Jordan University of Science and Technology

JUST

Faculty of Engineering

Mechanical Engineering Department

A Master's Program Proposal

In Mechanical Engineering / Mechatronics

Jordan Univesrsity of Science and Technology
Faculty of Graduate Studies

Course Curriculum for Master Degree in

Mechatronics Engineering

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SECTION 1. OBJECTIVES, CURRICULUM DESIGN, AND OUTCOMES

1.1 Objectives

The primary objectives of the program are:

1. To provide industry with highly trained engineers having interdisciplinary skills necessary to deal with state of the art tools in design, development and advancing of modern engineering systems.

2. To develop graduates confident in addressing open-ended problems and who possess an attitude of self-learning.

3. To develop appropriate skills of modeling and simulation of modern integrated engineering products, thus enabling participants to carry out the design and development of 'smart' products.

4. To apply the latest techniques in precision mechanical engineering, control theory, computer science and engineering, and electronics to the design process to create more functional, adaptable, and cost effective products

5. To insure that all students are familiar with advanced systems elements and able to apply mechatronics principles in their own disciplines and in the broad context of engineering system design.

1.2 Design of the Curriculum

The curriculum design includes an integrated system of research, development, and training in the fields of advanced online monitoring, industrial automation, manufacturing techniques, and mechatronics systems in modern state-of-the-art vehicles, electro-hydraulic and pneumatic control systems, and precision electro-mechanical devices.

Distinctive features of the program are:

- A program curriculum that places great emphasis on recognition of engineering as an integrative process in which analysis and synthesis are supported with sensitivity to social needs and environmental fragility.
- Courses that train graduate students to master the critical thinking that underlies problem definition (modeling, simulation, experimentation, optimization) and derives from an in-depth understanding of the physical, life, and mathematical sciences, as well as the humanities and social sciences where addressed.
- Education experiences in which engineers learn the creation and elegant implementation of useful systems and products, including their design and manufacture.
- A program designed to graduate individuals able to understand and contribute to the economic, industrial, and international environment in which engineering is practiced.

- A focus on the working partnership between academe and practice. It responds to the growing needs for integration and interdisciplinary education. It is committed to the idea of offering individuals the opportunity of acquiring the necessary skills to face the challenges of modernization consequently, the graduates of the mechatronics program will be leading in technology transfer and industry modernization.

Hence, graduates are prepared to be better decision makers and team leaders of multidisciplinary engineering systems. This is in concurrence with the University mission to enable students to comprehend the dynamism and complexity of contemporary global processes and to empower them to guide these processes in constructive directions.

1.3 Expected Student Outcomes

Graduates of the MS in Mechatronics Engineering program will have the following abilities:

1. **Integrated systems:** Work with, and develop, integrated systems through all stages. This includes design, operation, fault diagnosis and troubleshooting.

2. **Leadership:** Lead industry modernization and automation effort; make decisions when selecting, procure and commission advanced engineering systems; lead and manage their multidisciplinary technical teams.

3. **Innovation:** Develop competitive and innovative technical solutions to complex engineering problems while driving innovations into the resulting product.

4. **Broad-based**: Adapt research and development to achieve optimal technical solutions, and take into account socioeconomic, environmental, and innovative technology.

SECTION 2. PROGRAM EVALUATION AND ASSESSMENT

2.1 Evaluation Procedures and Assessment Strategies

Evaluation will be conducted for the following program elements:

- **Curriculum:** How the curriculum accomplishes the program objectives?
- **Students:** How the student demonstrates course outcomes. Performance in class projects and open-ended engineering problems? How student performs on a multidisciplinary team. Are they learning to be innovative and creative?
- **Faculty**: How are the faculty interacting, motivating and challenging students to be more creative? Are students involved in research activities?

- **Resources:** How are resources serving program needs? Are they being developed to enhance program elements?

To assess these outcomes, evaluation tools other than regular course work assessment have been developed. These tools are managed, developed, and transformed into corrective measures for all the elements of the program from goals and objectives to individual course introduction, restructuring, or elimination.

The assessment tools are as follows:

- Academic oriented tools for online tuning of the program (affecting individual courses)

    1. Course portfolios and student's feedback
    2. Projects, presentations
    3. Comprehensive exams (course option) and thesis defense (thesis option)

- Industry feedback regarding a graduate's performance (affecting short term program goals and objectives)

    1. Industry questionnaires
    2. Graduate's promotion
    3. Leadership of graduates in their workplace
    4. Activities of graduates in local, regional, and international professional societies
    5. Attracting industry projects and funds
    6. Alumni feedback
    7. Professional societies feedback
    8. Local workshops and seminars

- Program response emerging and projected trends in science and technology (affecting long term and short term program goals and objectives)

    1. Faculty participation in major professional meetings
    2. Graduates participation in major professional meetings
    3. Publication in refereed journals and major conferences
    4. Admission to PhD programs in high quality research institutions
    5. Partnership with world class institutions in the field

SECTION 3. MECHATRONICS ENGINEERING PROGRAM COURSES

3.1 Course titles and classification

3.2 Catalog description of courses

The Master Degree in Mechatronics Engineering is awarded by the Faculty of Graduate Studies at Jordan University of Science and Technology (JUST) upon the fulfillment of the following requirements:

1) Compliance with the J.U.S.T. Master Degree regulations approved by the Dean Council (No. 25/2017), dated 19/6/2017.
2) Successful completion of (34) credit hours in one of the following tracks:

First: Thesis Track

1. Compulsory Requirements: (16) credit hours as follows:

Course Symbol and Number	Course Name	Credit
ME 701	Advanced Applied Mathematics	3
ME 770	Embedded Systems for Mechatronics	3
ME 771	Advanced Control Systems	3
ME 773	Modeling and Simulation of Dynamics Systems	3
ME 781	Artificial Intelligent Systems	3
ME 790	Seminar	1
	Total	**16**

2. Elective Requirements: (9) credit hours from the following*:

Course Symbol and Number	Course Name	Credit
ME 715	Advanced Vibration	3
ME 774	Programming Tools and Methods for Mechatronics Engineers	3
ME 775	Power Electronics and Electrical Drives	3
ME 776	Electro-Pneumatic and Hydraulic Systems	3
ME 777	Advanced Industrial Instrumentation and Control	3
ME 778	Sensors and Actuators	3
ME 779	Real-Time Systems	3
ME 780	Automated Manufacturing Systems	3
ME 783	Distributed Control Systems	3
ME 784	Introduction to Robotics	3
ME 785	Micromechantronic Systems and Applications	3
ME 786A	Special Topics in Mechatronics System Applications A	3
ME 786B	Special Topics in Mechatronics System Applications B	3
ME 787	Introduction to Computer Networking	3
ME 789	Advanced Robotics Control	3
ME 762	Project Management	3
ME 792	Intelligent Control Systems	3
ME 793	Mechatronics System Design-I	3
ME 794	Mechatronics System Design-II	3
ME 795	Mobile Robots	3
ME 796	Machine vision	3

* The student may study not more than 6 credit hours from courses of 700 or 800 level offered by other programs related to his field of study upon approval of the Dean of Graduate Studies based on the recommendation of the departmental graduate studies committee.

3. Master Thesis: total of 9 credit hours as follows:

Course No.	Course Title	Credit hrs.
ME799 A	Master Thesis	9
ME799 B	Master Thesis	6
ME799 C	Master Thesis	3
ME799 D	Master Thesis	0

Second: Comprehensive Exam Track

1. Compulsory Requirements: (25) credit hours as follows:

Course Symbol and Number	Course Name	Credit
ME 701	Advanced Applied Mathematics	3
ME 770	Embedded Systems for Mechatronics	3
ME 771	Advanced Control Systems	3
ME 773	Modeling and Simulation of Dynamics Systems	3
ME 774	Programming Tools and Methods for Mechatronics Engineers	3
ME 778	Sensors and Actuators	3
ME 781	Artificial Intelligent Systems	3
ME 784	Introduction to Robotics	3
ME 790	Seminar	1
	Total	**25**

2. Elective Requirements: (9) credit hours from the following*:

Course Symbol and Number	Course Name	Credit
ME 715	Advanced Vibration	3
ME 775	Power Electronics and Electrical Drives	3
ME 776	Electro-Pneumatic and Hydraulic Systems	3
ME 777	Advanced Industrial Instrumentation and Control	3
ME 779	Real-Time Systems	3
ME 780	Automated Manufacturing Systems	3
ME 783	Distributed Control Systems	3
ME 785	Micro-mechatronics Systems and Applications	3
ME 786A	Special Topics in Mechatronics System Applications A	3
ME 786B	Special Topics in Mechatronics System Applications B	3
ME 787	Introduction to Computer Networking	3
ME 789	Advanced Robotics Control	3
ME 762	Project Management	3
ME 792	Intelligent Control Systems	3
ME 793	Mechatronics System Design-I	3
ME 794	Mechatronics System Design-II	3
ME 795	Mobile Robots	3
ME 796	Machine vision	3

*The student may study not more than 6 credit hours from courses of 700 or 800 level offered by other programs related to his field of study upon approval of the Dean of Graduate Studies based on the recommendation of the departmental graduate studies committee.

3. Must pass the comprehensive Exam ME 798 (0.0 cr.)

Catalog Description of Courses

ME 701: Advanced Applied Mathematics
Integral Transforms, Fourier Transforms, Legendre Transforms, two-sided Laplace transforms, special functions (Gamma, Beta, and Bessel functions), Legendre polynomials, and error function. Partial differential equations (different methods of solution). Linear algebra. Applications in Mechanical Engineering.

ME 715: Advanced Vibration
Elements of analytical dynamics: Principle of Virtual work, Hamilton's principle and Lagrange's Equation. Forced damped vibration of multi degree of freedom systems. Exact and approximate vibration solutions of continuous systems. Finite Element Method in vibration. Introduction to Experimental Modal Analysis. Machine vibration measurements and analysis for machine fault diagnoses.

ME 762 Project Management
This course focuses on the management and reporting activities of typical engineering development projects. Through seminars and workshops it builds the student's skills at estimating project cost and schedule, keeping a project on track, and handing over the completed project to a customer or another team. A writing workshop emphasizes techniques for writing proposals, and writing and controlling documentation.

ME 770 Embedded Systems for Mechatronics
Microprocessor hardware and software modules. Microcontrollers hardware and software architectures, microcontrollers programming and interface with real-time mechatronics systems. Designing stand-alone embedded systems for mechatronics products. Case studies and course projects

ME 771 Advanced Control Systems
Analog controller design methods: lead and lag compensators, pole placement, model matching, two-parameter configuration, introduction to state-space control system, state estimator and state feedback, canonical realizations, stability, controllability and observability, minimal realizations, introduction to optimal control, linear quadratic regulator, introduction to robustness, introduction to digital control system, and intelligent control.

ME 773 Modeling and Simulation of Dynamics Systems
Introduction to multi-domain systems. Mechanical, thermal, fluid, electrical, electronic, electromechanical system dynamics, emphasis on modeling and simulation of hybrid systems using modern computer-aided tools.

ME 774 Programming Tools and Methods for Mechatronics Engineers
Review of the practical aspects of software development: basics in procedural language scripting language and object-oriented language, shell programming for mechatronics, implementation, control version systems, usability testing, documentation, bug report and code maintenance.

ME 775 Power Electronics and Electrical Drives
Energy conversion and electric power conditioning. AC-DC and DC-AC converters for electrical drives, analysis of electrical drives. Dynamic models of DC and AC machines. Control principles of variable speed and servo drives. Scalar control of DC-servo motors. Scalar and vector control principles of AC-Motors. Practical control examples.

ME 776 Electro-Pneumatic and Hydraulic Systems
Fluids and fluid flows in high-performance actuators and controllers. Power flow and fluid power elements, valve and pump control, linear and rotary motion. State space descriptions. Design of electrohydraulic position and velocity control servomechanisms for high performance with stability.

ME 777 Advanced Industrial Instrumentation and Control
Field instrumentation. Cabling and rounding. Data acquisition, signal processing and transmission. Smart sensors and sensor diffusion. SCADA systems. Computer based control. Direct digital control. Supervisory control. Programmable logic controllers and industrial controllers. Introduction to distributed control systems.

ME 778 Sensors and Actuators
This course introduces sensors and actuators used in electromechanical, computer-controlled machines and devices. Topics operating principles, design considerations, and applications of analog sensors, digital transducers, stepper motors, continuous-drive actuators, and drive system electronics. Component integration and design considerations are studied through examples selected from applications of machine tools, mechatronics, precision machines, robotics, aerospace systems, and ground and underwater vehicles.

ME 779 Real Time Systems
Basic concepts in real-time systems, real-time, hardware and process interfacing, real-time computer control systems, real-time kernels and programming languages, structured design of real-time systems, modeling real-time systems, synchronous programming languages, scheduling in real-time systems, keeping time and clock synchronization.

ME 780 Automated Manufacturing Systems
Description and demonstration of automated machine tools and machining cells. Machining canter configuration and operation, machine tool controller, machining code generation, in-process sensing and control, cell controllers, and system simulation.

ME 781 Artificial Intelligent Systems
Biological and cognitive paradigms, concepts of machine intelligence, intelligent agents, vision and image analysis, principles of decision-making, fuzzy logic, decision trees, case-based reasoning, genetic algorithms, neural networks, expert systems. .

ME 783 Distributed Control Systems
Distributed computer systems architecture. System elements. Data communications links. Software algorithms. Reliability. Applications.

ME 784 Introduction to Robotics
Types of industrial robots and their applications. Mathematical analysis for robot manipulation: Homogeneous transformations; definition and solution of kinematics equations governing the position and orientation of the hand. Force analysis and static accuracy; forces and moments of inertia, dynamic equation of equilibrium, and differential equations of motion of robotic arms. Introduction to mobile robots.

ME 785 Micro-mechatronics Systems and Applications
Introduction to Micro-mechatronics systems and devices: microfabrication techniques; lithography and etching; anisotropic etching. Sensors and actuators, variable capacitance motors, material considerations, mechanical property characterization, measurements, application to examples in biomedical, industrial and space technology areas.

ME 786 Special Topics in Mechatronics Systems Applications
Selected topics that meet student interest and reflect recent trends in the field of mechatronics.

ME 787 Introduction to Computer Networking
Connection of multiple systems in a networked environment OSI model, switching techniques, error handing, multiple access protocols, communication protocols, LAN'S WAN'S, SAN'S, TCP/IP, web-based programming and applications**.**

ME 789 Advanced Robotics Control
The course represents advanced approaches to modeling, control and applications of robot manipulators. Topics include kinematics modeling of manipulators using the theory of screw and screw operators; methods for obtaining dynamic model of manipulators; control of manipulators based on independent joint and multivariable control approaches, control of the contact forces between a manipulator and its environment; and adaptive control of manipulators. The course also discusses modeling and control of grasping/manipulation using dexterous end-effectors

ME 790 Seminar
Seminar on project planning development and realization, case studies of engineering systems design and realization, current research topics in mechatronics engineering including areas such signal processing, image processing, control, robotics, intelligent systems, computer vision, MEMS, Etc.

ME 792 Intelligent Control Systems
Introduction to intelligent control methods and their application to the monitoring and control of uncertain, complex dynamical systems. Neural control systems, fuzzy control systems, fault diagnosis.

ME 793 Mechatronics System Design-I
Introduction and team projects involving the development and integration of hardware and software into a "smart" system, which includes the sensing, processing, and controlling functions.

ME 794 Mechatronics System Design-II
(Long term project, could be a continuation of ME 793)**:** The MS project is an extended project of interdisciplinary nature. Elements of computing, mechanics, and electronics should be involved.

ME 795 Mobile Robotics
An introduction to mobile robot essentials covering the following topics: mobile robot types, categories, platforms, locomotion mechanisms, kinematics, modeling, autonomous systems sensing / perception, motion and feedback control, path planning and navigation.

ME 796 Machine Vision
Machine Vision introduces the process of generating a symbolic description of an environment from an image. Lectures describe the physics of image formation, motion vision, and recovering shapes from shading. Binary image processing and filtering are presented as preprocessing steps. Further topics include photogrammetry, object representation alignment; Applications to robotics and intelligent machine interaction are discussed.

ME 799 Research Thesis
The thesis is an individual and original work by the student that is completed over a period of two semesters.