Regulations for the
M.Eng. in Mechatronics Engineering
Master's Program in the Department of Computing and Software at McMaster University

September, 2009

1 Master of Engineering (M.Eng.) in Mechatronics Engineering

This program is intended for those interested in a career as a practicing professional in Mechatronics Engineering. Students must:

1. Successfully complete six half (one-term) graduate courses.
2. Complete an independent Mechatronics design project, including professional oral and written reports, demonstrating the ability perform independent study, apply the material studied and reach a satisfactory conclusion in an area of Mechatronics Engineering.

1.1 Admission Policy and Standards

Students can be admitted to the M.Eng. program in Mechatronics Engineering if they have a recognized Bachelor's degree in Mechatronics Engineering, Mechanical Engineering, or Electrical/Computer Engineering. Students with a degree in another field and substantial background in Software, Mechanical, Electrical or Computer Engineering may also be considered. Admissions are on a competitive basis.

1. The admission requirements are as given in the General Regulations of the Graduate School.

2. The Admission's committee may restrict a student's course choices in order to ensure appropriate depth and breadth in Mechatronics Engineering.

3. Students should have completed the following courses:

    - *Basic Mathematics*
        - Three courses in calculus
            * Calculus 1
            * Calculus 2
            * Calculus 3
        - One course in scientific computation
        - One course in linear algebra
        - One course in discrete mathematics and predicate logic
    - *Basic Mechatronics Engineering*
        - Basic Electronics
        - Basic Mechanics
        - Basic Software
        - Basic Control Systems

1.2 Advanced Credit Option

Students in McMaster's Mechatronics Engineering undergraduate program may apply for the Advanced Credit Option. To take the Advanced Credit Option, a student must have an average of at least B− in the third year of study and are invited to apply by the department after a review. Students taking the Advanced Credit Option are allowed to take two 600 level courses while in level 4. These are core 400 level courses in the Mechatronics Engineering program with an additional graduate component. A student may be admitted to the advanced credit option of the M. Eng. program in Mechatronics Engineering after completing level 4 and

- Completing the advanced credit courses with a minimum of B− for each.

- Having a minimum of B− sessional average in level 4 of their undergraduate program.

1.3 Funding Models

Funding is normally the responsibility of the candidate. Funds may be available in the form of teaching assistantships, entrance scholarships and funding to support the Mechatronics design project (see Section 1.6). Students may also enter the program on a part-time basis. In most instances, part-time students will have external employment while participating in the program.

1.4 Supervisor

All students will have a supervisor in CAS to guide them through the program. The supervisor will be assigned in the offer of admission and in particular serves as the project supervisor (see Section 1.6).

1.5 Course Requirements

All students in the Mechatronics Engineering M. Eng. program must complete six half (one-term) graduate courses. Students must complete:

1. SFWR ENG 6GA3 and MECH ENG 6K03
2. Two 700 level courses taken from the list of approved courses for the M.Eng. in Mechatronics Engineering published by the Department of Computing and Software. These courses focus on Mechatronics Engineering.
3. At least two additional 700 level courses.

The two 600 level courses may be taken as an Advanced Credit in the last year of undergraduate studies.

1.6 The Project

The project provides an opportunity for students to demonstrate that they can apply what has been learned in the program.

1. This project should produce a Mechatronics product to be utilized by users other than the developer.
2. Projects will be specified by the supervisor in CAS, possibly in collaboration with industry.

3. The duration of a project is typically four months. A project could be completed at a company, but it must be conducted under the supervision of a faculty member who can supervise students within the program.
4. An Examination Committee is formed, consisting of the supervisor(s) and at least one faculty member in CAS. The student and the supervisor(s) nominate the Examination Committee. The committee is appointed by the Chair or delegate.
5. Students must submit the project, including all documentation, to the Examination Committee for evaluation.
6. The project will be judged on more than its functionality.
7. The documentation must include an "executive level" description of the product and its structure.
8. The Examination Committee decides on the outcome: pass or fail. If the decision is fail, comments must be provided to aid in a revision. The decision must be made within three weeks of receipt of the project.
9. If the initial decision was fail, the student may resubmit the project after addressing the committee's concerns. If the subsequent decision is fail, the student is dismissed from the program.

1.7 Program Timing

1. All courses should be completed within 16 months of entry into the program.
2. The software development project should be completed within 20 months of entry into the program.

M.Eng. Mechatronics
Course List

Core Courses:

***6GA3 / Real-Time Systems and Computer Game Applications / Staff**

Hard and soft real-time systems. Safety classification. Fail-safe design, hazard analysis. Discrete event systems. Modes. Requirements and design specifications. Tasks and scheduling. Clock synchronization. Date acquisition. Applications in real-time networking, quality of service and multimedia.

***704 / Embedded, Real-Time Software Systems / Staff**

Continuous and discrete event dynamical systems. Stability, controllability and observability. State space control. Scheduling for soft and hard real-time software systems. Design of software real time control systems and codesign issues.

***6K03 / Introduction to Robotic Mechanics / G.M. Bone**

This course considers spatial descriptions and transformations, manipulator kinematics, inverse kinematics, Jacobians, and dynamics.

Elective Courses:

COM SFWR

***701 / Logic and Discrete Mathematics in Software Engineering / Staff**

Mathematical objects and logical concepts used in Software Engineering. Higher-order logic. Partial functions and undefined terms. Practical application of the axiomatic method. Recursive definition and inductive proof. Survey of common mathematical structures and axiomatic theories used in Software Engineering. Effective use of mechanized mathematics systems.

***702 / Data Structures and Algorithms / Staff**
(Same as Computational Engineering & Science *782)

The course will cover some basic material encountered at the relevant undergraduate courses on data structures and algorithms plus more advanced material on topics such as network flows, linear programming, computational geometry and NP-completeness. There will be emphasis on techniques such as greedy and dynamic programming.

***703 / Software Design / Staff**

Formal specification methods. Requirements specifications. Fail-safe systems. Verification of safety critical applications. Systematic testing. Specification and design of concurrent, multi-process and distributed systems.

***708 / Scientific Computation / Staff**

Floating-point arithmetic, solutions of systems of linear equations by direct and iterative methods, sparse matrix algorithms, solving systems of nonlinear equations, integration, differentiation, eigenvalue problems, methods for initial value problems in ordinary differential equations, and automatic differentiation.

***723 / Distributed Real-Time Systems / W.F.S. Poehlman**
A study of hard and soft systems: specifications, event processing, data concurrency, distribution completeness, corrections, integrity fallback, fault tolerance and applications; timing analysis: synchronization, deadlock, modeling.

***724 / Concurrency Theory / R. Janicki**
Models based on interleaving and partial order paradigms including the Calculus of Communicating Systems (CCS), Communicating Sequential Processes (CSP), Actors, Petri Nets, Pomsets and COSY. Basic properties of concurrent systems such as deadlock, liveness, safety, fairness, etc. Temporal Logic techniques. The growing role of concurrent systems in many diverse scientific and engineering activities will also be discussed.

***725 / Formal Methods of Real-Time Systems / M. Lawford**
Introduction to formal methods including equivalence verification, model-checking and theorem proving. Emphasis on verification of safety-critical real-time control systems using automated theorem provers and simple programming techniques.

***730 / Machine Learning and Related AI Topics / I. Bruha**
A broad study of major approaches and methodologies related to machine learning from the viewpoint of artificial intelligence. Symbolic algorithms of learning. Statistical algorithms of learning. Well-known existing learning systems. Data mining and knowledge discovery.

***736 / Analysis of Stochastic Networks / D. Down**
Techniques for the analysis of large networks that can be modeled in a statistical manner. Single queues, product form networks and mean value analysis. Fluid and diffusion approximations. Simulation techniques, including variance reduction. Hybrid simulation. Current research directions in Stochastic networks.

***740 / Numerical Methods for Ordinary Differential Equations and Differential-Algebraic Equations / N. Nedialkov**
(Same as Computational Engineering & Science *740)

Numerical methods for ODEs and DAEs; Runge-Kutta, multistep methods; convergence, accuracy, consistency; error estimation and propagation, stepsize and order control; stability, non-stiff and stiff methods; software for ODEs and DAEs.

***745 / Supervisory Control of Discrete-Event Systems / R. Leduc**

This course is an introduction to the control of discrete-event systems (DES), asynchronous systems discrete in space and time (e.g. manufacturing systems, communication systems, etc.). The course will provide a solid foundation for research in this area, focusing on architectural issues such as modular, decentralized, and hierarchical control. The course will also discuss timed DES, as well as current topics of interest.

***748 / Analysis and Synthesis of Sound / M. V. Mohrenschildt**

Sound as signals (Fourier Analysis, basic harmony theory), Sound analysis (filters, FFT), Synthesis (band limited signals), over-sampling, real-time signal processing, user interfaces (real time interaction with algorithms), vocoders, physical modelling (fast DSP algorithms to solve PDE's).

***750 / Model-Based Image Reconstruction / C. Anand**
(Same as Computational Engineering & Science *750)

An overview of three themes in advanced image processing: functional analysis (e.g., Fourier, Wavelet and SVD methods), PDEs (e.g., anisotropic diffusion), optimization of statistical models (e.g. Total Variation regularization). And, a detailed look at specific methods and techniques for applying these methods in new areas: medical imaging, visual process control. Including all phases of application development from mathematical modelling, through complexity analysis.

***753 / Specifying, Implementing and Verifying Timing Behaviours for Hard Real-Time Systems / A. Wassyng**

Hard-real-time systems are those in which timing requirements are just as important as any other requirement. The course will present a number of timing specification models and methods, such as timed automata, as well as new methods that cope with tolerances on the time durations. Techniques for implementing timing behaviours and verification of those behaviours, both mathematical and testing-based, will be included.

MECH ENG

***702 / Advanced Dynamics of Machines I / M.A. Dokainish**

The study of structural damping; shock loading response spectra; random vibration; self-induced vibration; nonlinear systems; introduction to elastic wave theory; dynamic criteria of failure; and Hamilton's principle and Lagrange's equations.

***728 / Manufacturing Processes I / P. Koshy**

Fundamentals of metal cutting: cutting process, cutting forces and temperatures, tool wear, machinability of materials, machined surface quality and integrity, optimization of cutting conditions. Applications to single edge and multiple edge operations and grinding.

***729 / Manufacturing Systems / T. Nye**

This course studies the organization and control of manufacturing systems. Types of production systems, the role of inventory, capacity and production control planning, scheduling, push-, CONWIP- and JIT-systems. Use of analytic, heuristic and numerical analysis and design methods.

***736 / Special Topics in Mechanics / Staff**

***750 / Computer Integrated Manufacturing / Staff**

Computer integrated manufacturing. Flexible manufacture. Retrieval and generative process planning. Design for manufacturability, assembly and inspection. Simulation of manufacturing systems. Manual, automated and robotic assembly. Integrating sensors in manufacturing.

***751 / Advanced Mechanical Engineering Control Systems / G.M. Bone**

Design of digital control systems with emphasis on mechanical engineering applications, sampling characteristics, z transforms and z transfer functions. Root Locus in the z plane, frequency response, transient response. State space analysis, Eigen values, Eigen vectors, controllability, observability (SISO). State space design, pole assignment, state feedback, output feedback, modal control. Introduction to adaptive control, self-tuning regulations, model reference adaptive systems.

***757 / Simulation of Manufacturing Systems / T.J. Nye**

Introduction to discrete event simulation as applied to the design and analysis of manufacturing systems. Modeling of manufacturing systems, simulation software, data collection and input analysis, random number generation, validation, output analysis for single and multiple systems, variance reduction techniques and experimental design. Students will apply these skills to a major project, where they will define the problem, develop and validate a conceptual and computer model, perform an analysis, and make managerial recommendations.

ELEC ENG

*726 / Local Area Networks in a Manufacturing Environment / B. Szabados

Overview of user constraints for LAN in manufacturing environment. Overview of existing protocols leads into MAP and TOP standards emerging as the leading protocols. Study of MAP 2.1 and 3.0 with emphasis on physical layer and link layer structures, based on ISO 802.4 token passing bus protocol. Top 1.0 for office protocol using ISO 802.3 CSMA protocol. Extension to fibre optic technology and emerging standard for active bus. Emphasis on design and criteria for implementation of these LAN's, including state of the art hardware technology.

*742 / Digital Integrated Circuits / T. Szymanski

Digital IC Design Flow, Deep Submicron Design Flow, VHDL hardware description language, synthesis of VHDL, CMOS logic, standard cell libraries, high speed clocking, verification, simulation, and testing, IC packaging, high speed I/O, ECL, LVDS, memory structures, Computer Aided Design algorithms.