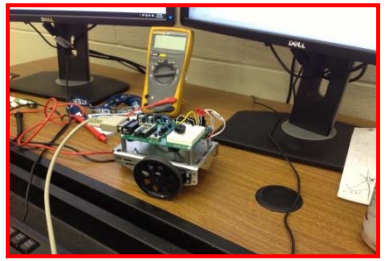


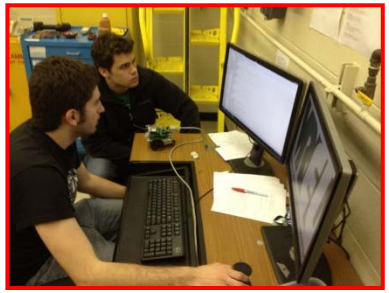
Robot Dynamics and Design

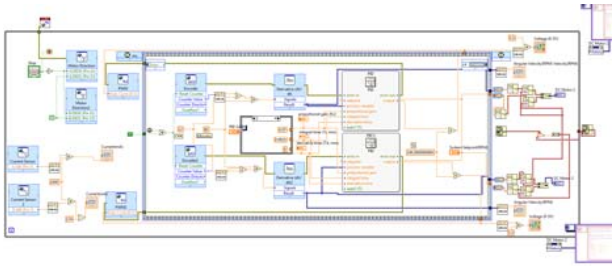




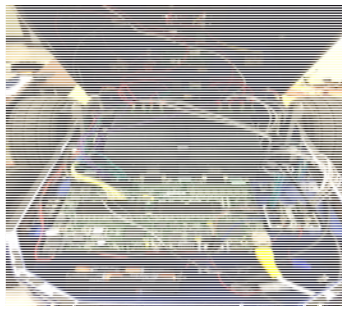
3-Wheel Robot Project

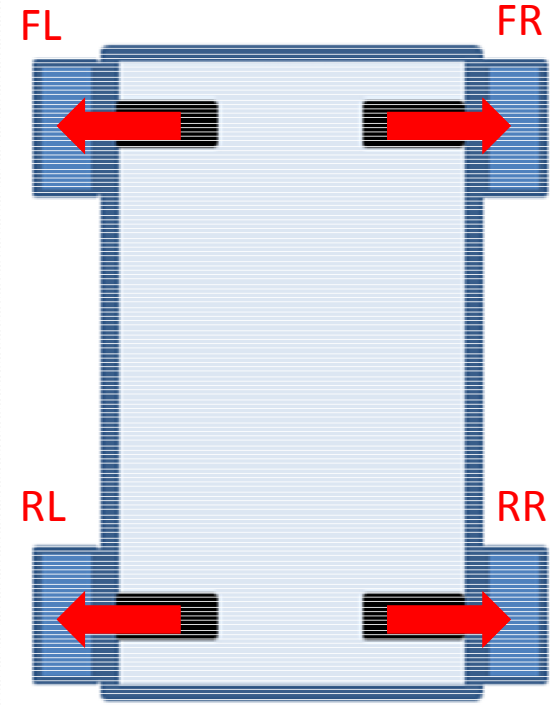


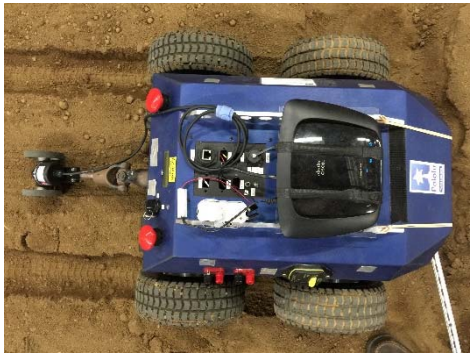




Unmanned Ground Vehicle with Individual Wheel Electric Drives



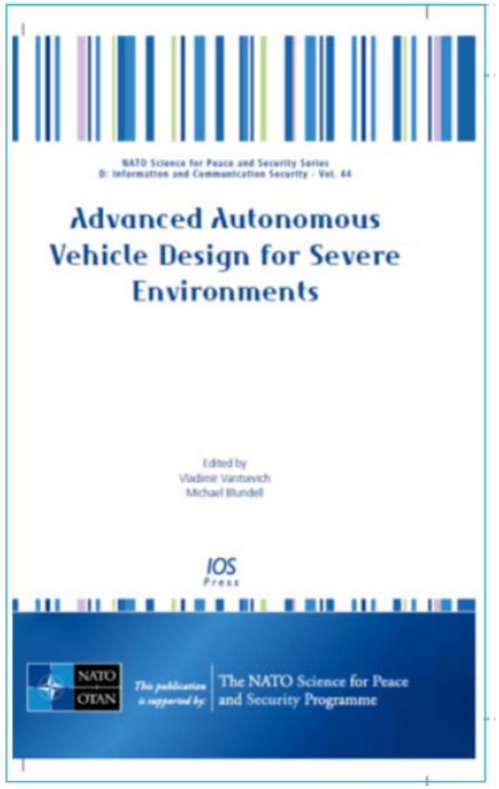




Publications of BSME, MSME and PhD Students
2013 – 2016

(31) Conference and Journal Papers

(2) Chapters in Book:
"Advanced Autonomous Vehicle Design for Severe Environments",
Editors: V. V. Vantsevich and M. V. Blundell,
NATO Science for Peace and Security Series, D: Information and Communication Security - Vol. 44, IOS Press, 2015.



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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

UAB SCHOOL OF ENGINEERING

NYU TANDON SCHOOL OF ENGINEERING

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VEHICLE & ROBOTICS ENGINEERING LABORATORY