Proposal for undergraduate program in Robotics and Mechatronics Systems Engineering

University of Detroit Mercy

shuvra das

in consultation with: Mark Paulik, Mohan Krishnan, Sandra Yost, Chaomin Luo, Utayba Mohammed, Jonathan Weaver, Nassif Rayess, Richard Hill, Darrell Kleinke
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University of Detroit Mercy
PROPOSAL FOR A NEW PROGRAM Bachelor of Robotics and Mechatronic Systems Engineering

A. Summary
Give a short (one page) summary of the important aspects of the proposed program that are detailed below. This summary will be used at various agendas including the Board of Trustees meeting.

The term Mechatronics was first used by Japanese engineers in the mid-sixties to signify a combination of mechanical and electronics principles in product design. There are many formal definitions of the term available in open literature but the one that is most commonly used is “Synergistic Combination of precision mechanical engineering, electronic control, and intelligent software in a systems framework, used in the design of products and manufacturing processes.” More simply stated, Mechatronics is “Designing intelligent or smart machines.” Robots are probably one the earliest and most well known examples of mechatronic systems. At the current time mechatronics principles are in use in a variety of fields including automotive, aerospace, power generation, personal communication, automation, manufacturing, healthcare, and others. Last year the U.S. Dept. of Education revised the 2010 Classification of Instructional Programs (CIP) to include new codes for Mechatronics, Robotics, and Automation Engineering.

Figure 1 shows a pictorial representation of the field of Mechatronics depicting the multi-disciplinary nature of technology of the modern times. In order for tomorrow's engineer to be a leader in product development in the area of smart systems they need to have this multi-disciplinary training. With this in mind we are proposing to start an undergraduate program in Robotics and Mechatronic Systems Engineering. This program will be offered jointly by the ME and ECE departments. It is expected that over time the Software Engineering faculty will play a role as well.

![Figure 1: Competency areas for Mechatronics.](image)
A review of programs across the country shows that there are only about 3-4 programs across the country that are similar to the one being proposed and there are no such programs in Michigan of this type. Nearly all of the courses necessary for this program are already offered at UDM. Only four new courses will need to be developed. As a result, the program can be launched with very limited amount of new resources. It is estimated that a program can be launched accommodating up to 20 freshmen without new full-time faculty or space. The program will be jointly administered by the ECE and ME departments. The Associate Dean for Research and Outreach will be directing it in coordination with a curriculum committee consisting of faculty from these two departments. Marketing funds to advertise the program, and funding for some laboratory equipment for a new Mechatronics/Robotics laboratory are the only new expenses requested. Accreditation through the Accreditation Board for Engineering and Technology (ABET) will be sought after the first graduating class.

Many high school students who are interested in Math and Science are also excited about Robotics. The evidence for this high level of enthusiasm is in the large number of participants in the First Robotics competitions. The number of Michigan teams in this competition is among the highest in the nation from any one state. A survey of the robotics and mechatronics industry indicates that there is a significant need for engineers trained in this background. An undergraduate program that is focused on the theme of Robotics will attract these students who are already interested in this field. Across the US there are only a handful of programs that are focused on this theme and all of them are experiencing significant growth. UDM’s existing expertise in this field enables us to offer this undergraduate program with few new resources. So it is expected that with proper marketing this new program will help boost our enrollment numbers significantly without a lot of new financial investment.

B. Description of the Program
1. Provide a narrative description of the program as it would appear in the catalog.

**Bachelor of Robotics and Mechatronic Systems Engineering** is an undergraduate degree program that is focused on the fundamentals necessary for the design of "intelligent" systems and products in which mechanization and control requiring sensing, actuation, and computation are combined to achieve improved product quality and performance. Such intelligent systems include robots, as well as modern intelligent automobiles, airplanes, defense systems, assistive devices, and a wide variety of other systems, even those that are not as obvious, such as appliances and game and entertainment systems. Modern technological advancements have been able to harness the innovations occurring in a variety of disciplines into designing efficient systems. This program is designed to train undergraduates to be innovative in this multidisciplinary world.

The skills that students will acquire in this program will be valuable to employers
from a variety of industrial sectors including aerospace, automotive, manufacturing, communications, defense, electronics, and healthcare.

The specific objectives of this proposed program are:

- Develop a strong understanding of the fundamentals of mechanical engineering, electrical and computer engineering, software engineering, and control systems in a synergistic framework.
- Develop strong teamwork and communication skills to solve complex problems across disciplinary boundaries.
- Design, develop and implement intelligent engineered products and processes to solve challenging technological problems or meet specific human needs effectively using a variety of innovation methods.
- Develop innovative approaches and an entrepreneurial mind set to problem solving.

2. Provide a matrix that shows each course in sequence, by term, taken by a full time and/or part time student.

The program flowchart as well as a tabulated list of all the courses are shown here.
Bachelor of Robotics and Mechatronic Systems Engineering

**Freshman Year**

<table>
<thead>
<tr>
<th>Fall</th>
<th>cr</th>
<th>Winter</th>
<th>cr</th>
<th>Summer</th>
<th>cr</th>
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</thead>
<tbody>
<tr>
<td>MTH 1410 Calc I</td>
<td>4</td>
<td>MTH1420 Calc II</td>
<td>4</td>
<td></td>
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</tr>
<tr>
<td>ENGR1000 Engineering Ethics</td>
<td>2</td>
<td>PHY1600/1610 Physics</td>
<td>4</td>
<td></td>
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</tr>
<tr>
<td>ENGR 1050 Intro to Engineering Graphics &amp; Design</td>
<td>2</td>
<td>ENGR1070, Intermediate CAD and Design</td>
<td>2</td>
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<td></td>
</tr>
<tr>
<td>CHM 1070, 1100 General Chem. I &amp; Lab</td>
<td>4</td>
<td>Science Elective</td>
<td>3</td>
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</tr>
<tr>
<td>ENL1310: Composition</td>
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<td>CST1010</td>
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**Sophomore Year**

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<tbody>
<tr>
<td>MTH2410 Calc III</td>
<td>4</td>
<td>MTH 3720 Diff Eqn.&amp; Linear Algebra</td>
<td>4</td>
<td>CTA3010 Coop</td>
<td>2</td>
</tr>
<tr>
<td>PHY1620/1630 Physics</td>
<td>4</td>
<td>ENGR3120 Statics</td>
<td>3</td>
<td></td>
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</tr>
<tr>
<td>CEC3000 Coop Prep</td>
<td>1</td>
<td>ELEE 2640, 2650 Digital Logic &amp; Lab</td>
<td>4</td>
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<td></td>
</tr>
<tr>
<td>CSC1710, Computer Sc. I</td>
<td>3</td>
<td>ELEE 2520, 2530 Fundamentals of ECE II&amp; Lab</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ELEE 2500,2510 Fundamentals of ECE I &amp;Lab</td>
<td>4</td>
<td>PHL 1000 Intro to Philosophy</td>
<td>3</td>
<td></td>
<td></td>
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<tr>
<td>ENL 3030, Technical Writing</td>
<td>3</td>
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### Junior Year

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</thead>
<tbody>
<tr>
<td>ENGR3260/ Mechanics</td>
<td>3</td>
<td>CTA3020 Coop</td>
<td>2</td>
<td>ENGR 4520 Sensors and Actuators</td>
<td>3</td>
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<tr>
<td>ENGR 3130 Dynamics</td>
<td>3</td>
<td></td>
<td></td>
<td>ELEE 4000 Hardware and Software Integration</td>
<td>2</td>
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<tr>
<td>CSC1720 Computer Science II</td>
<td>3</td>
<td></td>
<td></td>
<td>ENGR3220 Control Systems</td>
<td>3</td>
</tr>
<tr>
<td>ELEE 3860, 3870 Introduction to Microprocessors</td>
<td>4</td>
<td></td>
<td></td>
<td>ENGR XXXX Mechanics of Robots</td>
<td>3</td>
</tr>
<tr>
<td>MTH 4270 Applied Probability and Statistics</td>
<td>3</td>
<td></td>
<td></td>
<td>CCOBJ4</td>
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<tr>
<td>ENGR3010 PWOW I</td>
<td>1</td>
<td></td>
<td></td>
<td>CCOBJ 4</td>
<td>3</td>
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<td>ENGR 3020 PWOW II</td>
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<td>2</td>
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<td></td>
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### Senior Year

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<tbody>
<tr>
<td>CTA3030 Coop</td>
<td>2</td>
<td>MENG 3920</td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>ENGR 4790, Mech. Modeling &amp; Simulation</td>
<td>3</td>
<td>Technical Elective 1</td>
<td>3</td>
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<tr>
<td></td>
<td></td>
<td>ENGR XXX Senior Design I</td>
<td>3</td>
<td>ENGR XXX Senior Design II</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ELEE 3720 Electromechanical</td>
<td>3</td>
<td>Technical Elective 2</td>
<td>3</td>
</tr>
</tbody>
</table>
3. List all courses in the curriculum: catalog number, title, description and units of credit, as they would appear in the catalog. Indicate which courses are new (+) and which are already being offered and in which program (*). Fully developed syllabi should be included in an appendix.

Please refer to the proposed flowchart for all the courses that will be in the program and a term-by-term plan for offering these courses that have been included in the previous section. Majority of these courses already exist and are being regularly offered as part of either the ME or the ECE program. Short course descriptions are included in Appendix A. Four new courses will have to be designed and offered for the first time. This does not mean that these courses have to be created entirely from scratch. The content of most of these courses are already in existence within other graduate or undergraduate courses. Using those materials these new courses have to be formulated. Catalog description of these courses is included here. Two of these courses are titled: Mechanics of Robots and Mobile Robotics, respectively. Currently, in the ME curriculum there is a course titled Robotics (MENG 4900). In the ECE curriculum there is a graduate course that is titled Autonomous Mobility Robotics (ECE5540). Both these courses are regularly offered. The ME course focuses on Kinematics and Kinetics of Robots the ECE course focuses on mobile robots. The two proposed courses (Mechanics of Robots and Mobile Robotics) will be designed mostly from the content of these two courses. The modification will involve reviewing content, removing any duplication that may exist, and making other necessary modifications that will make the courses appropriate for junior/senior undergraduate students. Sample Syllabi for both these planned courses are included in the appendix.

The other two courses that need to be included are the senior or capstone design courses. Although these two courses will have new numbers for this program the structure of these will follow closely similar courses in the ME and ECE curriculum. Draft catalog descriptions of the four courses are provided below. Also sample syllabi for the courses are included in the appendix.
ENGR XXXX  Mechanics of Robots

The modeling and analysis of robotic systems. Key topics will include spatial description and transformations, forward and inverse kinematics, jacobians, dynamics, an introduction to machine vision, and task planning. Students program a robot to perform a task.

ENGR XXXX  Mobile Robotics

Mobile Robotics will focus on autonomous Mobility and will focus on the theory and applications associated with the development of mobile robots that possess sensors and local intelligence sufficient to operate independently in constrained environments. Topics are selected from the four sub-areas of perception, localization, cognition, and motion control.

ENGR XXXX Senior Design I

The first half of a two-term sequence dealing with the solution of a real-world design problem. Students work in teams to design, analyze, construct and test a working prototype of the solution to a specified problem. Students have an opportunity to participate in a creative and realistic design effort requiring written, oral, and visual communication skills, as well as teamwork and planning. Meeting customer needs is of prime importance. The preparation and presentation of design proposals are central to the course.

ENGR XXXX Senior Design II

The second half of the two-term sequence that begins with Senior Design I. This course must be taken in the same academic year as Senior Design I. The fabrication and testing of a working prototype is emphasized. The methods for the presentation of results and alternative solutions are central to the sequence.

A Mechatronics Laboratory

Engineering has several laboratories that support our existing programs, e.g. the manufacturing lab, measurements lab, microprocessor lab, CAE lab, etc. All these labs will be available for use in relevant courses of the proposed program. However, a Mechatronics laboratory will be necessary to focus solely on providing the experiences unique to this program. Currently there are a lot of hands-on mechatronics activities going on in our robotics and mechatronics courses but there is no designated laboratory space, equipment and support structure associated with that. With a new program focused on Robotics and Mechatronics a laboratory is essential. It is expected that this new laboratory and its equipment will be used by students at all levels in the curriculum.

For the students at the early stage of the program the space will be learner focused. The lab will have workspaces/stations where student groups
can work on experiments in which the activity will be narrow in scope even while allowing scope for exercise of creativity. It is well known that learners are more engaged when they learn the principles of physics and engineering by building functioning machines. Students will learn to apply and test concepts by doing open-ended group exercises designed by instructors. For example, students may learn to integrate sensors and actuators in a system and program a microcontroller to control devices, or reverse engineer a product. Figure 2 shows the type of projects that could be done at this level. For these types of exercises we will use mechatronic or robotic kits and parts. Learning outcomes will include mastering basic technical concepts, integration of components into functional systems as well as teamwork and communication.

For students at the middle of the program (sophomore/junior) activities will be knowledge focused. For these exercises modular lab stations will enable us to cost effectively employ the same core of equipment to perform experiments at different levels of sophistication teaching concepts of varying levels of complexity. Examples of these types of setups include control of the inverted pendulum, helicopter control, robot arms, active suspension system (see Figure 3 for a Quansar product) etc. Learning outcomes for these types of exercises will include technical and professional competencies such as control algorithm implementation, software-hardware interaction, technical communication and teamwork.

Beyond these traditional structured experiments some lab space will be dedicated for fabrication and design of new mechatronic/robotic devices for design projects that will be required for some of the courses in the senior year. These activities will be assessment focused in that the students’ ability to use the concepts learned in the earlier courses to synergistically design and build new products will be evaluated. Examples of projects could be to design and build a device to aid a disabled individual with a unique disability or the construction of a set of robots that are autonomous, and are wirelessly communicating with each other, design of a vehicle for the IGVC competition (Figure 4).

While this laboratory will be used by several courses and course outcomes will be defined during the design of the individual course, some of the expected outcomes are: (a) students will learn complex concepts by integrating theory with hands-on activities, (b) students in this program will learn to think synergistically about multi-disciplinary products and (c) some of these laboratory activities will be suitably modified to create stand-alone modules for pre-college programs. A list of the equipment that will be purchased for this laboratory is given in the table below. The list is given in two parts. The first part is a list that will be initially acquired. In this case detailed price list is given. The second list consists of additional items that will be purchased as funding becomes available. The funds for laboratory items will not be requested directly from the University. As part of the Engineering 100 year anniversary celebration a “next century fund” has been created and a portion of this will be used for new programs. At the inception of the program 54K of this fund will be spent on the items listed in the first list. As more money is raised the items on the second list will be purchased over time. In addition, faculty members will continue to attempt to obtain funds through competitive grants from federal and state agencies as well as private entities such as foundations.
In this discussion we have talked about this laboratory space as if there is a large room available in the Engineering building that will be converted into this space. However, that is not so. There is no large room available in the building that could be easily converted into a new lab and we are therefore not proposing to do that. There is however space in several labs in the building that could be used for this purpose. The senior level design activities can easily happen in the Autonomous Robotics laboratory. The mid-level and freshmen level work can happen in two lab spaces, E340, and E 363. There is enough space in these labs and recently E340 was refurbished with new furniture and storage space. Thus freshmen level student work can be stored away in secure cabinets when this space is used for Advanced Electric Vehicle Courses or any other activities. If the enrollment grows significantly beyond the projected numbers we will need to look for a dedicated laboratory space. Refurbishing of the Annex would be necessary at that point.

**Table I List of Items to be initially purchased**

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Price</th>
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</thead>
<tbody>
<tr>
<td><strong>Quanser Inc.</strong></td>
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</tr>
<tr>
<td>QBOT System SYSTEM INCLUDES:</td>
<td>5115</td>
</tr>
<tr>
<td>- QBOT - Roomba ICreate Platform with HiQ/Gumstix Board</td>
<td></td>
</tr>
<tr>
<td>- Camera, IR Sensors, Sonar Sensors, Battery</td>
<td></td>
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<tr>
<td>- QuaRC - Control Software integrated with Matlab/Simulink</td>
<td></td>
</tr>
<tr>
<td>- Detailed Manuals and Curriculum</td>
<td></td>
</tr>
<tr>
<td><strong>Active Suspension System - Active Suspension System</strong></td>
<td>27885</td>
</tr>
<tr>
<td>SYSTEM INCLUDES:</td>
<td></td>
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<tr>
<td>- Active Suspension Experiment</td>
<td></td>
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<tr>
<td>- Q4 Data Acquisition Board</td>
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<tr>
<td>- AMPAQ - Linear Current Amplifier</td>
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<tr>
<td>- QuaRC - Real Time Control Software</td>
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<tr>
<td>- VRML – Virtual Plant Simulation</td>
<td></td>
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<tr>
<td>- Detailed Manuals and Curriculum</td>
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<tr>
<td><strong>QET - DCMCT - Quanser Engineering Trainer</strong></td>
<td>4620</td>
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<tr>
<td>- DC Motor Control - features analog, microprocessor, and computer control</td>
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<tr>
<td>capabilities.</td>
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<tr>
<td>- Includes complete student manual authored by Dr. Karl Johan Åström.</td>
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<tr>
<td>- Includes QIC Processor Core (16-Series -based on Microchip PIC16F877).</td>
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<tr>
<td>- Demonstrate Haptics in an easy-to-use graphical user interface.</td>
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<td>- Includes individual power supply and carry case.</td>
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</table>
TABLE II List of items that will be purchased after the program has been launched

<table>
<thead>
<tr>
<th>#</th>
<th>Equipment description</th>
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<tbody>
<tr>
<td>1</td>
<td>DC Motor Control Trainer (QET DCMCT)</td>
</tr>
<tr>
<td>2</td>
<td>Active Suspension Experiment with multi-dof mass-spring system (ACTIVESUSP)</td>
</tr>
<tr>
<td>3</td>
<td>OMNI Bundle Serial Small-Scale Manipulator Package</td>
</tr>
<tr>
<td>4</td>
<td>Rotary Servo Plant with potentiometer, optical encoder and tachometer for rate control (SRV02-ET)</td>
</tr>
<tr>
<td>5</td>
<td>Rotary Flexible Link Module with strain gage (FLEXGAGE)</td>
</tr>
<tr>
<td>6</td>
<td>Self-Erecting - Rotary Inverted Pendulum with optical encoder (ROTPEN-SE)</td>
</tr>
<tr>
<td>7</td>
<td>5DOF ROBOT - 5 DOF Open Architecture Robot</td>
</tr>
<tr>
<td>8</td>
<td>2 DOF Robot Module – requires 2 SRV02’s and 2 UPM’s</td>
</tr>
<tr>
<td>9</td>
<td>Ball Balancer Module - 2DOF Ball &amp; Plate Module</td>
</tr>
</tbody>
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MECHKIT - Mechatronics Kit
System Includes:
- DC Motor
- Reaction Wheel
- Pendubot & Rotpen experiments
- Detailed Manuals and Curriculum

Parallax
Sumobot kit
8X160 = 1280

Stingray kit
8X 300 = 2400

Miscellaneous parts needed for senior level fabrication (sensors, actuators, data acquisition boards, etc.)

<table>
<thead>
<tr>
<th>Type projects</th>
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<tr>
<td></td>
<td>5000</td>
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<td>54539</td>
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4. **Indicate delivery format of new courses e.g. traditional day time classes, night classes, intensive weekends, etc. Indicate whether online course delivery is intended and if so, whether it will occur immediately or in the future.**

Just like the other four engineering undergraduate programs, this program is intended to be offered as a traditional program with classes during the day and in the early evenings.
5. Describe how the proposed program respects academic integrity and intellectual merit.

All courses currently in engineering programs have a long history and high standards of academic integrity and intellectual merit.

Students will be required to follow the UDM policy on academic integrity as found in the 2010-2011 Undergraduate Catalog:

As members of an academic community engaged in the pursuit of truth and with a special concern for values, students must conform to a high standard of honesty and integrity in their academic work. Instances where academic misconduct occur include, but are not limited to, falsification or misrepresentation of material used in the admission process, presenting the work of other’s as one’s own, theft, plagiarism and cheating. These actions pose a threat to the academic integrity of the University and its mission and will be treated accordingly. Academic misconduct is subject to disciplinary sanctions. These sanctions include, but are not limited to, reprimand, probation, suspension and dismissal. Students are required to familiarize themselves with the specific protocols of their school or college, available in each respective Dean’s office or Academic Policy Handbook.

Intellectual Merit:

The curriculum was designed so that the program could be accredited by the Accreditation Board for Engineering & Technology (ABET). Hence the intellectual merit of this curriculum meets the same standard already established for other engineering programs within the college.

6. Indicate unusual or unique characteristics of the proposed program.

There are several unique characteristics of the program. They can be itemized as follows:

- The program is interdisciplinary, mainly drawing from the domains of mechanical, electrical and computer engineering, and software engineering
- The program is available in very few universities for the undergraduate population across the US (although it is more common in Europe, Asia, Australia and Canada)
- The program is designed to address the need to educate innovators in a technological world that is becoming more and more multi-disciplinary.
- The program builds mostly on existing courses but develops a new niche

7. Describe how the proposed program affects related departments or fields of concentration.

As the flowchart of the program shows it has been designed to be quite similar in structure to other engineering programs. The freshmen year courses are the same across all disciplines. As a result of this program the freshmen year courses will see additional enrollment. For courses beyond the freshmen level all except two
engineering courses exist either in the Electrical and Computer Engineering curriculum or in the Mechanical Engineering curriculum (and two more have to be revised from two current courses). All the non-engineering courses are already being offered as well. The main impact of this new program is an increase in enrollment in the currently existing courses. The new courses will be designed and offered by faculty of the Mechanical and/or Electrical and Computer Engineering Departments who have the necessary background in those areas. It is expected that in the near future software engineering faculty will be more involved in this program as well. At the time of writing the proposal two new junior faculty members were hired for the software engineering program. They will be encouraged to participate in this program in a way that fits their expertise and experience.

C. Mission

1. Describe how the proposed program fulfills the mission of the University.

The University of Detroit Mercy, a Catholic university in the Jesuit and Mercy traditions, exists to provide excellent, student-centered, undergraduate and graduate education in an urban context. A UDM education seeks to integrate the intellectual, spiritual, ethical, and social development of our students. The proposed program on Robotics and Mechatronics is designed to address the need for modern engineers to be educated in an area that is multi-disciplinary in nature. By addressing this need that arises from the changing technological world we are going to help our students stay current, be educated and trained for the technological challenges of tomorrow and be competitive in their profession. This fits in very well with our student-centered mission for excellence in undergraduate education. The program structure is also designed in a style similar to our other engineering programs so that we address not only the need to be educated in their professional discipline but also address the need for the whole self. Many of the current applications of robotic and mechatronic systems include areas that serve humankind such as assistive and medical devices, protection from attacks by terrorists, replacing human workers in hazardous environments, making cars safer through mechanisms for accident avoidance, etc. Training students who will serve the humanity by working in some of these areas fit very well with our mission.

2. Describe how the proposed program fulfills the mission of the College or School.

“Excellent student centered undergraduate and graduate education” is at the core of UDM’s mission. As a result of technological advancements traditional barriers between individual engineering disciplines in product development have broken
down; however most undergraduate academic programs across the country are still rooted within the different traditional disciplines such as Mechanical, Electrical and Computer, Civil Engineering, etc. Although there are only 3-4 programs in this area (Mechatronics and/or Robotics) across all of US, there are more than 50 similar accredited programs in Europe, Australia, and Canada.

Through this proposed program we plan to make the engineering undergraduate program reflect the current technological needs of interdisciplinary expertise by building on the already strong departmental offerings of Mechanical and Electrical and Computer Engineering. The objectives of this proposed program not only addresses the training of students in important interdisciplinary technological areas but also emphasizes the development of skills such as teamwork, ability to communicate, and entrepreneurial mindset all of which are much needed skills for the engineer today. So this proposal strongly reflects the mission of providing high quality, student centered education that is both current and relevant.

This program will also be of direct service to the companies and government agencies that employ our graduates and support our college: auto companies, aerospace companies, TARDEC, MDOT, DTE, etc.

D. Market and Need

NOTE: At the time of submission of this proposal to MFA, i.e. after it was approved by the college committee and Dean Hanifin, we found out that Lawrence Tech. just launched an undergraduate Robotics Engineering program starting in Fall 2011. Instead of trying to modify the proposal with this additional information we decided to add this note as new information for the readers.

1. Provide the results of a market study for the program and the methodology of the study i.e. survey, focus groups, etc. Indicate a conservative estimate of new student enrollment for a five year period and the estimated number of credit hours per year the student is likely to take.

Robotics and Mechatronic Systems Engineering is not a very common major in Universities across the country. So it is hard to get data about the demand for such a program.
One measure that provides some idea of the potential demand for such a program is the participation of the number of high school and middle school children in the FIRST Robotics Competition and the FIRST Lego League.

A study by Brandeis University on the effectiveness of USFIRST can be found on FIRST's website (www.usfirst.org). The study reports that the First Robotics Alumni are:

- Significantly more likely to attend college on a full-time basis than comparison students (88% vs. 53%)
- Nearly two times as likely to major in a science or engineering field (55% vs. 28%) and more than three times as likely to have majored specifically in engineering (41% vs. 13%)
- Roughly 10 times as likely to have had an apprenticeship, internship, or co-op job in their freshman year (27% vs. 2.7%) and
- Significantly more likely to expect to achieve a postgraduate degree (Master's degree or higher: 77% vs. 69%).

Since Michigan has a very strong presence both in the FIRST robotics as well as the FIRST Lego League (the number of Michigan team in FIRST is one of the top among all the states, Figure 5 shows all the Michigan FIRST Robotics teams), we already serve many of the FIRST students and have several K-12 programs structured around mobile robots, we clearly have access to a fertile ground for recruiting. USFIRST website indicates that over 450,000 high school students participated in it in 2010, 146,000 students from across the world participated in the middle school Lego League in 2009, and 9,000 students participated in the junior Lego League in 2009. Given that these kids are obviously interested in Robotics and more likely to choose Engineering as a major of study it is logical to offer an engineering program in Robotics and Mechatronics Systems Engineering. The recruitment pool is quite large and these kids are already excited about this inter-disciplinary field of engineering.
In the past years E&S developed several new K12 outreach programs. In 2008/9 alone, the eleven E&S K12 programs served over 5,396 pre-college students (Dean’s college status report). Of the programs that the college sponsors are the First Robotics Competition, the First Lego League, NSF “STAR” robotics camp, and DAPCEP courses focused on Robotics; all are focused on the main theme addressed in this program. This is a good recruiting pool for the program.

There are several industry groups in the state that are organized around this technical discipline. One such organization that UDM is a member of is the Robotics Technology Consortium (RTC). Their website (http://www.roboticstechnology.org/) lists over 200 corporate and university members of this organization. A survey of these members was conducted and the Table below summarizes the result of this survey where 40 individuals responded. Apart from the responses received (summarized in Table III) six industry members volunteered to be part of the advisory panel for this proposed program as well.
TABLE III

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you feel that there is a need for an undergraduate program in Mechatronics and/or Robotics engineering?</td>
<td>82%</td>
<td>18%</td>
</tr>
<tr>
<td>If you are an Industry would you be willing to hire a student in such a program for a Co-op or internship (provided funds are available)?</td>
<td>81.5%</td>
<td>18.5%</td>
</tr>
<tr>
<td>Will your company be able to hire undergraduates from this program as full time engineers?</td>
<td>78%</td>
<td>22%</td>
</tr>
<tr>
<td>If you are a University, would you be interested in considering students from this program for your graduate programs?</td>
<td>90%</td>
<td>10%</td>
</tr>
<tr>
<td>Will you be interested in serving on the advisory council for this program?</td>
<td>35.5%</td>
<td>64.5%</td>
</tr>
<tr>
<td>How many undergraduate engineers do you hire on a full-time basis per year?</td>
<td>69.6%</td>
<td>21.7%</td>
</tr>
</tbody>
</table>

This survey clearly indicates that there is a significant demand if a program such as this was made available.

Also, the recent success of UDM in the IGVC competition has created the right “buzz” for UDM. We are getting some advertisement and name recognition around this.

Projected Enrollment
(Conservative estimate of the projected enrollment at steady state.)

From new students: 12 to 100 freshmen per year.
From current students: 2 to 4 internal transfers per year.
Total: 16 to 110 freshmen per year.

2. Describe the competition for the program. Are there similar programs at other institutions in Michigan? If yes, list the institutions, briefly describe the similarities and differences to the proposed program and indicate the enrollment in the competing program.

Mechatronics and Robotics Systems Engineering is not a common major in Universities across the US. A detailed search produced a few similar programs and the enrollment data for some of these programs are shown in Table IV. Apart from the programs listed there are two other programs at Colorado State University at
Pueblo and Southern Polytechnic State University in Marietta, Georgia. Enrollment data for these programs could not be found. This could be because they may be reported as part of Electrical, Mechanical or General Engineering data for these programs. All of these programs are relatively new and some are not yet ABET accredited (although other Engineering programs at these schools are) because the first groups of students have not graduated yet. Obviously, in the state of Michigan there are no programs on Robotics and Mechatronic Systems Engineering. Lawrence Technological University offers a Master’s program in Mechatronics Systems Engineering that is primarily targeted towards practicing professionals.

There are only two other programs in the country that could be considered similar to the program that is being proposed here. They are at California State University in Chico and at Worcester Polytechnic University. Enrollment data from these two schools and a couple of other schools that have related programs (including the LTU Master’s program) are given below along with two Masters level programs. There are several other programs at the Master’s level that are not included here because they are not from this geographical area.

**TABLE IV**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cal State-Chico (CA)</td>
<td>Mechatronics Engineering (B.S.)</td>
<td>96</td>
<td>85</td>
<td>85</td>
<td>97</td>
<td>90</td>
</tr>
<tr>
<td>Worcester Polytechnic University (MA)*</td>
<td>Robotics Engineering (B.S.)</td>
<td>20</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wentworth Institute of Technology (MA)</td>
<td>Electromechanical Engineering (B.S.)</td>
<td>228</td>
<td>212</td>
<td>190</td>
<td>184</td>
<td>174</td>
</tr>
<tr>
<td>Loras College (IA)</td>
<td>Electromechanical Engineering (B.S.)</td>
<td>32</td>
<td>32</td>
<td>43</td>
<td>24</td>
<td>32</td>
</tr>
<tr>
<td>University of Denver (CO)</td>
<td>Mechatronic Systems Engineering (M.S.)</td>
<td>42</td>
<td>74</td>
<td>40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lawrence Technological University</td>
<td>Mechatronic Systems Engineering (M.S.)</td>
<td>33</td>
<td>24</td>
<td>6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*The data in this table is from prior years. As per latest information WPI has 229 majors in the program in 2011.

This data shows that the programs that were started in this discipline have been quite successful in attracting students and there is little or no competition in the state. Also, recent anecdotal evidence (conversation with colleagues from some of
the above mentioned universities) indicate that their recent enrollment numbers gave gone up significantly.

We have provided a list of all the Universities across the world that offers Mechatronics Engineering program (see Appendix C). It is important to note that the list is rather long but most of these Universities are in foreign countries and only a very small number of institutions in the US offer this program.

3. For professional programs indicate the job market for graduates including national or regional data on jobs available and job growth trends. For nonprofessional programs, indicate career or graduate study trajectories.

It is hard to predict this information, particularly because the bureau of labor statistics does not ([http://stats.bls.gov/oco/home.htm](http://stats.bls.gov/oco/home.htm)) list Mechatronics Engineer or Robotics Engineer as a category. Either Mechanical or Electrical and Computer Engineering Data could have been used but that data is much more extensive and contains a number of positions that will not fall under the Robotics/Mechatronics category.

For the purpose of this proposal a simple search of two common job search sites was performed with keywords that are associated with this proposed program and the results are shown in Table V. Data from these sites have been obtained at intervals of many months at a time and is included here. It is quite clear that the need for individuals trained in this multi-disciplinary area is clearly there.

<table>
<thead>
<tr>
<th>Job site</th>
<th>Mechatronics</th>
<th>Robotics</th>
<th>Electromechanical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monster.com</td>
<td>6</td>
<td>386</td>
<td>381</td>
</tr>
<tr>
<td>Juju.com</td>
<td>45</td>
<td>1195</td>
<td>994</td>
</tr>
</tbody>
</table>

(Data from September 2009)

<table>
<thead>
<tr>
<th>Job site</th>
<th>Mechatronics</th>
<th>Robotics</th>
<th>Electromechanical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monster.com</td>
<td>19</td>
<td>261</td>
<td>471</td>
</tr>
<tr>
<td>Juju.com</td>
<td>149</td>
<td>2515</td>
<td>2265</td>
</tr>
</tbody>
</table>

(Data from December 2010)

<table>
<thead>
<tr>
<th>Job site</th>
<th>Mechatronics</th>
<th>Robotics</th>
<th>Electromechanical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monster.com</td>
<td>28</td>
<td>322</td>
<td>667</td>
</tr>
<tr>
<td>Juju.com</td>
<td>177</td>
<td>2707</td>
<td>2300</td>
</tr>
</tbody>
</table>

(Data from May 2011)

Also conversation with the professor in-charge of the Mechatronics Engineering curriculum at California State University at Chico revealed the following list of companies who regularly visit their campus to specifically hire students from their Mechatronics Engineering curriculum.

- Nav Air
• Medtronic
• Encon
• Northrop Grumman
• General Electric
• USS POSCO
• Flight Link
• Banks Integration
• Lemo USA
• F.M. Global
• NVision
• Bently Nevada
• NEC
• HP
• Agilent Technologies
• Siemens
• Rockwell Automation
• Lawrence Livermore National Laboratories
• Sytron Donner Inertial

The survey results of the Robotics Consortium members (reported earlier in TABLE III) also indicate that the demand for engineers in this proposed field will be considerable.

4. Describe the market area of the program i.e. is it local, regional or national.

The market area is national. Except for the two programs at WPI and Cal State, Chico, there are no other similar programs. So students interested in this program could potentially come from anywhere in the country. It will therefore be very important that we advertise this program well; through both the traditional media outlets as well as the various social media networks.

5. Identify interest and potential partners in the program who can help make it successful e.g. students, alumni, local groups, industry leaders, etc.

There are several potential partners who could be helpful in making this effort successful. The college advisory board is made of alumni who are in top positions in their own fields and therefore would be a tremendous resource. Other active alumni, especially those from the ME and ECE programs would be valuable in this effort as well. Many of our alumni work for companies who would be interested in hiring students from this program or hiring co-ops from this program. They would be particularly helpful. Also, two Robotics consortiums/trade groups have already shown a lot of interest to help us launch the program, particularly by spreading the word out to their membership. These two consortiums are: Robotics Industries Association and Robotics Consortium. The army’s Joint Center for Ground Robotics was recently established in Warren in the facilities of the Army Tank command.
The college (in particular the ECE faculty) already has a very close relationship with the leadership of this organization.

An advisory board consisting of industry leaders as well as educators has already been formed and the table below identifies the membership. This group will be a valuable resource in helping us with the launch of this program. Effort is underway to include more members on this committee including relevant individuals from the Automotive industry, TARDEC and other Robot manufacturers such as KUKA and FANUC. The list will be expanded as soon as consent is available from individuals willing to serve.

### TABLE VI

<table>
<thead>
<tr>
<th>Name</th>
<th>Company</th>
<th>Company Focal Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Michael Castillo,</td>
<td>President, American Reliance Inc.</td>
<td>Equip homeland security and military forces with <strong>rugged computer</strong> and <strong>biometric</strong> solutions to strengthen global security. Mitigate global energy crisis by delivering consumer-affordable <strong>renewable energy systems</strong> to remote areas of the world. Prevent heart disease and save lives through non-invasive <strong>early cardiac diagnosis</strong></td>
</tr>
<tr>
<td><a href="mailto:michaelc@amrel.com">michaelc@amrel.com</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Paul Fleck,</td>
<td>President, Dataspeed Inc.</td>
<td>Dataspeed Inc. was established to provide consulting and contract services in the electronics manufacturing sector.</td>
</tr>
<tr>
<td><a href="mailto:pfleck@dataspeedinc.com">pfleck@dataspeedinc.com</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Patrick McKinney,</td>
<td>Chief Executive Officer, Recon Robotics, Inc.</td>
<td>ReconRobotics is the world leader in tactical, micro-robotic systems. Worldwide, more than 1,300 of the company’s robots have been deployed by the U.S. military and international</td>
</tr>
<tr>
<td><a href="mailto:Patrick.mckinney@reconrobotics.com">Patrick.mckinney@reconrobotics.com</a></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
friendly forces, federal, state and local law enforcement agencies, bomb squads and fire/rescue teams

| 4. | Jerry Lane, Gerald.r.lane@saic.com | Robotics Program Manager, SAIC | SAIC is a FORTUNE 500® scientific, engineering, and technology applications company that uses its deep domain knowledge to solve problems of vital importance to the nation and the world, in national security, energy and the environment, critical infrastructure, and health. |


| 6. | Prof. Gregory Fischer, gfischer@wpi.edu | Assistant Professor, Mechanical Engineering, Worcester Polytechnic Institute | |

| 7. | Arnis Mangolds, amangolds@c-2iinc.com | Chief Executive Officer, C-2i, Inc. | C-2i is a computer animation firm that specializes in 3-D visualizations. |

| 8. | Chris Brown, chris.brown@autonomoussolutions.com | VP Business Development, Autonomous Solutions | Autonomous Solutions, Inc. designs and manufactures unmanned vehicle systems, software, and components for a |
Finally, a proposal has been submitted to the National Science Foundation to fund some of the curriculum development work associated with this program. Although
success of this proposal is not guaranteed but if the proposal is funded it will bring in additional resources that will be of significant help in launching the program.

6. Describe how the program will be unique and attract market share.

The uniqueness of the program can be described through the following statements:

- This program is an interdisciplinary program that is a combination of Mechanical, Electrical and Computer, and Software Engineering. It mirrors real world because of how technology has evolved to be very multi-disciplinary in nature.
- (As has been stated several times before) There aren't too many programs in the country that addresses this area. While this may seem to make this a niche market, the larger number of programs in other countries reflect the true breadth of interest and scale of mechatronics. At the same time, in our region and nation, there is very little competition. Attracting significant amount of market share (in a market that is likely to grow in the US) will not be very difficult.

E. Objectives, Learning Outcomes and Assessment
The objectives of this program are:

- Develop a strong understanding of the fundamentals of mechanical engineering, electrical and computer engineering, software engineering, and control systems in a synergistic framework.
- Develop strong teamwork and communication skills to solve complex problems across disciplinary boundaries.
- Design, develop and implement intelligent engineered products and processes to solve challenging technological problems or meet specific human needs effectively using a variety of innovation methods.
- Develop innovative approaches and an entrepreneurial mind set to problem solving.

2. Indicate the learning outcomes and which courses satisfy those outcomes.

Graduates from the Bachelor of Robotics and Mechatronics Systems Engineering program at the University of Detroit Mercy will have:

- an ability to apply knowledge of math, science, engineering and innovation principles to problems in mechatronic and robotic engineering.
- an ability to design and conduct experiments, as well as to analyze and interpret data relating to mechatronic and robotic systems.
- an ability to design innovative mechatronic and robotic systems, components or processes to meet desired needs with realistic constraints such as economic,
environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

d. an ability to function effectively on multi-disciplinary teams.

e. an ability to identify, formulate, and solve mechatronic and robotic engineering problems.

f. an understanding of professional and ethical responsibility.

g. an ability to communicate effectively.

h. the broad education necessary to understand the impact of engineering decisions in a global, economic, environmental, and societal context.

i. a recognition of the need for, and an ability to engage in life-long learning.

j. a knowledge of contemporary issues related to the mechatronic and robotic engineering profession.

k. an ability to use techniques, skills, and modern engineering tools necessary for engineering practice.

l. the ability to be innovative and entrepreneurial in their approach to technical problem solving


3. Indicate how the learning outcomes and the objectives of the program will be assessed.

The Robotics and Mechatronics Systems Engineering program will seek accreditation through the Accreditation Board for Engineering & Technology (ABET). Such accreditation will require that the program have an active outcome and objective assessment process, as has been implemented by the same departments and faculty who will oversee and deliver this program.

In both the outcomes for the program as well as the objectives there are statements about the ability of students to be innovative and entrepreneurial in their problem solving. Although several courses have been developed in these areas none of those courses are listed as requirements for the program. It is therefore necessary to explain how this aspect of the outcome would be addressed. They will be addressed in the following fashion:

(a) Separate from this effort the content of the Professional World of work I & II are being modified extensively to teach innovation techniques as well as entrepreneurial thinking in problem solving. These courses will continue to be taken by all engineering students.

(b) Entrepreneurial case studies have been integrated into a variety of courses that will be taken by these students.
(c) Innovation and Entrepreneurship are being specifically addressed in the senior design classes and will be done for these students as well.
(d) Finally, if some of these students choose to do a minor in innovation and entrepreneurship, that will also address the innovative and entrepreneurial abilities of these students. Doing a minor, however, will increase the number of credits that these students will take beyond the 142 that they will be taking for this program.

Assessment of Program Educational Objectives:

Every three years a report will be written on the program education objectives. A primary source of information about achievement of objectives will be a survey of alumni from the program. Initially, until the first group of alumni is available the advisory board will be the group that will be surveyed.

Assessment of Learning Outcomes:

A yearly report on learning outcomes will be written. Table VII shows how the assessment methods correspond to the learning outcomes.

Definitions:

a) In-Course Assessments: In-Course assessments are not grades. The in-course assessments are initially performed by the instructors or the course coordinators when there are multiple sections of a course. The coordinator creates a worksheet that cites various student work. The worksheets may also cite external juries as available. Next, the program curriculum committee meets and reviews the instructor’s draft assessment.

b) Coop Employer Survey: There is a mandatory coop training program for all UDM engineering students. The coop office visits the job site during the first placement to ensure a quality learning experience. All employers evaluate their student trainees at the end of their placement.

c) External Evaluators: Industrial representatives often evaluate student work or presentations. Having external industrial representatives view student work gives greater authority to the assessment of student work.

d) Senior Exit Survey: A survey will be given to all seniors when they graduate from the program. It will ask them about how confident they are with each of the learning outcomes.

e) Fundamentals of Engineering Exam: It is expected that all seniors in this program will take the Fundamentals of Engineering Exam to start the training processes for professional licensure. The exam statistics are available to the sponsoring program.
### Table VII Outcome Assessment Tools

<table>
<thead>
<tr>
<th>Program Outcome</th>
<th>Assessment Tool</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>In Courses assessments</strong></td>
<td>Coop Employer Survey</td>
</tr>
<tr>
<td>a. an ability to apply knowledge of math, science and engineering principles to problems in mechatronic and robotic engineering.</td>
<td>Most Classes</td>
</tr>
<tr>
<td>b. an ability to design and conduct experiments, as well as to analyze and interpret data relating to mechatronic and robotic systems.</td>
<td>PHY 1630, ENGR 3610, ELEE2510, ELEE 2530</td>
</tr>
<tr>
<td>c. an ability to design mechatronic and robotic systems, components or processes to meet desired needs with realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.</td>
<td>ENGR 1050, MENG 3920, ELEE 2500, ELEE 2510, ELEE2520, ELEE2530, ELEE 2640, ENGR 3120, ENGR 3130, ENGR 3260, Senior Design I&amp;II, Mechanics of Robots, Mobile Robotics</td>
</tr>
<tr>
<td>d. an ability to function effectively on multidisciplinary teams</td>
<td>ENGR 1050, ELEE2510, ELEE 2530, Senior Design I &amp;II</td>
</tr>
<tr>
<td>e. an ability to identify, formulate, and solve mechatronic and robotic engineering problems.</td>
<td>Most Classes</td>
</tr>
<tr>
<td>f. An understanding of professional and ethical responsibility.</td>
<td>ENGR 1000, ENGR 3010, 3020</td>
</tr>
<tr>
<td>g. an ability to communicate effectively.</td>
<td>ENGR 1050, ELEE2510, ELEE2520, ELEE 2530, ENGR 3010,</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>3020, ENGR 3610, Senior Design II</td>
<td></td>
</tr>
<tr>
<td><strong>h.</strong> the broad education necessary to understand the impact of engineering decisions in a global, economic, environmental, and societal context.</td>
<td>UDM Core, ENGR 1000, ENGR 3020, CTA 3010-3030</td>
</tr>
<tr>
<td></td>
<td>√</td>
</tr>
<tr>
<td><strong>i.</strong> a recognition of the need for, and an ability to engage in life-long learning.</td>
<td>ENGR 3020,</td>
</tr>
<tr>
<td></td>
<td>√</td>
</tr>
<tr>
<td><strong>j.</strong> a knowledge of contemporary issues related to the mechatronic and robotic engineering profession.</td>
<td>ENGR 3020, Senior Design I&amp;II</td>
</tr>
<tr>
<td></td>
<td>√</td>
</tr>
<tr>
<td><strong>k.</strong> an ability to use techniques, skills, and modern engineering tools necessary for engineering practice.</td>
<td>ENGR 1050, ENGR 1070, CS 1710-1720, ELEE 2500, ELEE 2510, ELEE 2530, ELEE 2540, ENGR 4790, Mechanics of Robots, Mobile Robotics</td>
</tr>
<tr>
<td></td>
<td>√</td>
</tr>
<tr>
<td><strong>l.</strong> the ability to be innovative and entrepreneurial in their approach to technical problem solving</td>
<td>PWOW I</td>
</tr>
<tr>
<td></td>
<td>√</td>
</tr>
<tr>
<td></td>
<td>PWOW II</td>
</tr>
<tr>
<td></td>
<td>Senior Design I&amp;II</td>
</tr>
</tbody>
</table>

**F. Students**

1. *Based upon the market study above, describe the typical student of the program including whether the student will be full time or part time.*

The typical student will be a recent high school graduate, although based on room within the program transfers will be accepted.

Primarily, full-time students will be recruited.

Students will be subject to the standards of admission to an engineering program:

To be admitted as first year students to the College of Engineering & Science, applicants must meet UDM’s general entrance requirements. In addition, they should have completed at least four units of mathematics, two units of laboratory science, four units of English, and three units of social studies.
The College of Engineering & Science does not admit those who, in its judgment, do not have the background to succeed in its academically demanding programs. Applicants should rank in the upper two-fifths of their high school classes and should have at least a B average in high school mathematics, sciences and English. Special note is taken of scores on the College Entrance Examination (SAT) or the American College Test (ACT).

Therefore, the students will match the high quality of academic preparation found in most engineering students.

2. If the program is intended to provide an option for existing students in the University, describe the enrollment impact on other programs.

It is expected that this program will primarily attract new freshmen to the University who would have otherwise not come here. However, it is possible that students from other programs, particularly other Engineering disciplines might be interested in transferring.

The freshmen year curriculum for Mechanical, Electrical and Civil Engineering programs in the college is almost the same (with the exception of one course, ENGR 1070, which the MEs take but others don’t). Only the Architectural Engineering freshmen curriculum is substantially different from the other three disciplines. The freshmen curriculum for this proposed program has been kept the same as that of Mechanical Engineering. So it is easy for any engineering student from one of the ME, EE& CE programs to transfer to this program after their freshmen year. Beyond that it is likely that Mechanical or Electrical and Computer Engineering students could choose to transfer to this program. Majority of the engineering courses beyond the freshmen year are derived from those two programs and therefore the students from those programs could likely transfer. They may have to take additional courses that they had not already taken.

Students transferring from any other UDM program will essentially have to be freshmen. If not, they will have to start by taking some courses at the freshmen level.

3. If the program will attract new students to the University describe who these students are and whether they have special needs or requirements not currently provided by the University.

According to the section above titled “D1 Market Study”, the new students will primarily be recent high school graduates.

According to the section above titled “F1 Typical Student”, the students will have to meet the admission standards for all UDM Engineering programs. It is not expected that these students will put an increased demand on remedial learning services.
4. Describe how the program will attract a diverse student body.

Gender diversity:
The Engineering programs at UDM have a far better representation of female students compared to the national average. (22% vs. 18%)

Racial diversity:
The Engineering programs at UDM have an excellent representation of underrepresented minority students compared to the national average. (24% vs. 13%).

Being located in Detroit, UDM has a unique authority for recruiting minority students. UDM engineering administrators and faculty members go on recruiting visits at regional and national high schools and the college operates many K12 outreach programs that serve underrepresented minority populations (and a new robotics summer camp will be developed for initial delivery in the summer of 2012). To recruit minority students, the high school visits will focus on schools serving a large portion of minority students.

At this point there are no plans to hire new faculty members. However, if enrollments justified building instructional capacity, the program would exceed UDM requirements for encouraging diverse prospective faculty members to apply to UDM.

5. If the proposed program is an expansion of existing program, or is a new degree level, list the number of majors and degrees in the present program for the past five years.

This is a new interdisciplinary program but it relies heavily on the current Mechanical and Electrical and Computer Engineering programs.

G. Faculty
1. Provide a list of faculty who will be involved in the new program.
Since this is an interdisciplinary program primarily building on the current strengths of the ME and EE departments all the faculty members within those two departments will be involved in it. However, faculty members who will have major involvement are:

Shuvra Das-Mechanical Engineering
Jonathan Weaver-Mechanical Engineering
Darrell Kleinke-Mechanical Engineering
Richard Hill-Mechanical Engineering
Nassif Rayess-Mechanical Engineering
We recently hired two new faculty members in the software engineering program. They will be encouraged to get involved in areas that match their interest and experience.

2. *Indicate whether new full time or part time faculty are required to operate the program at its optimum through the first graduating class.*

Two new adjunct faculty members are requested for this program. No full-time faculty positions are requested.

There are four new courses for this program.

Mechanics of Robots: Will be designed through the modification of a current ME tech elective

Mobile Robotics: Will be designed through the modification of a current EE tech elective

Senior Design I, Senior Design II will be taught jointly by ME and EE faculty members but two new adjunct positions will be necessary to relieve them of some of their current responsibilities.

Both new expenses begin in the 4th year of offering the new program.

*Note: if enrollments in this program exceed 22-25 per year, then many service courses will have to be split and new faculty hired or additional adjunct or overload assignments made. If demand for the program warrants offering more sections, the UDM leadership will be approached with that opportunity. If the enrollment is low, we have very little risk. These students can be included within the senior design classes of either the Mechanical or the Electrical Engineering programs without any problem.

3. *Describe how the program will attract a diverse faculty.*

No new full-time faculty slots will be filled unless enrollment exceeds 22-25 and the UDM administration agrees to that opportunity.

Two part-time positions will be created. These positions are usually filled through personal contacts rather than national searches. Women and minority candidates will be encouraged to apply through those contacts.
4. *Indicate what fields of specialization require new full time or part time faculty.*

As per the plan the faculty members who teach the Senior Design classes will be relieved of some other teaching responsibility that the adjunct faculty will be hired to teach. It is not possible to predict at this stage what those courses might be. Hence the field of expertise of the adjunct faculty that would be required is not known at this point. Both the ME and the ECE departments have contacts with a substantial number of professionals that are available to teach almost in all areas of specialization. Hence, finding the right person would not be a problem.

**H. Administration and Support**

1. Indicate how the program will be administered.

The Robotics and Mechatronic Systems Engineering program will be administered jointly by the Electrical and Computer and Mechanical Engineering Departments and the Associate Dean for Research and Outreach.

All curricular decisions will be proposed through the Curriculum Committee consisting of:

- Associate Dean for Research and Outreach
- ME & ECE chairs
- ME & ECE faculty members who teach in this program.

Major curricular decisions are brought to the new advisory board for approval, and as appropriate to other bodies throughout the College and University.

2. *Indicate whether support personnel are required for the program including secretarial, information technology and lab support.*

No new support personnel are required.

Secretarial: None needed since no new administrative structures are created.

IT: Students in this new program will use the existing IT infrastructure.

Lab support: The laboratory experience and needs were discussed in the section on new courses at the beginning of this proposal. The equipment needs were also specified there.

3. *Indicate whether academic support will be required from existing programs on campus such as UAS, Coop, Writing Lab, etc.*
No new remedial staff is expected to be needed. These students will meet the admission requirements of other engineering programs, most of who have generally lower remedial needs. And even if they need remedial help their needs will be similar to students in other engineering programs.

Coop: Enrollments in the other engineering programs is below recent historical highs. Therefore, adding students will not cause any immediate need to increase staffing the coop office. However, we plan to develop relationships with more companies, particularly those who would be hiring more of these engineers. With the co-op coordinator now being part of the college the development of new relationships will be well coordinated by the college administration, the faculty and the co-op coordinator.

While it is very hard to estimate accurately all the needs of the program if it grows at a very fast pace we have attempted to provide some estimates of where those needs would be and what those needs are expected to be. No cost analysis is done for these estimates. Also, if this type of growth becomes a reality then we need to review the needs for the program at that point in time and determine the proper course of action. The information is shown in Table VIII.

Table VIII

<table>
<thead>
<tr>
<th>Incoming Freshmen</th>
<th>New Full Time Faculty</th>
<th>Laboratory Space/renovation/other expenditure</th>
<th>Help with the Co-op Office</th>
<th>Program Administration</th>
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<tr>
<td>0-20</td>
<td>None</td>
<td>None other than specified in the analysis</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>20-40</td>
<td>One additional faculty member*</td>
<td>Renovate Annex or some other space for additional space</td>
<td>Additional student help than is available now</td>
<td>None</td>
</tr>
<tr>
<td>40-60</td>
<td>None</td>
<td>Hire one more full-time co-op co-ordinator</td>
<td>1 Administrative Assistant needed</td>
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</tbody>
</table>

* The request for additional faculty will be reviewed in the light of what happens with the enrollment numbers in Mechanical and Electrical Engineering Departments. If these numbers are down significantly then there might not be a need for new faculty.

I. Library Resources

1. Indicate the University’s library resources available in direct support of the proposed program: reference and periodical holdings, software, audiovisuals and other instructional materials.
2. List the library resources and funding needed to support the degree program through the first five years. Indicate the ability of the library to purchase recommended resources. The Dean of the Library shall prepare this report and sign it.

The library resources report can be found in Appendix D. The report clearly indicates that the material already available in the library is more than adequate to support this undergraduate program. The report also identifies some Journals that the library currently does not subscribe. This list is relevant to the program but is not absolutely necessary to launch the program since we already have an extensive collection. After the second year, provided the enrollment numbers hold as predicted, we will subscribe to an additional journal “IEEE/ASME Transactions on Mechatronics,” and keep subscribing to it in future years. At a later date we can consider whether it would be necessary to subscribe to more journals from the “wish list.” At this moment no additional investment is needed.

J. Facilities
1. List the facilities which are currently available at the University for the program including administrative office space, class room space, and the like.

Administrative space:

- Chair office of Mechanical and Electrical and Computer Engineering, rooms 214, 330 Engineering Bldg.
- Faculty office space for a coordinator of this program. (a current faculty member will be the designated coordinator).

Classroom space:

- Engineering building classroom space. 
  *Most of the classes are current sections of mechanical or electrical engineering courses. The classrooms that these courses are held in have capacity to seat the new students.

  Four new courses for the program will be offered per year. Two of them will be modified versions of existing courses and the other two will be senior design courses. The senior design courses will be offered one each in the winter and summer terms. Therefore, there will not be a noticeable increase in classroom demand.

Labs:

- Engineering labs currently have capacity for more students. Also, multiple sections of many laboratory classes can be offered to accommodate
increasing student numbers. More space may be needed if the annual enrollment numbers go beyond 20. A qualitative estimate is provided in Table VIII.

2. *Indicate whether the Registrar has any concerns over provision of classroom space for the program.*

The Registrar indicated that we may run into space issues if the new courses that we are adding “need to be taught at specific times and days when we are already at maximum classroom capacity, such as 10:00 or 11:00 MWF or 9:55-11:10 or TR 11:20-12:35”

As per the current plan there will only be two new courses (the other two are modified version of the existing courses). These two are scheduled in the Winter and Summer terms of the senior year. These courses need not be scheduled in those particular time slots. This only means the course assigners will need to be aware that the new courses should be assigned at times other than the ones mentioned above.

3. *Indicate whether any facilities such as laboratories, classroom and office space have to be built, renovated or added to deliver the program and what the cost of same would be based upon a review and cost study by the University Facilities Management Department.*

None of these would be necessary at this point.

**K. External Support**

1. Describe any accreditation available in the field and recommend whether such accreditation should be sought.

Robotics and Mechatronics programs can be accredited through the Accreditation Board for Engineering & Technology (ABET) either under Mechanical, Electrical and Computer Engineering, General engineering or Systems Engineering. The curriculum was design so that program could be accredited by ABET. Over 90% of the courses are currently part of other programs that are accredited.

Accreditation is typically sought through ABET after the first class has graduated. Their work is the evidence used to support accreditation. The degrees granted to that first class are then accredited. We intend to follow this procedure in this case as well.

2. *If the program has been reviewed by an external consultant, professional organization, employers, etc. include a copy of their report in the appendix E.*
This program proposal has been sent to the advisory board for review and their feedback comments are included in the appendix along with appropriate responses.

3. Describe any external funding that has been received or can be expected to be received to support the program. Include the duration of any grants or any continuing commitments that have future budget implications.

A grant application has been made (in January 2011) to the National Science Foundation's TUES program. The requested funding of close to $600,000 is to pay for some of the development work (particularly the new courses and laboratory activities and equipment) and for organizing workshops to train faculty from other Universities to start similar programs. The grant duration, if approved, will be for three years.

NOTE: We did not receive this grant but we intend to re-submit the proposal or parts of it to other programs within NSF and/or other agencies and foundations.

4. Describe whether any resources are to be reallocated from existing programs to support this new program.

The program is designed to be an interdisciplinary program using existing resources from primarily Mechanical Engineering and Electrical and Computer Engineering programs. This means that the students in these programs will be taught primarily by the faculty of ME and ECE departments, they will share classroom with students from these majors and work in laboratories that these two majors use.

L. Operating Revenue and Costs

1. Provide a five year projection of revenue and expenses for the program utilizing the projected number of students from the market study and the projected credit hours taken per year.
2. Revenue should include tuition and external support.
3. Expenses should include scholarships, graduate assistantships or other tuition reduction costs.
4. The spreadsheet of revenue and expenses should follow the format and categories for program budgets used throughout the University (see attached spreadsheet format). A narrative of assumptions should define the parameters of the projection.
5. The difference between revenue and expense should be totaled at the bottom as the Net Margin for the indirect expenses of the University.
6. The year one projection should include all start up costs and capital expenditures necessary to begin the program.
*Table IX shows the proposed budget for the program.*
### Table IX

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- **notes**
  - $60K from restricted funds spent during 2011/12 and 2012/13
  - IEEE/ASME Transactions on Mechatronics
  - one four-year FIRST scholarship awarded in each of the first two years
  - the 2011-12 promotion supported by restricted funds; subsequent years supported from budget

**Net Margin for UDM funds**: $137,900.00

**Total from UDM operating funds**: $137,900.00
Notes:

a) As per the plan and timeline shown here we will have less than a full year to advertise and recruit students for this program. So the number of students for the first year is shown to be a conservative estimate (6). In the second year the number is projected to double (12). And the projected estimate in subsequent years is assumed to be 16.

b) The initial tuition is based on current 2010-2011 rates. The flat rate is $32,090 per year for full time students. After that it was assumed that the tuition increased by 6% every year. The revenue calculations were done using the lump-sum tuition rate for a full-time student.

c) No external support for tuition is included in this study.

d) Administration duties of the program will be shared by the chairs of ME and ECE departments, and the Associate Dean for Research and Outreach. The main administrative tasks are the following: planning the course offerings, advising, assessment report writing and other assessment related tasks, and outreach to companies and potential employers. Since majority of the courses are offered from either ME or ECE departments the chairs will be doing the course assignment anyway. A large number of faculty from both these departments will be involved in this program so they should be able to advise the students properly. Outreach to employers will be primarily done by the Associate Dean of Research and Outreach, Shuvra Das. He is the author of the proposal and does outreach activities for the college anyway. He will also use the established outcomes assessment process in ME and ECE to develop the annual program assessment report for this new program. In the fourth year of the program when we would likely apply for ABET accreditation additional work will be necessary to put together the final assessment report. For that $4500 is budgeted so that a course release could be given to the ABET assessment coordinator for the program.

e) The operating cost of the laboratory that includes parts and supplies needed to keep the lab running are not included in the first four years of the program since there is a special lab equipment fund that will be used to buy all the necessary supplies during that time period. After that $2000 will be budgeted for lab expendables.

f) The proposal specification requests that start up costs be placed in year one. However, marketing costs would be required in year “zero.” In the 2011-12 the promotional cost is kept at a minimum level of $7,000 and this will be paid from college’s restricted account. This fund will be used primarily to print tri-fold flyers and brochures to advertise the program and for their mailing. These will be mailed to all the students who had inquired about the engineering programs. In 2012-2013 a significant amount of money for publicity and advertising has been budgeted from the operating budget (and supported by a large revenue from tuition). This is when we will use marketing budget to get the word out about the program.

g) UDM’s standard scholarship program is the main source of scholarship for these students. The scholarships are based on what the students would most likely receive from existing scholarship programs at UDM. For the purposes of this budget the scholarships are calculated at the rate of 50% of tuition.
h) The lab equipment line indicates a cost estimate of all the equipment that will be bought during the first four years of this program. More details of the cost of some of the equipment that will be bought in the first two years were provided in this document in an earlier section (TABLE I). The lab equipment expenditure in the 2011-12 and 2012-13 (a total of $60,000) will be covered by the “Centennial Fund,” a restricted account created from the fundraising associated with the one hundred year celebration of engineering. In subsequent years laboratory equipment will be purchased from the operating budget for the program. We will review the needs at that point in time to determine exactly what equipment will be purchased.

i) Two adjuncts are requested to relieve the ME and/or EE faculty members teaching the senior design courses in this program. This is only needed in the senior year of the curriculum.

j) There is a small amount of travel money included in the budget to support local travel to relevant employers and high schools for establishing contacts as well as for recruitment.

k) The primary means of marketing of the program in 2011-12 will be through reaching the FIRST robotics competition teams. This will be done by offering a $5,000 UDM FIRST scholarship to a student who is part of a team in this competition. This scholarship will be in addition to the regular UDM scholarship that the student might get and will be supported from E&S restricted funds. The scholarship will be advertised through the FIRST organization. This scholarship opportunity provides a unique access to the FIRST community of students who would be naturally inclined to choose this program of study. The marketing opportunities available are described in the next section.

FIRST Marketing Plan

As per the FIRST organization’s website and conversation with their representative, the scholarship opportunity provides the following benefit to the University:

- Attract the best and brightest minds to your campus. Promote your school to over 50,000 talented and motivated high school students who are interested in a range of engineering disciplines, mathematics, science, computer programming, and technology.
- Attract students who are more likely to succeed in college. FIRST students have learned problem-solving and time management skills, have had hands-on experience, and know the power of teamwork and gracious professionalism. The life skills learned in FIRST make these students more successful in college.
- Recognize and reward students who have learned the value of hard work, careful study, determination, and project completion.
- Funding a scholarship is often just a matter of re-designating existing scholarship funds.
Scholarship Marketing by FIRST and Exposure for FIRST Scholarship Providers include:

**Throughout the year** - FIRST Scholarships are promoted to students, parents, teachers, and mentors throughout the year on the FIRST website, via email blasts to teams, eNewsletter articles, and handouts at events.

**September** - Scholarship offerings (complete details) for the coming year are posted on the FIRST website. This is where the students research available scholarships and find out how and when to apply. Listings are added throughout the season as new scholarship providers join the program.

**January** - The logos of all scholarship providers are displayed at the FIRST Kickoff Event in early January. All teams watch this event via NASA TV Broadcast and web cast at over 46 regional kickoff sites throughout the nation, Brazil, Canada, and Israel.

**March/April** - The FIRST Robotics Competition program books (for over 60 Regional/District events and the Championship) list the name of each scholarship provider. Scholarship display tables at Regional events, where allowed, are offered to local scholarship providers.

**April** - FIRST Scholarship providers whose yearly offerings are valued at a total of $40,000 or more receive a display booth to promote their institution to approximately 10,000 high school students at the FIRST Championship in St. Louis, April 25-28, 2012.

**April through July** - As each scholarship provider reports their scholarship winners to FIRST, the names and home states of students who have been offered FIRST Scholarships are posted on the FIRST website.

Full utilization will be made of this opportunity by college faculty, administration and staff to recruit students for this program. Admissions personnel will be invited to the relevant events as well, for recruitment. This population of students will not only be a feeder for the proposed program but also for the other engineering programs in the college. Most importantly all the FIRST competitions take place during the Winter/Spring semester (specifically in the months of March and April). In fact the FIRST season launch happens in January and the first set of mailings go out to the teams in January as well. So even in this academic year we have a good opportunity to get the word out about our program and get some applicants.
M. Approval Process

1. List University committees or bodies required to approve the program. If approval has been previously obtained from a committee, so indicate and include in the Appendix the written approval.

College Committee for Academic Standards, Dean of Engr.& Sc., McNichols Faculty Assembly, Academic Leadership Team, Academic Vice President, President's Council, President, UDM Board of Trustees.

2. Indicate any other University support that has been obtained. Include support letters from internal or external sources.

Letters of Support written for the NSF proposal are included in the Appendix.

3. You are invited to submit anything additional which will help any committee in its decision.

N. Appendices

1. Include in an appendix any material which would help support the program including the market study, course syllabi, cost studies, grants, etc. used to draw conclusions described above.

2. Please submit any suggestions for improvement in this proposal document or process (optional).
APPENDIX A  Catalog description of Courses

ENGR 1050 Engineering Graphics and Design (2)

This course provides an introduction to the engineering disciplines and computer graphics. Its emphasis is on design, solution of unstructured problems, visualization and communication of a design using proper drafting techniques. The mode of delivery is a mixture of lecture and laboratory. The laboratory experience takes the form of hands-on activities. The course contains a series of experiences drawn from different engineering disciplines to illustrate design methodology and engineering problem solving.

ENGR 1070 Introduction to Solid Modeling (2)

Prerequisites:
ENGR 1050 (Minimum Grade of D, May not be taken concurrently)

An introduction to feature based solid modeling of three dimensional components and assemblies. Topics will include: Design in the context of computer tools and concurrent engineering; 2D versus 3D CAD modeling; Sketching and constraining 2D cross sections and creating 3D features from those sections; Feature based solid modeling; Fundamentals of parametric modeling; Constructive solid geometry and Boolean operations on solids; Creating multi-level CAD assemblies.

ENGR 3120 Statics (3)

Prerequisites:
PHY 1600 (Minimum Grade of C, May not be taken concurrently)

Corequisites: MTH 2410

The application of equilibrium equations to the analysis of particles and rigid bodies. Topics include: vector algebra, moments, couples, free body diagrams, external forces and internal forces. The inertial properties of areas and solid objects are covered. Application of equilibrium to beams and other load supporting structures is described.

ENGR 3130 Dynamics (3)

Prerequisites:
ENGR 3120 (Minimum Grade of C, May not be taken concurrently)
The application of kinematics and kinetics to particles and rigid bodies. The course considers fixed and moving reference frames, momentum and energy methods and applications in engineering problems.

ENGR 3260 Mechanics of Materials (3)
Prerequisites:
ENGR 3120 (Minimum Grade of C, May not be taken concurrently)
Response of non-rigid solids to different types of loads such as tension, compression, torsion and bending. The course considers stress-strain relationships and their use in the analysis and design of structures, pressure vessels and machine components. The concept of stability is introduced as applied to the buckling of columns.

MENG 3610 Mechanical Measurements Laboratory (2)
Prerequisites:
ENGR 3120 (Minimum Grade of D, May not be taken concurrently)
MTH 4270 (Minimum Grade of D, May not be taken concurrently)
An extensive set of laboratory experiences to illustrate mechanical measurements and data analysis. Experiments are designed to demonstrate the application of force, temperature, pressure and other transducers. Data acquisition and presentation of data are emphasized.

MENG 3920 Machine Design (3) (TO BE MODIFIED)
Credit Hours  Recitation/Lecture Hours  Studio Hours  Clinical HoursLab Hours
Prerequisites:
MENG 3900 (Minimum Grade of C, May not be taken concurrently)
The solution of problems involving systems of machine elements. The use of gears, springs, shafts and bearings is treated in depth. Static and dynamic considerations are made to system design. Design projects are used as a principal method of instruction.
ELEE 3720 Electromechanical Energy Conv (3)
Analysis and design of magnetic circuits, transformers, induction motors, synchronous motors and generators, DC motors and generators.

ELEE 4000 Hardware and Software Integration (2)
A course that integrates aspects of the hardware design of electrical and electronic circuits with the software design of computer-based visualization and control systems. Among the topics to be covered: interpreted vs. compiled programming languages, algorithm testing, software optimization, and an introduction to Operating Systems (OS) with the focus on writing device drivers.

CSSE 1710 Intro to Programming I (3)
Overview of computer organization, algorithm design, introduction to programming in C++, input/output statements, arithmetic expressions, assignment statements, logical expressions, conditional statements, control statements, functions and function calls, math Library, I/O library, character library, introduction to arrays and pointers, program testing and debugging.

CSSE 1720 Intro to Programming II (3)
Built-in and user-defined data types, arrays, lists, strings, records, classes and data abstraction, C++ object-oriented software developments, inheritance, composition, dynamic binding and virtual functions, pointers, dynamic data, reference data types, recursion.

ENGR 3220 Control Systems (3)
Modeling of chemical, electrical, mechanical and hydraulic systems. Analytic solution of open loop and feedback type systems. Routh criteria. Root Locus methods in design of systems and evaluation of system performance. Time and frequency domain design of control systems.

ELEE 2500 Fundamentals of ECE I (3)
A spiral coverage of the fundamental principles of Electrical and Computer Engineering involving DC and transient circuit analysis techniques, diodes, operational amplifiers, logic circuit concepts, DC motors. The course will feature an intertwined development of theory and applications of the above topics.

ELEE 2510 Fundamentals of ECE I Lab (1)

A companion laboratory course to ELEE 2500 that provides practical insights for the theoretical topics covered in that course. Analysis and design of simple circuits involving applications of diodes, operational amplifiers, digital logic circuits, motors. Introduction to Electronic Design Automation software. Introduction to use of basic electronic instrumentation.

ELEE 2520 Fundamentals of ECE II (3)

Continuation of a spiral coverage of the fundamental principles of Electrical and Computer Engineering, providing an integrated treatment of advanced circuits, electronics, and power electronics. The course will feature an intertwined development of theory and applications of the above topics.

ELEE 2530 Fundamentals of ECE II Lab (1)

A companion laboratory course to ELEE 2520 that provides practical insights for the theoretical topics addressed in that course. Analysis and design of circuits involving applications of diodes, operational amplifiers, digital logic circuits, motors, and other components.

ELEE 2640 Digital Logic Circuits I (3)


ELEE 2650 Dig Log Circ Lab (1)

Design and implementation of combinational and sequential logic circuits including counters, adders, shift registers, etc. Computer simulation of logic circuits.
ELEE 3860 Intro to Microcontrollers (3)

Credit Hours Recitation/Lecture Hours Studio Hours Clinical Hours Lab Hours

Microprocessor evolution, microprocessor and microcomputer organization, assembly language, interrupts, peripherals, interfacing, A/D and D/A systems.

ELEE 3870 Intro to Microcontrollers Lab (1)

Familiarity with microprocessor/microcontroller development and training systems: memory, I/O CPU. Assembly language. Hardware and software experiments. Microcontroller design projects involving design, prototyping and construction.

ENGR 4520 Sensors and Actuators (3)

Study of fundamental transduction mechanisms of common sensors and actuators. Principles of data acquisition. Use of software tools for data interaction with sensors and actuators. Introduction to micro electro-mechanical systems (MEMS). A key component of this course will be laboratory exercises involving sensors and actuators.

ENGR 4790 Mechatronics: Modeling and Simulation (3)

Analysis, synthesis and design of mechatronic systems through the use of modeling and simulation tools. Use will be made of a unified energy flow approach to model mechatronic systems that comprise multi-disciplinary components. Computer simulation exercises to enhance student learning will be a key component of this course.

CHM 1070 General Chemistry I (3)

Prerequisites:

CHM 1050 (Minimum Grade of C, May not be taken concurrently)

Corequisites: CHM 1100 MTH 1400

Stoichiometry, thermochemistry, states of matter, selected properties of the elements, solutions, atomic and molecular structure.
CHM 1100 Chemistry Laboratory I (1)

Prerequisites:

Corequisites: CHM 1070

Basic laboratory techniques are introduced including the qualitative analysis of the common inorganic cations and anions.

MTH 1410 Analytic Geometry and Calculus I (4)

Prerequisites:

MTH 1400 (Minimum Grade of C, May not be taken concurrently)

Functions; limits and continuity; derivatives and integrals of polynomial, rational and trigonometric functions. Computer laboratory included.

MTH 1420 Analytic Geometry and Calculus II (4)

Prerequisites:

MTH 1410 (Minimum Grade of C, May not be taken concurrently)

Topics in analytic geometry, differentiation and integration of exponential, logarithmic and inverse trigonometric functions; sequences and series. Computer laboratory included.

MTH 2410 Analytic Geometry and Calculus III (4)

Prerequisites:

MTH 1420 (Minimum Grade of C, May not be taken concurrently)

Plane curves; polar coordinates; vectors in two and three dimensions; analytic geometry in the three dimensions; vector valued functions; partial derivatives and multiple integrals.

MTH 3720 Differential Equations with Linear Algebra (4)

Prerequisites:

MTH 1420 (Minimum Grade of C, May not be taken concurrently)
Linear dependence; linear differential equations and applications; systems of linear differential equations; series solutions.

ENL 3030 Technical Writing (3)
Practical application of basic technical writing principles and acceptable guidelines in scientific and industrial reporting. Students use an audience-centered approach on lab and field studies, memoranda, progress reports, detailed instructions, and typical formal documents.

PHL 1000 Introduction to Philosophy (3)
An introduction to philosophy through a consideration of such topics as the person, human values, freedom, morality, knowledge, death, the meaning of life, God, and the nature and destiny of human existence. Students come to understand that philosophy asks the most fundamental questions about ourselves, the world, and the relationship between the two. The method of philosophical thinking and critical reflection will be stressed. Note: This course fulfills Objective 4a of the University Core Curriculum.

New Courses

XXXXX Mechanics of Robots (Similar to MENG 4900)
The modeling and analysis of robotic systems. Key topics will include spatial description and transformations, forward and inverse kinematics, jacobians, dynamics, an introduction to machine vision, and task planning. Students program a robot to perform a task.

XXXXX Mobile Robotics(similar to ELEE 5200)
Mobile Robotics will focus on autonomous Mobility and will focus on the theory and applications associated with the development of mobile robots that possess sensors and local intelligence sufficient to operate independently in constrained environments. Topics are selected from the four sub-areas of perception, localization, cognition, and motion control.

XXXXX Senior Design I
The first half of a two-term sequence dealing with the solution of a real-world design problem. Students work in teams to design, analyze, construct and test a working prototype of the solution to a specified problem. Students have an opportunity to participate in a creative and realistic design effort requiring written, oral, and visual communication skills, as well as teamwork and planning. Meeting customer needs is of prime importance. The preparation and presentation of design proposals are central to the course.

XXXXX Senior Design II
The second half of the two-term sequence that begins with Senior Design I. This course must be taken in the same academic year as Senior Design I. The fabrication and testing of a working prototype is emphasized. The methods for the presentation of results and alternative solutions are central to the sequence.
Appendix B: Sample Syllabi for New/Revised courses

ENGR XXXX Mechanics of Robots
Instructor: Jonathan Weaver, Mechanical Engineering Department

COURSE DESCRIPTION: Credit 3. The modeling and analysis of robotic systems. Key topics include spatial description and transformations, forward and inverse kinematics, Jacobians, dynamics, and an introduction to machine vision and task planning. Some lab work with a small robot.

PREREQUISITES: Lower level engineering classes. Prior knowledge of Matlab helpful but not required.

PREREQUISITES BY TOPIC: Trigonometry and Linear Algebra, Partial Differentiation, Statics, Dynamics, Structured Programming.

REQUIRED TEXT: Required: Introduction to Robotics, 3ED, by John J. Craig, Published by Addison-Wesley, 2005.

SOFTWARE: Students without easy and frequent access to Matlab in the UDM PC labs are strongly encouraged to purchase the Matlab Student Edition.

OTHER EQUIPMENT: Tinkertoys (available at most stores with a toy department) are suggested as a visualization aid.

INSTRUCTOR INFO: Jonathan Weaver, Room E214. Telephone: 313.993.3372
E-mail: weaverjm@udmercy.edu.

OFFICE HOURS:

COURSE OBJECTIVES: The goal of this course is to provide engineers with important background knowledge for anyone who will be involved with robotics. Students completing the course will understand and be capable of applying science and engineering to the sub-discipline of mechanical manipulation.

COURSE OUTCOMES: After taking this course, students will be able to:

1. Mathematically model the position and orientation of a solid in space.
2. Develop workspace models for robots of various configurations.
3. Develop forward and inverse kinematics models of various planar and spatial robots.
4. Develop animations in Matlab which illustrate many key principles of robotics.
5. Compute the joint torques required to achieve a prescribed motion for robot.
6. Model the relationship between joint motion and spatial motion of a robot using the Jacobian.
7. Explain basics of machine vision and its role in robotic applications.
8. Choose an appropriate robot configuration for a specific task.
9. Program a small robot program to execute a specific task.

**COMPUTER USAGE:** Extensive Matlab use is required. Usage will include matrix algebra functions, symbolic math, and graphics/animations.

**COURSE WEBSITE:** Blackboard will be used for posting of assignments and for Q&A (via the discussion board). Students must be in frequent contact with their email and the course webpage for important course information.

**TOPICS:** It is planned to cover most material in the first 9 Chapters of Craig with supplemental material and examples/case studies introduced as appropriate. Chapters 10 through 13 will not be covered rigorously although some important material therein will be presented. Key topics will include:

1. Background material and notation
2. Mathematics of position and orientation
3. Forward kinematics
4. Inverse kinematics
5. Dynamics
6. Trajectory planning
7. Mechanical design issues
8. Intro to motion control
10. Overview of task planning
11. Robot programming (laboratory based)
12. Animation (In-class demos and assignments)

**GRADING:**

<table>
<thead>
<tr>
<th>Homework</th>
<th>60%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quizzes (lowest of first 4 dropped)</td>
<td>40%</td>
</tr>
</tbody>
</table>

**GRADING SCALE:**

| Grade: | A | A- | B+ | B | B- | C+ | C | C- | D | F |
OTHER POLICIES:

1. Homework is due at the BEGINNING of the lecture on the assigned due date. Homework will NOT be accepted at the END of the lecture since much of the early part of the lecture may be spent discussing the homework. Thus, if you come to class late, your best bet to get some credit on the homework is to drop it off as you enter class rather than holding it until the end.

2. While consulting fellow students to UNDERSTAND the material is encouraged, each individual or team homework MUST represent work done INDEPENDENTLY. If it is clear this rule has been violated all parties involved will receive a zero for the grade in question.

3. Quizzes will be about 30 minutes long. All quizzes will be open book and open notes. Calculators will be required for the quizzes (computers may not be used). Quizzes will generally NOT be comprehensive (except to the extent that the subject matter itself is comprehensive). The knowledge to do well on the quizzes should be gained by successfully completing and understanding the homework assignments. Sharing of notes, books, or calculators during a quiz is PROHIBITED.

4. The lowest quiz grade will be dropped. There will be NO makeup quizzes. If you must miss one, that will be the grade which is dropped. NO EXCEPTIONS! If class is canceled for any reason on a scheduled quiz date then the quiz will occur the next class meeting. The privilege to drop the low quiz score is in effect an attendance bonus for those attending all five quizzes.

5. Requests for re-grades on homework, quizzes, or exams must be submitted IN WRITING within one week of my return of the item on which you question the grade. In this event, the ENTIRE quiz/exam/homework will be re-graded with possible adjustment in either direction.

ACADEMIC INTEGRITY: Everything submitted for grading is expected to be a student’s own work (or the work solely of the students on the team for assignments which allow team submission). Anything suspected otherwise will be dealt with according to the College policy - see the Engineering & Science Student Handbook.
ENGR XXXX: Mobile Robotics

Catalog course description:

Autonomous Mobility Robotics is concerned with the theory and applications associated with the development of mobile robots that possess sensors and local intelligence sufficient to operate independently in constrained environments. Topics are selected from the four sub-areas of perception, localization, cognition, and motion control.

Pre-requisites by topic:

Engineering programming, calculus and differential equations, probability, linear algebra/matrix algebra.


Reference material:


Other reference material including research literature will be identified as the course evolves.

Instructor: Dr. Mohan Krishnan
Office: Room E328
Contact info: 313-993-3367, mohank@udmercy.edu
Office hours: As posted outside office. Other hours by appointment.
Lecture hours:

Course web site:

A web site for the course is available at http://knowledge.udmercy.edu/. Through this site you can participate in discussions, access announcements pertaining to the course such as hints on homework assignments, last minute information on quizzes and tests, etc. It is very important for you to periodically access and check the web site for new information, as often this might be the only way in which such information is disseminated! Make sure that your correct email address is listed on the site so that I am able to communicate with you in a timely manner; this is your responsibility!
Course objectives:

To provide an introduction to the fundamentals of autonomous mobile robots, through broad coverage of its component areas of mechanical construction and motion, perception, localization and cognition.

Course outcomes:

Upon completion of the course, the student should be able to:

a) Analyze the motion of a mobile robot as it relates to its mechanical configuration.
b) Process the raw sensory data from a sensor and demonstrate the ability to extract higher-level information from it through appropriate processing.
c) Demonstrate the ability to determine where a robot is positioned in the environment within which it is moving.
d) Demonstrate the ability to map an unknown environment.
e) Apply a cognitive algorithm based on available sensor information pertaining to some aspect of a robot’s operation.
f) Demonstrate a self-learning ability by practical implementation of a concept pertaining to autonomous mobile robots in the term project.
g) Use the Player-Stage simulation environment to implement and validate algorithms pertaining to robot operation.

Course topics:

Introduction to Autonomous Mobile Robots (Chapter 1)

Robot programming in the Player-Stage environment

Locomotion (Chapter 2)

Mobile Robot Kinematics (Chapter 3)

Perception (Chapter 4)

Mobile Robot Localization & Mapping (Chapter 5)

Planning and Navigation (Chapter 6)

Note: The above listing provides a roadmap of course topics and their associations with chapters in the textbook. It should be noted, however, that autonomous robotics is a very broad and constantly evolving area; the coverage in class will, consequently, be representative without being exhaustive.

Computer usage:
Extensive use of MATLAB® will be required in simulating and/or implementing robot algorithms in the homework assignments and term project. Often it will need to be used in conjunction with Player-Stage, an open-source "robot operating system" that includes a simulator for robot motion within an artificially created environment.

Grading policy:

Tests - 25%
Quizzes - 10%
Homework (including computer assignments) - 30%
Term project - 35% (with the following breakdown)
  Proposal - 8%
  Report - 17%
  Presentation - 10%

The tentative grading scale for the course is as follows:

<table>
<thead>
<tr>
<th>%</th>
<th>95-100%</th>
<th>90-95%</th>
<th>85-90%</th>
<th>80-85%</th>
<th>75-80%</th>
<th>70-75%</th>
<th>65-70%</th>
<th>60-65%</th>
<th>55-60%</th>
<th>50-55%</th>
<th>0-50%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade</td>
<td>A</td>
<td>A-</td>
<td>B+</td>
<td>B</td>
<td>B-</td>
<td>C+</td>
<td>C</td>
<td>C-</td>
<td>D+</td>
<td>D</td>
<td>F</td>
</tr>
</tbody>
</table>

Other policy issues:

1. Normally no make-up tests will be conducted. Exceptions will only be made under compelling circumstances. Students must check with the instructor before absenting themselves from the scheduled grading components of the course. Even if a make-up test is granted, it will be of a greater level of difficulty than the regularly scheduled exam.
2. It is expected that work submitted by students in quizzes, assignments, projects, etc., is a product of the student's own efforts (or that of the student team in the case of a design project). Cheating on tests, homework assignments, or design projects will not be tolerated and will result in a grade of zero for that particular exercise for all parties involved, as well as additional penalties as prescribed in the Student Handbook of Policies and Procedures for the College of E & S. Please also note the policy forbidding plagiarism in the compilation of your reports. This issue will be discussed further in class.
3. Class attendance is considered to be a very important component to achieve success in this course. Unexplained absences will be interpreted as a lack of interest and effort!

1/6/11
ENGR XXXX Senior Design I

TERM II

COURSE DESCRIPTION: The first half of a two-term sequence dealing with the solution of a real-world design problem. Students work in teams to design, analyze, construct and test a working prototype of the solution to a specified problem. Students have an opportunity to participate in a creative and realistic design effort requiring written, oral, and visual communication skills, as well as teamwork and planning. Meeting customer needs is of prime importance. The preparation and presentation of design proposals are central to the course.

PREREQUISITES: Students should have taken all junior level classes in the program flowchart

PREREQUISITES BY TOPIC: Design of electrical and mechanical components

REQUIRED TEXT: NONE

GOALS AND OBJECTIVES:
Upon the successful completion of this course, students will be able to:
1. Recognize societal or business needs and properly formulate the corresponding problem. (Outcome e and j)
2. Conduct literature, patent and standards search to establish the state of the art of a design problem. (Outcomes j and k)
3. Carry out and apply the design process beginning from a recognized need and ending in a final and complete design. (Outcomes a, c, e and k)
4. Separate complex systems into major components and then apply the design process and mathematical modeling on each subsystem. (Outcome c)
5. Use state of the art computer software to conduct virtual prototyping. (Outcome k)
6. Work in diverse teams consisting of students, faculty and industry sponsors. (Outcome g, d)
7. Professionally communicate and present ideas, concepts and design details. (Outcome g)

INSTRUCTOR: TBD
OFFICE HOURS: After lecture, or email, or by appointment.

LECTURE:

DESIGN PROJECTS: Students will work in groups to solve problems. Students will be given problem scenarios which simulate real-world situations. Team members will be expected to respond with professional-quality drawings and documents. Teams will be assigned by the instructor.

FORMATS:
Memo – A memo-style cover page with heading, foreword and summary, followed by pages of detail. All assignments must have a cover memo.
Report – Complete multi-page document including cover page, executive summary, table of contents, body text, references, bibliography, appendices.
**Presentation** – PowerPoint style visuals presented in an orderly format which includes an introduction, problem/solution summary, relevant details, conclusions and recommendations.

**GRADING:**
Description Weight Adjusted April 13
Attendance ...................................... 5% 5%
Assignments .................................... 30% 30%
Presentation: Project Proposal ............. 10% 10%
Informal Present. / Design Rev (Concept) 5% 10% (1st best of 3)
Informal Present. / Design Rev (Final)..... 5% 10% (2nd best of 3)
Presentation: Final ........................... 10% Moved to ME495
Report: Progress ............................ 10% Combined with Final
Report: Final .................................. 15% 25%
Perform. Evals; Peers + Instructor......... 5% + 5% 5% + 5%
Late submissions will be penalized 10% per 24 hours past due.

**GRADING SCALE:** A 95-100, A- 90-94, B+ 85-89, B 80-84, B- 75-79,
C+ 70-74, C 65-69, C- 60-64, D+ 55-59, D 50-54, F <54

**HOMEWORK POLICY:** No homework problems.

**ATTENDANCE POLICY:** Lecture attendance is mandatory and will be noted by the instructor. Students are responsible for ALL material covered in lectures and on the syllabus, even if there is not enough time to cover it in lecture. Active participation in team projects is mandatory and peer evaluations will be conducted. Poor attendees and poor team performers will be penalized up to a full letter grade. Attendance at presentations is mandatory. Missing a presentation, without prior arrangement with the instructor, will likely result in a zero for that work. Depending on the significance of the presentation, this may result in a failing class grade. You may be required to makeup the work, but for zero credit.

**CONTESTED GRADE POLICY:** If you are not satisfied with your grade on an assignment, you can request a review. All requests must be made via memorandum from you, explaining why you think your work merits a different grade; and this must be submitted within one week of receipt of the grade. Keep in mind: a) re-grade implies re-grading the entire assignment; thus the revised grade could be lower than the original grade, and b) if you request a re-grade based on a fellow student’s grade, you must have the fellow student’s permission to reference their work, and the re-grade request could result in a lower grade for your fellow student.

**DISCIPLINE POLICY:** It is expected that you complete all work on time according to the syllabus schedule. If you miss a deadline, your work will be penalized 10% per 24 hours. With prior notification, legitimate excuses are accepted, and arrangements will be made to complete the work late. You must discuss your options with the instructor before the assignment is due. You may be asked to furnish a written note to explain and verify the circumstances surrounding the excuse. Any situation resulting in a protracted absence or seriously jeopardizing your ability to complete course work will be referred to your Advisor for consideration.
ACADEMIC INTEGRITY: Everything submitted for grading is expected to be a student’s own work. Anything suspected otherwise will be dealt with according to the College policy - see the Engineering Science Student Handbook. You are required to properly attribute credit for all work, and avoid taking credit for the work of others.

The following list provides some guidance:
• No individual or team may take credit for a portion of a report that was done by someone else.
• All co-authors’ names must appear on all copies of a team report or homework. If a student's name appears on a team report, this means that student has fairly contributed to it.
• If you allow a teammate's name to appear on a team report to which he or she has not fairly contributed, then you have breached the integrity policy.
• Individuals and teams may enlist the aid of another person to proof-read assignments for grammar, spelling, or punctuation.
• No individual or team may use information from any source, whether published or not, unless that source is credited.

TOPICS COVERED:
• Fundamentals of the Engineering Design Process
  a. The Design Process and the Engineering Team
  b. Teamwork
  c. Writing Technical reports
• Needs Assessment and the Search for a Solution
  a. Establishing Needs and the Design Proposal
  b. Formulating the Problem Statement
  c. Strategic Search for Solutions
• Evaluation of Alternatives
  a. Rank Order Options
  b. Economic Analysis
  c. Decision Analysis
• Abstraction, Modeling and Synthesis
  a. Model Formats and Types
  b. System and Process Models
  c. Combination of Alternatives
• Legal and Ethical Issues
  a. Product Liability
  b. Ethical Considerations
  c. Intellectual Property
  d. Hazard and Failure Avoidance
ENGR XXXX  Senior design II  
TERM III

COURSE DESCRIPTION: The second half of the two-term sequence that begins with Senior Design I. This course must be taken in the same academic year as Senior Design I. The fabrication and testing of a working prototype is emphasized. The methods for the presentation of results and alternative solutions are central to the sequence.

PREREQUISITES: Senior Design I

REQUIRED TEXT: None

INSTRUCTOR: TBD

OFFICE HOURS: TBD

LECTURE: TBD

COURSE OBJECTIVES: To develop the ability to carry out the design process starting from an initial design concept, through a complete design package, including assembly. The course culminates with a fully functional, working, verified prototype.

COURSE OUTCOMES: After taking this course, students will be able to:
1. Recognize societal or business needs and properly formulate the corresponding problem. (Outcome e and j)
2. Conduct literature, patent and standards search to establish the state of the art of a design problem. (Outcomes j and k)
3. Carry out and apply the design process beginning from a recognized need and ending in a final and complete design. (Outcomes a, c, e and k)
4. Separate complex systems into major components and then apply the design process and mathematical modeling on each subsystem. (Outcome c)
5. Use contemporary computer software to conduct virtual prototyping (Outcome k)
6. Feel comfortable working in diverse teams consisting of students, faculty and industry sponsors. (Outcome g, d)
7. Professionally communicate and present ideas, concepts and design details. (Outcome g)

COMPUTER USAGE: Catia, MATLAB/SIMULINK, Word, Excel and Powerpoint.

DELIVERABLES: Deliverables are highly dependent on the nature and scope of the project. Each team will propose a set of deliverables by each team member, and will be expected to gain instructor buy-in. Each person is responsible to accept a fair share of the work load. The grade weighting will depend on the project’s goals. Deliverable content and grade weighting may vary significantly from individual to individual. For example; one team member may have significant documentation and data responsibilities, while another person may have heavy fabrication duties.
**GRADING**: Description (+) Weight (-) (2 letter grades)
Peer Evaluation 10% 20%
Attendance 10% 20%
Final Report: 20% 20%
Final Presentation: 10% 20%
Deliverables
Instructor: 20% 20%
(example: quality of device, represent UDM proudly)
Client: 15% 20%
(example: meets QFD high priorities, customer satisfied)
Sponsor: 10% 20%
(example: value added to organization, reasonable budget)
Shop Tech.: 5% 20%
(example: follow safety and housekeeping rules)
The measure of success:
(1) All participants are happy about participating in the project.
(2) The product lives up to customer expectations.

**EXAMS and HOMEWORK**: No Exams No Homework

**GRADING SCALE**: A 95-100, A- 90-94, B+ 85-89, B 80-84, B- 75-79,
C+ 70-74, C 65-69, C- 60-64, D+ 55-59, D 50-54

**ATTENDANCE**:  
Lectures: Many team discussions will take place immediately after lectures; therefore attendance at lecture sessions is mandatory and will be noted by the instructor.
Team Meetings: Off-hours team meetings are crucial to successful projects. Attendance at team meeting will be evaluated on peer review forms.
Design Reviews: Your colleagues depend on your feedback and suggestions at design reviews. All team members are expected at design reviews, unless advance notice is given to the instructor. At least two team members must attend any given design review. Very poor attendees could be penalized up to two full letter grades.

**DISCIPLINE POLICY**: NO INCOMPLETES
It is expected that you complete all work on time according to the agreed deliverable schedule. Missing a deliverable date, without prior arrangement with the instructor, will likely result in a zero for that work. Depending on the significance of the work, this may result in a failing class grade. In some cases, you may be required to makeup the work, but for zero credit. With prior notification, legitimate excuses may be accepted, and arrangements made to complete the work. You must discuss options with the instructor before the assigned date. You may be asked to furnish a written note to verify the circumstances. Any situation that results in protracted absence, or that seriously jeopardizes your ability to complete the work, will be referred to your Advisor for consideration.
### Appendix C: Mechatronics Programs

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<tr>
<th>Mechatronics Program</th>
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<tr>
<td>Ingeniería Mecatrónica</td>
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</table>

**Appendix D: Library Report**
February 3, 2011

Dr. Shuvra Das
Associate Dean for Research and Outreach
College of Engineering and Science
University of Detroit Mercy
4001 W. McNichols Rd.
Detroit MI 48221

Dr. Das,

A review of the book and journal holding in robotics engineering has been completed by George Libbey, Associate Dean for Public Services and Cindy Gillham, librarian consultant assigned to the College of Engineering and Science.

There are sufficient print and electronic books to support the proposed robotics degree program. Although there appears to be sufficient full-text electronic and print journals to support this program there is a hole in the collections with the absence of the IEEE journals noted as not available below.

There are approximately sixty (60) print book titles that are strictly from the engineering standpoint of robotics with a third of them published in the last ten years. In addition, there are thirty (30) titles on pattern recognition and another twenty-one (21) titles on kinematics of machinery, with some overlap. There are one hundred nineteen (119) electronic robotics books with the search restricted to robotics and engineering in the contracted ebrary service provided by the university libraries. When searching robotics as a broader subject there are approximately four hundred (400) electronic titles.

The Libraries subscribe to the following full-text electronic journals which would support the robotics engineering degree program:
- AAMAS: Autonomous Agents and Multiagent Systems (ACM Digital Library)
- ACM Transactions on Autonomous and Adaptive Systems (ACM Digital Library)
- AGENTS: International Conference on Autonomous Agents (ACM Digital Library)
- Automatica (ScienceDirect)
- Computer Integrated Manufacturing Systems (ScienceDirect)

http://research.udmercy.edu
• Computer Methods in Applied Mechanics and Engineering (ScienceDirect)
• Computers and Electrical Engineering (ScienceDirect)
• Computers and Industrial Engineering (ScienceDirect)
• DAC: Annual ACM IEEE Design Automation Conference (ACM Digital Library)
• IEEE/ACM transactions on computational biology and bioinformatics (ACM digital Library)
• IEEE/ACM transactions on networking (ACM Digital Library)
• IEEE International Symposium on Mixed and Augmented Reality (ACM digital Library)
• Journal of Manufacturing Systems (ScienceDirect)
• Mechanism and Machine Theory (ScienceDirect)
• Mechatronics (ScienceDirect)
• Pattern Recognition (ScienceDirect)
• RKRAS: Research in Knowledge Representation for Autonomous Systems (ACM)
• Robotics and Autonomous Systems (ScienceDirect)
• Robotics and Computer Integrated Manufacturing (ScienceDirect)
• VIS: IEEE Visualization (ACM Digital Library)

It is acknowledged that library personnel did not search each of these journals for the specific number of robotics engineering articles.

In addition, the current print subscriptions for the following journals are maintained:
• IEEE Control Systems
• IEEE Signal Processing Magazine
• IEEE Transactions on Circuits and Systems
• IEEE Transactions on Computer Aided Design of Integrated Circuits & Systems
• IEEE Transactions on Neural Networks
• IEEE Transactions on Signal Processing
• IEEE Transactions on Vehicular Technology

There are a number of journals which the libraries do not subscribe to and funds are not available in the budget to support. These include:
• Autonomous Robots (Springer) $1268
• IEEE/ASME Transactions on Mechatronics $850
• IEEE Robotics and Automation Magazine $385
• IEEE Transactions on Pattern Analysis and Machine Intelligence $2130
• IEEE Transactions on Robotics $990
• IEEE Transactions on Systems, Man and Cybernetics, Part B $575
• International Journal of Computer Vision (Springer) no price available
• International Journal of Robotics and Automation $350
• International Journal of Robots Research (Sage) $1829
• Journal of Dynamic Systems, Measurement, and Control (ASME Digital Library) no price available
• Journal of Mechanical Design (ASME Digital Library) no price available
• Journal of Field Robots (Wiley) $3551
• Robotica (Cambridge) no price available

The libraries maintain over 400 interlibrary loan agreements in Michigan and the United States and through membership in OCLC has access to resources in over 43,000 libraries worldwide. If the UDM libraries do not own or provide electronic access to a specific resource every effort is made to obtain the requested materials from another library.

Should you need any further information, please do not hesitate to ask.

Sincerely,

[Signature]

Margaret E. Auer, Dean
University Libraries/Instructional Design Studio
Appendix E Comments from External Reviewers

(a)

Dear Dr. Das,

I am sorry for the late reply. This proposal looks fantastic. It is very thorough and comprehensive. I must commend you for this excellent job you have done in putting this proposal together in a very thorough manner.

Good luck with the launch of this program and do not hesitate to let me know should you need any further input from me.

Best,
Pinhas

Prof. Pinhas Ben-Tzvi, Ph.D.
Assistant Professor, Department of Mechanical & Aerospace Engineering
Director, Robotics and Mechatronics Laboratory
The George Washington University
Academic Center, Suite 731
801 22ND Street NW, Washington, DC 20052
Tel: (202) 994-6149; Fax: (202) 994-0238
Email: bentzvi@gwu.edu
Web: www.seas.gwu.edu/~bentzvi

(b)

Hello Dr. Das,

You have done a wonderful job with the proposal. Wish you the best with your efforts and looking forward to having one more voice promoting Mechatronic Engineering.

Hopefully, Mechatronic Engineering will be accepted, one day in the US, as a discipline unto itself as it should be. Maybe then, ABET will create a Mechatronic Engineering category. It could be a decade from now, but I know your program will help create the critical mass needed for Mechatronic Engineering to be considered a discipline. Elsewhere in the world it is a discipline and continues to grow.

You have made a beautiful case for the program in the proposal. Thank you for sharing it.
All the best to you and best regards,

Ramesh Varahamurti

Ramesh Varahamurti  Ph.D.
Prof. of Mechanical Engineering
Program Coordinator of Mechatronic Engineering
CSU-Chico
CA. 95929-0789
530.898.6353

(c)

Shuvra -
Now that I've had the opportunity to review the proposal, I must say you've done a very thorough job. I'd support such a program! I have a few questions, however. Take your time getting back to me, no rush at all. Good luck!
- Mike

Major Comments
Needs an Executive Summary of 1-2 pages.

The proposal states repeatedly that "The program is interdisciplinary, mainly drawing from the domains of mechanical, electrical and computer engineering, and software engineering" [emphasis mine]. Yet there appears to be no involvement by faculty in the Mathematics, Computer Science & Software Engineering Department. Why not? This is a potentially fatal shortcoming.

Response: The faculty in the software engineering program are not currently involved in any of these activities. However, two new faculty members have been hired in this program within the last few months and we will encourage them to get involved.

One of the program objectives is to "Develop an entrepreneurial mind-set to problem solving." However, there are no outcomes, activities, nor assessment instruments to support this objective. Without these, the objective is meaningless.

Response: Outcomes and assessment vehicles have been added to address this issue.

If you and the Administration are serious about the program, you should plan to hire full-time faculty to support it. Reasons: 1) You will need them as the program grows; your current faculty is not sufficiently involved in robotics to cover the field, 2) This is your one and only chance to get administration commitment for new faculty — don't pass it up!, 3) Adjuncts, no matter how well-intentioned, cannot replace full-time faculty,
especially for senior design courses, 4) ABET will expect new faculty for a new program that attracts additional students, 5) The budget can easily support it – you project 64 students each year and I expect you will see more than this, 6) Could recruit top-notch faculty from, e.g., U. Michigan.

Response: The reality right now does not allow for this. However, if projected growth is seen in the program we will certainly lobby for new faculty.

Identify the program coordinator in the proposal. It must be a tenured faculty member with sufficient experience and power to get things done. If I were an Administrator, I would insist on this.

Response: We found no reason to delay the proposal in order to do this. There are several tenured faculty involved in this effort, many of whom have had experiences in being chairs of departments. So there is not much concern regarding this comment.

Moderate Comments
Did you consider another program title other than "Robotics and Mechatronic Systems Engineering"? It doesn't exactly roll off one's tongue and students are apt to shorten it "Robotics" or "Remsee" anyway. Table 3 suggests that "robotics" is more important than "mechatronics" as a keyword.

Response: This is a good point and we will continue to have discussions around it. However, by naming this program either “Robotics” or “Mechatronics” we might end up losing a sub-group of the audience. Hence the compromise title.

Because the word "Systems" appears in the program name, I would like to know if there anything that makes this program more systems-focused than the ME or EE programs?

Response: All our programs focus quite a bit on systems rather than components. Employers of our students acknowledge this as well. So this new program will continue to be in the same tradition.

Is CSC 171 Introduction to Software Engineering and CSC 172 Introduction to Software Engineering II enough CS? Given the importance of Software Engineering as expressed in the specific objective "Develop a strong understanding of the fundamentals of ... software engineering", should the program require CSC 315 Software Engineering? I am concerned that without at least CSC 315, students will not be competent to write professional-grade software and will not be able to get co-ops that involve software development.

Response: Good point. But there is plenty of software development experience in the courses that are included in the plan so we will not try to fit in another course that we do
According to the course flowchart, the first course that is specifically robotics & mechatronics is Mechanics of Robots in Junior Summer, followed by Mobile Robotics and Mechatronic Modeling and Simulation in Senior Winter. That raises 2 questions: Is this too late to keep students interested in R&MSE? Will they have enough background when they start the senior design?

Response: We will discuss this among the team and make a decision regarding this point. It is too early to comment on what that decision could be.

Introduction to Mechanics of Robots lists machine vision in the course description and as a course outcome. However, I have doubts about the extent to which vision can be covered at all in the course; it is not listed among the course topics and I do not know if the text covers it at all.

Response: We will review this comment and address it when the final syllabus is prepared.

What does the Admissions Office think of the program – do they believe that students will come? Of course they will, but it strengthens your proposal to have the Director of Admissions say so. Much better to have "Attracting significant amount of market share will not be very difficult." come from them than from you.

Response: Due to the success of the IGVC team the University community knows about our work in the Robotics area and the Admissions team feel that this will be a good program to recruit for.

Table 2 – Enrollment data is badly out of date. Get new numbers. WPI’s program had 229 majors in Jan 2011.

Response: Data is not publicly available, but comments have been added to reflect known information about current enrollment numbers.

The Advisory Council must have at least 1 member from the Big 3 auto companies (Big 2.5?), 1 from a major robotics manufacturer (ABB/ Fanuc / Kuka), and 1 from TARDEC or other government lab or agency. In general, the proposal fails to take advantage of these major potential employers / industry partners. Asking them for input on the proposal is an excellent way to strengthen your relationships with them.

Response: We are working on this.

All Advisory Council members should have their titles listed so that one knows approximately how significant these players are. It makes a big difference whether you have an engineer or a VP on board.
Response: Taken care of.

Should have a table relating Program Outcomes to Objectives. You will need this for ABET eventually.

Response: Assessment Table has been included.

It appears that Mechanics of Robots is a lab course whereas Mobile Robotics has no lab component. Is this correct? Although I would prefer that both courses have labs, it is OK if the 2nd one does not; however, it should be clear that this is the case.

Response: The courses are currently listed as lecture courses but could contain a lab component in the form of a series of hands-on activities or a single end-of-term hands-on project.

You will need some support personnel, even if it is only 0.5 or 0.25 FTE secretarial support. Include it.

Response: Not possible at this moment until the enrollment numbers go up.

I am skeptical about the claim that no new labs will be needed. If the program is a success, you may well have to add more lab capacity, even if that is accomplished through re-allocating current lab resources. However, the fact that the new Intro to Robotics courses are based on existing courses somewhat alleviates this concern.

Response: A laboratory equipment plan is included.

You will need more than $2K / year for lab costs. Trust me; I've been there, done that! The senior design courses alone will require more than $125 / student for supplies.

Response: Laboratory numbers have been modified.

Is the adjunct cost correct? Is their compensation $4,000 / course plus $500 benefits? Seems a bit low on both.. Won't matter if you replace them with a FT faculty member.

Response: That is our current rate.

Advisory Council membership list appears twice. What is its real function? Having the Council approve curricular decisions is not necessarily the best use of our time. We should be more strategic. How often does the Council meet?

Response: Removed one table.

Any thoughts on a potential graduate program?
Response: We do have graduate concentrations in this area.

Minor Comments

Greg Fischer is at wpi.edu, not wpi.com

Response: Corrected.

--
Prof. Michael A. Gennert
Computer Science Department
Electrical & Computer Engineering Department
Director, Robotics Engineering Program

Worcester Polytechnic Institute
100 Institute Road
Worcester, MA 01609-2280
Work: 508-831-5476
Fax: 508-831-5776
Email: michaelg@wpi.edu@michaelg@cs.wpi.edu>
URL: http://www.cs.wpi.edu/~michaelg/

Shuvra Das
It generally looks good. Somewhere along the line they should receive some systems work. Robotics is the understanding and solution of a problem using disparate subsystems and technologies. Maybe that is included in the intro to robotics?

All the best

Arnis Mangolds
C-2I, Inc.
978-298-5365
978-257-4820 (cell)
amangolds@c-2iinc.com
www.c-2iinc.com

Appendix F Letters of Support
Dear Dr. Pimmel:

As President of the Automation Technologies Council, an umbrella trade group representing nearly 600 companies involved in robotics, motion control, and machine vision, I was delighted to learn of the new undergraduate major in mechatronics/robotics planned by the University of Detroit Mercy.

Mechantronics and robotics are critical technologies to the success of our nation in the 21st century. One of the areas holding back their rapid application in industry is the lack of qualified engineers who understand all of the disciplines necessary to successfully apply these technologies in real-world environments.

The UDM proposal addresses this major need by incorporating synergistic mechatronic design activities, hands-on laboratory exercises, inter-disciplinary teamwork and communications skills, and formal instruction in the innovation and entrepreneurship.

To teach this modern curriculum, the instructors plan to use modern teaching techniques. One such technique that caught our attention, and that we will be happy to assist with, is the incorporation of innovation case studies. We also stand ready to assist with other elements of the program such as helping students secure co-op placements and serving as industrial advisors to this curriculum. We believe that this program can play a vitally important role for the industries we represent.

It’s also interesting to note that UDM plans workshops for faculty from other Universities so that they can learn from UDM experiences and get inspired to start similar programs at their own university. This is a great idea that we fully support.

Our staff, and the companies who are members of our association, look forward to working with the UDM team as they educate the next generation of engineers.

Sincerely,
Jeffrey A. Burnstein
President
Dr. Shuvra Das  
Professor of Mechanical Engineering  
University of Detroit Mercy  
4001 W. McNichols Road  
Detroit MI 48221

January 10, 2011

Subject: Letter of support for Mechatronics program development proposal.

Dear Professor Das,

It is my pleasure to provide a letter of support for your effort to expand the opportunity for Mechatronics education for you students at University of Detroit Mercy. It is my understanding that you are planning to start an undergraduate program in Robotics and Mechatronic Systems Engineering and you are seeking NSF funding for part of this development effort. I also understand that you have planned a set of workshops for faculty from other Universities so that they can learn from your experiences and get inspired to start similar programs at their own places. As the developer of the first Mechatronics Engineering program in the US, I am truly excited that you are planning to start this program and conduct workshops.

As I mentioned to you in our conversation, our program at California State University at Chico is ABET accredited and is more than fifteen years old. The demand for our program has always been very strong and we are currently considering expanding it by adding more seats. Our industrial partners are also very satisfied with the unique multi-disciplinary skills that our Mechatronics Engineering graduates bring to the workplace. The industrial partners show their support by coming back every year to hire new graduates.

I would be most happy to serve as an advisor to your program and would like to invite you to come and visit us so that you can learn more about our program and learn from our experiences. I look forward to our partnership and wish you success.

Sincerely,

Rama Varahamurti, Ph.D.  
Professor of Mechanical Engineering,  
Mechatronic Engineering Program Coordinator,  
California State University, Chico,  
Chico, CA 95929-0789  
rvarahamurti@csuchico.edu

The California State University
January 12, 2011

National Science Foundation
4201 Wilson Boulevard
Arlington, Virginia 22230

To: The National Science Foundation

Pratt & Miller Engineering is a technology focused business providing engineering services within the automotive, defense and motorsports industries. Within those industries, we see a large need for the integrated knowledge base of both mechanical and electrical engineering disciplines. Although we have a small staff with these very skills, presently, there are an insufficient number of engineers in the job market with both mechanical and electrical engineering skills/competencies. Mechatronics is emerging as an independent discipline that combines mechanical and electrical engineering and addresses a key skill requirement within the automotive and defense industries.

In the automotive and defense industries, mechatronics principles have found their way into a variety of products ranging from engine and powertrain control, anti-lock braking, drive-by-wire technology, intelligent navigating systems, mems sensors and actuators, manufacturing automation and many others. As part of the current push to improve fuel efficiency and design hybrid vehicles, mechatronic design concepts and their use in new product development have become even more important.

While the field of Mechatronics has grown rapidly, engineers experienced in this field are still very hard to find. Engineers from the more traditional fields of Electrical or Mechanical Engineering usually have a difficult time in adapting to this new mode of thinking in a multi-disciplinary world. As a growing employer of UDM's graduates and CO-OP students, we have been pleased to see the curriculum that UDM has developed with previous NSF support. Nonetheless, we have a difficult time in identifying enough candidates from all university sources who would be successful in the area of mechatronics mostly because there are so few of them out there.

We see a core competency in mechatronics as a vital requirement as we grow our engineering services business within the automotive and defense sectors. I was very pleased to learn that the UDM team developed a very successful set of mechatronics courses and were able to integrate mechatronics principles throughout the engineering curriculum quite well. The inter-disciplinary teamwork of their students in the context of a mechatronics product development is an extremely valuable training for the real world. We plan to offer job opportunities for interns, co-op's and graduate students within the mechatronics discipline.

Pratt & Miller Engineering can offer these candidates experience with world class motorsports programs competing on the professional global stage. Opportunities also exist to lead the development of cutting edge technologies that could drastically change the landscape of today's automotive and defense vehicle fleets. Improvements in safety can be made through many mechatronic developments such as smart armor on military vehicles or accident avoidance on passenger cars.
The UDM team led by Dr. Das has now developed a new proposal. This proposal addresses a major need in the area of mechatronics/robotics education: an undergraduate major in this vital area. Key features of this educational program will include synergistic mechatronic design activities, hands-on laboratory exercises, learning inter-disciplinary teamwork and communications skills in the context of this technical area, and formal instruction in the area innovation and entrepreneurship. UDM’s Engineering program had always been very successful at attracting minorities and women. We expect to see this good track record to continue with this new program as well.

To teach this modern curriculum, the instructors plan to use modern teaching techniques. One such technique that is worth mentioning is their plan to use innovation case studies as part of their instruction. I feel this will add great value to their courses. I am also pleased to see that the team includes an expert on assessment. We are also excited to learn about UDM’s planned workshops for faculty from other Universities. We feel the sharing of lessons learned from UDM’s experience could be significantly beneficial to other Universities with an ultimate goal of inspiring similar programs across the country.

I support this proposal wholeheartedly and Pratt & Miller Engineering looks forward to working with the UDM team to help bring best industrial practices into the classroom. I am also looking forward to their success in teaching these new concepts to the next generation of engineers. Their success will simply create engineers with capabilities that are critical to the success of Pratt & Miller and to the entire automobile and defense industries.

Sincerely,

Brandon Widmer
Business Development Manager
Pratt & Miller Engineering
Appendix G: Committee Approval

College of Engineering and Science

CES Curriculum and Standards Committee

To: Shuvra Das, Associate Dean of Research and Outreach
College of Engineering and Science

From: Liz Roberts-Kirchhoff, Chair
CES Curriculum and Standards Committee

Re: Proposal for the new program Bachelor of Robotics and Mechatronic Systems Engineering

Date: August 15, 2011

The CES Curriculum and Standards Committee met during August 2011 to discuss the Bachelor of Robotics and Mechatronic Systems Engineering proposal.

Committee members recommend the approval of the proposal, Bachelor of Robotics and Mechatronic Systems Engineering

If you have questions and/or need clarification, please do not hesitate to contact Liz Roberts-Kirchhoff, Chair (robkires@udmercy.edu)

cc: CES Curriculum and Standards Committee Members
Leo Hanifin, Dean College of Engineering and Science

Committee Members: Liz Roberts-Kirchhoff (CHM), Chair, Jonathan Weaver (ME) 4001 W. McNichols Road
Sandra Yost (ECE), Nart Shawash (MSE), Katy Snyder (Associate Dean) Detroit, Michigan
Alan Hoback (CAEE), 48221
Appendix H: Draft FIRST Scholarship Announcement

FIRST Scholarship

Scholarship Description

In support of the FIRST mission, University of Detroit Mercy is offering one, merit-based scholarship, of $5,000 per year, to entering freshmen who have participated on a FIRST team during their school career. This scholarship should be utilized for UDM’s Bachelor of Robotics and Mechatronics Systems Engineering Program. The scholarship is renewable up to a total of $20,000 over four years, contingent upon maintaining good academic standing. The recipient must meet the regular academic requirements for admission to the College. If accepted in the program all applicants will be considered for all the other scholarship opportunities at UDM. So, it is highly likely that all applicants will receive some level of scholarship from UDM if they are accepted in the program.

Eligibility

To be eligible for this scholarship, you must:

- Be a senior in high school
- Have participated on a FIRST Robotics Competition (FRC) team or a FIRST Tech Challenge (FTC) team.
- Apply and be admitted to University of Detroit Mercy’s Bachelor of Robotics and Mechatronics Systems Engineering program as a full time student. (However, you do not need to have already been admitted at the time you apply for this scholarship.)
- Have a minimum ACT of 24 and a GPA of at least 3.0 (on a scale of 4.0).
Scholarship Application Package Contents

To apply for the UDM FIRST Scholarship, complete the application package, including:

- A completed UDM FIRST Scholarship Application
- A 500 word essay regarding how your FIRST experience has affected your career goals
- A letter of recommendation from an adult mentor/coach on your FIRST team

Submission of Scholarship Application

The completed FIRST Scholarship application package must be submitted, no later than

March 1, to:

Ms. Tyra Rounds
Undergraduate Admissions Office
University of Detroit Mercy
4001 W. McNichols Road
Detroit, MI 48221
About University of Detroit Mercy

The University of Detroit Mercy (www.udmercy.edu), a Catholic university in the Jesuit and Mercy traditions, exists to provide excellent, student-centered, undergraduate and graduate education in an urban context. A UDM education seeks to integrate the intellectual, spiritual, ethical, and social development of our students. The University of Detroit Mercy has one goal – to help our students realize their dreams and ambitions. We fulfill that goal by offering challenging academic programs taught by talented, committed professors and supplemented by hands-on research, co-op, and internship opportunities. The University has seven units:

- School of Architecture
- College of Business Administration
- School of Dentistry
- College of Engineering and Science
- College of Health Professions
- School of Law
- College of Liberal Arts and Education

In 2011 we are celebrating 100 years of Engineering. The Engineering programs in the college (http://eng-sci.udmercy.edu/programs/eng/index.htm) include Mechanical, Civil and Environmental, Electrical and Computer, Architectural, and Robotics and Mechatronics Systems Engineering. Our average student to teacher ratio is 14:1 and we take pride in our ability to provide personal attention to our students. The engineering programs include a variety of design projects that teach students how to practice what they learn. The engineering program requires one full year of paid co-op in industry and is only one of two programs in Michigan that has this requirement and the only one where you can graduate in four years with one full year of co-op experience. We have a very attractive merit-based scholarship program and across the University about 85% of our students receive some sort of scholarship or financial aid. The average size of our scholarship is a little more than $11000.

Bachelor of Robotics and Mechatronic Systems Engineering is an undergraduate degree program that is focused on the fundamentals necessary for the design of "intelligent" systems and products in which mechanization and control requiring sensing, actuation, and computation are combined to achieve improved product quality and performance. Such intelligent systems include robots, as well as modern intelligent automobiles, airplanes, defense systems, assistive devices, and a wide variety of other systems, even those that are not as obvious, such as appliances and game and entertainment systems. The skills that students will acquire in this program will be valuable to employers from a variety of industrial sectors including aerospace, automotive, manufacturing, communications, defense, electronics, and healthcare.
University of Detroit Mercy

FIRST Scholarship Application

Personal Information

Name_______________________________________

Address_________________________________________________________________

City_____________________________________ State_________ Zip ______________

Country______________________________      US Citizen: □ Yes □ No

Telephone (____)_________________   E-mail _________________________________

FIRST Team Number______  FIRST Team Name _____________________________

FIRST Program: □ FRC  □ FTC       Year(s) of participation _____________

Intended College Major ____________________________________________________

UDM Admission Application (www.udmercy.edu/apply):

□ Has already been submitted       □ Will be submitted by March 1

Signature: ___________________________   Date: ______________
Additional Materials

Be sure to include the following materials in your application package:

- A 500 word essay regarding how your FIRST experience has affected your career goals
- A letter of recommendation from one of your FIRST adult mentors.

Application Submission

Your FIRST Scholarship Application and materials must be received by March 1.

Please send your application package to:

Ms. Tyra Rounds
Undergraduate Admissions Office
University of Detroit Mercy
4001 W. McNichols Road
Detroit, MI 48221

Questions? Call Tyra Rounds at 313-993-1046 or send email to roundstc@udmercy.edu.