MASTER OF ENGINEERING (MECHATRONICS AND AUTOMATIC CONTROL)

PROGRAMME SPECIFICATIONS

Mechatronics and Control Engineering is a multi-disciplinary subject, with applications across a wide range of industrial sectors. The M.Eng. (Mechatronics and Automatic Control) program aims to equip graduates, with both the theoretical and the practical skills necessary to apply modern control techniques to a wide range of industrial problems and/or embark on further research. This program covers all the major aspects of control theory and mechatronics including adaptive and robust control, artificial intelligence, process control, industrial instrumentation, robotics and control applications in mechatronic systems and its application to the design of control systems. Students will also acquire expertise in the use of computer packages for control design. Outstanding students on this program may continue with research leading to a Ph.D.

Option for double-degree: This program also offers option for double-degree mode with University of Burgundy (UoB), where upon completing an extra semester in UoB, students are eligible for conferment two Master degrees from UTM and UoB. This study option takes a minimum of 4 semesters to complete.

- Semesters 1 and 2 in UTM
- Semester 3 in UoB
- Semester 4 in either UTM or UoB

This study option would require students to apply for admission to UoB themselves. Students must complete the first two semesters of study in UTM, followed by one semester in UoB. The final semester can be done either in UTM of UoB.

Program Educational Objectives (PEO)

PEO1 Mastery of knowledge and competency in advanced areas of mechatronics and control engineering field.

PEO2 Professionalism and high standards of ethical conducts within organization and society.

PEO3 Responsive to changing situations by continuously acquiring new knowledge and skills.

Program Learning Outcomes (PLO)

PLO1 Attain advanced knowledge on theories, methods and applications related to mechatronics and control engineering field.

PLO2 Demonstrate mastery in conducting research independently in solving problems related to mechatronics and control engineering field through relevant analytical methods, simulations and/or experiments.

PLO3 Synthesize engineering knowledge through design and development.

PLO4 Plan and perform research undertakings responsibly, professionally and ethically.

PLO5 Communicate and express knowledge and ideas effectively.

PLO6 Continue life-long learning and apply technology for the betterment of humanity.

GRADUATION CHECKLIST

To graduate, students must pass all the stated courses in this checklist. It is the responsibility of the students to ensure that all courses are taken and passed. Students who do not complete any of the course are not allowed to graduate.

NO.	CODE	COURSE	CREDIT EARNED (JKD)	CREDIT COUNTED (JKK)	TICK (√) IF PASSED
MASTER OF ENGINEERING (MECHATRONICS AND AUTOMATIC CONTROL)					
FACULTY COMPULSORY-12 CREDITS (4 COURSES)					
1	MKEM 1753	Advanced Instrumentation & Measurement	3	3	
2	MKEM 1833	Linear System Theory	3	3	
3	MKEM 1853	Discrete-Time & Computer Controlled System	3	3	
4	MKEM 1863	Design of Microprocessor-Based Mechatronic Systems	3	3	
FACULTY ELECTIVES-12 CREDITS (4 COURSES)					
5	MKEM 1713	Artificial Intelligence	3	3	
6	MKEM 1723	Advanced Process Control	3	3	
7	MKEM 1733	Adaptive & Self Tuning Control	3	3	
8	MKEM 1743	Modeling & Simulation of Dynamical Sys.	3	3	
9	MKEM 1763	System Identification & Estimation	3	3	
10	MKEM 1773	Multivariable & Optimal Control Systems	3	3	
11	MKEM 1783	Nonlinear & Robust Control	3	3	

		Systems			
12	MKEM 1793	Industrial Automation	3	3	
13	MKEM 1823	Advanced Robotics	3	3	
14	MKEM 1843	Advanced Digital Control	3	3	
15	MKEM 1873	Real-Time Control System Design	3	3	
16	MKEM 1883	Autonomous Mobile Robotics	3	3	
17	MKEM 1913	Mechatronic Design	3	3	
18	MKEM 1923	Sensor and Actuator	3	3	
FREE ELECTIVES FROM MKEL/MKEM/MKEP/MKET-3 CREDITS (1 COURSE)					
19	MKEx 1xxx		3	3	
MASTER'S PROJECT-10 CREDITS (2 COURSES)					
20	MKEM 1814	Research Project Proposal	4	4	
21	MKEM 1826	Research Project Report	6	6	
TOTAL CREDIT OF ELECTRICAL ENGINEERING COURSES (a)			**37**	**37**	
SCHOOL/UNIVERSITY COMPULSORY- 6 CREDITS (2 COURSES)					
22	MKEU 0013	Introduction to Research Methodology in Electrical Engineering	3	3	
23	Uxxx xxx3	Non-technical subject	3	3	
TOTAL CREDIT OF SCHOOL/UNIVERSITY COMPULSORY COURSES (b)			6	6	
TOTAL CREDIT TO GRADUATE (a + b)			**43**	**43**	

COURSE SYNOPSIS

CORE COURSES

MKEM 1753 - Advanced Instrumentation & Measurement

This course is an introduction to the advanced instrumentation and measurement. The course covers the techniques for sensing technology, electronic interfacing and signal conditioning circuits. Also, applications at a higher hierarchical level are included, such as self-testing, auto calibration, data evaluation and identification. Key components studied in detail are a review of powerful measurement techniques and basic principles and typical problems of sensor elements, detailed up-to-date reviews of the features of temperature sensors, displacement sensors, flow sensors, level sensors, position sensors, motion sensors and biometrics. Special topic in Flow Measurement Techniques use Process Tomography applications.

MKEM 1833 - Linear System Theory

This course is an introduction to the linear system theory. It is intended to be a fundamental course in graduate studies in control engineering field. Since it is a vast field, the discussion will be limited to the conventional approaches of state-space equations and the polynomial fraction method of transfer matrices. By adapting this knowledge, students will able to 1) construct the optimized realizations, 2) develop the correct partitioned model, 3) design the state observer, and, 4) design the state feedback controller using pole-placement technique.

MKEM 1853 - Discrete-time Systems & Computer Control

This course is an introduction to the discrete-time and digital control systems. The course covers the conversion of analog signals and system into their discrete and digital counterparts. The emphasis will be on the theoretical basis as well as efficient implementations. Key components studied in detail are the sampling process and theorem, hold devices, the z-transforms and its applications, modelling of discrete-time systems using classical and modern approaches, time domain performance specifications for discrete-time system, practical realization of discrete-time and digital system transfer function in various form, and effects of quantization errors.

MKEM 1863 - Design of Microprocessor-Based Mechatronic Systems

This course covers the applications of microprocessor or microcontroller in mechatronics systems. Details of microcontroller architecture and its internal peripherals are covered. Design of interface to mechatronics system utilizing the internal peripherals and programming of their operations using C language are emphasized.

ELECTIVE COURSES

MKEM 1713 - Artificial Intelligence

This course offers insights to the students into understanding two techniques of artificial intelligence (AI), namely, fuzzy logic and neural networks. Both techniques have been successfully applied by many industries in consumer products and industrial systems. Fuzzy logic offers flexibility in developing rule-based systems using natural language type of rules. Neural networks on the other hand, have strong generalization and discriminant properties and offer a simple way of developing system models and function approximation. They are highly applicable for many pattern recognition applications. This course offers basic understanding of these two AI techniques and their applications in the real world. The course also includes hands-on experiments and programming of fuzzy logic and neural networks concepts.

MKEM 1723 - Advanced Process Control

The advanced process control course deals with the implementation of control strategies in industrial process control. The course begins with the modelling of dynamic process models using theoretical and empirical modelling principals. Next, the control system design is presented including the dynamic behavior and stability of closed loop control systems. Following that, the two standard control types of feedback and feed-forward are discussed and control tuning of its parameters will be studied. In enhancing performance of the system, advanced control techniques are utilized. At the end of the course, several case studies related to real plantwide control is introduced to reflect process control ideas commonly present in an actual process. By combining the knowledge obtained, students will be able to conceptually design various types of controller for single input single output and multivariable process systems.

MKEM 1733 - Adaptive & Self-Tuning Control

This course introduces the students to adaptive and self-tuning control. The students will firstly learn the real-time parameter estimation technique, which will provide them with the key concepts required to understand many aspects of adaptive and self-tuning control. The students will then be exposed to the main techniques in Self-Tuning Control (STC), in particular the Pole Assignment and Minimum Variance Control. For the adaptive control, the students will be exploring the Model Reference Adaptive Control (MRAC) design using Gradient Approach/MIT Rule and Lyapunov method. Finally, some practical issues on implementation, applications and perspectives of adaptive and self-tuning control will be discussed.

MKEM 1743 - Modelling and Simulation of Dynamical Systems
This course focuses on modelling and simulation of dynamic systems. The course covers techniques for modelling of various physical systems involving linear and nonlinear systems such as mechanical, electrical and mechatronic systems. Solution and analysis of control system response based on time and frequency responses will be taught. Numerical solution techniques of differential equations using Euler's method and Runge-Kutta are introduced. Finally, several aspects for the development of simulation models using MATLAB are discussed. Several case studies and an actual system will be used to enhance the student understanding.

MKEM 1763 - System Identification & Parameter Estimation
This course is an introduction to the system identification and parameter estimation. The course covers an introduction to system identification, acquiring and pre-processing data, nonparametric model estimation methods, parametric model estimation methods, partially known estimation methods, model estimation methods in closed loop systems, recursive model estimation methods, analyzing, validating, and converting models and system identification case study. This requires an in-depth understanding of control system engineering, modern control system and digital control system. The emphasis will be on the theoretical basis as well as practical implementations. Key components studied in detail are time response analysis, frequency response analysis, correlation analysis, power spectrum density analysis, model structure, parametric model, parameter estimation method, test signals and model validation methods.

MKEM 1773 - Multivariable & Optimal Control Systems
This course introduces the students to the concept of multivariable and optimal control systems. Topics include: stability, observability, controllability and effect of interaction on multivariable systems; Analysis on MIMO performance through loop pairing, controller tuning and decoupling for static and dynamic control system; Introduce an optimal controller design concept for finite and infinite linear quadratic regulator (LQR) and Linear Quadratic Tracking (LQT) systems; Continuous and discrete time optimal control systems and constrained and unconstrained optimal control systems. The assignment for the course will be based on computer-aided (MATLAB®) design problems.

MKEM 1783 - Nonlinear and Robust Control Systems

This course covers the analysis and design of nonlinear control systems using Lyapunov theory. The contents of the course include properties of solutions of nonlinear dynamical systems (with special emphasis on planar systems), Lyapunov stability analysis techniques, effects of perturbations, input-output stability, feedback linearization, controllability, observability, and nonlinear control design tools for stabilization.

MKEM 1793 - Industrial Automation

This course focusses on two main topics in industrial automation which are discrete event systems (DES) and industrial control networks (ICN). In the former topic, the students will be introduced to the characteristics of DES and how it differs from the classical systems. The students will also learn about timed and untimed models of DES. Finally, the queueing theory will be discussed as a method of analysis and performance evaluation. In the latter topic, the students will be introduced to the characteristics of ICN. The students will be exposed to the fieldbus protocol. Finally, the students will have an experience to design an ICN system using DeviceNet protocol.

MKEM 1823 - Advanced Robotics

This is a graduate level course on robotic systems. The course covers various advanced control techniques for controlling robot manipulator systems. This requires an in-depth understanding of stability analysis methods based on Lyapunov stability theory, mathematical modelling of complete robot manipulator dynamic model inclusive of actuators dynamics and various advanced control concepts developed for the control of robot manipulators. The emphasis will be on the theoretical basis as well as efficient implementations and design. Key components studied in detail are stability analysis method using Lyapunov second method for nonlinear systems, integrated robot modelling based on state-space method, various advanced controller design for robot manipulator control based on centralized and decentralized approaches.

MKEM 1843 - Advanced Digital Control

This is a level course on digital control systems. The course covers current techniques for analysing and designing digital controllers for discrete-time and digital control systems. This requires an in-depth understanding of digital stability analysis methods and currents topics on digital controller design. The emphasis will be on the theoretical basis as well as efficient implementations. Key components studied in detail are stability analysis method using classical and modern approaches for digital control systems, discrete-time and digital controller design using classical and state-space approaches, various advanced controller design for discrete-time and digital control system such as variable structure approach and adaptive model reference approaches.

MKEM 1873 - Real-Time Control System Design

This course covers the hardware and software aspects for real-time implementation of control system. Multi-tasking requirements and issues for real-time control are addressed. Case studies of different design and implementation techniques will be used to enhance students understanding of the course.

MKEM 1883 - Autonomous Mobile Robotics

This course gives the students an in-depth treatment of main aspects of autonomous mobile robotics namely mechanism & locomotion, intelligence in mobile robotics and sensor fusion for autonomous decision-making capability. The course delivery is not limited to lectures, tutorials only but as well personal reading, research-based assignments on frontier knowledge materials and actual Doctoral experimental research carried out in UTM's mobile robotics laboratory. This course blends knowledge derived in-house with actual physical world autonomous mobile robotics, hence providing the unique experiential learning geared towards carrying out research.

MKEM 1913 - Mechatronics Design

This course introduces mechatronics as an integrated design approach with the synergistic combination of mechanical, electronics, control and computer engineering. It provides insight into advantages and challenges of mechatronics design approach. The course introduces the various aspects in mechatronics design including physical system modelling, simulation, sensors and actuators selection, computer interfacing and real-time control implementation. This course tries to balance between theoretical and practical aspects, and hardware implementation is emphasized. Laboratory based case-study and problem-solving approach of real systems are used throughout the course.

MKEM 1923 - Sensor and Actuator

This course introduces the working principle of sensor and actuators and its application in mechatronics systems. This course covers the fundamental of sensors and actuators, the details of its functionality, the characteristic, the fabrication and materials used, numerical study and the system integration of sensors and actuators in mechatronics system. Various case studies are introduced and discussed during classes to help further understanding of the diversity of mechatronics system in multidisciplinary fields.