Course Synopsis - Bachelor of Mechatronics Engineering with Honours

Course Code	Course Title	Synopsis
MCTA 1231	Fundamentals of Fluid Mechanics	This course covers the fundamental study of the behaviour of fluids at rest and in motion i.e. the dynamics of fluid flow. The course also covers linear momentum equation, Bernoulli equation, energy equations as well as measurement of fluid flow. Students will learn about internal flow which deals with fluid flow in pipes, as well as external flow which covers drag, lift forces and lift coefficients. The principle of compressible fluid will be introduced which covers bulk modulus of fluid and Mach number. Students will also be exposed to applications of fluid mechanics in machineries like pumps and propellers.
MECH 1240	Thermal Science	This course composes of Thermodynamics and Heat Transfer. This course is designed to provide an understanding of thermodynamics and heat transfer's application in real life. It discusses the basic laws of thermodynamics (Zeroth Law, First Law, Second Law, and Third Law-Entropy), analyses of energy for both open and closed systems, and ideal power cycles. This course also illustrates the use of tables for the pure substances. For Heat Transfer, this course covers the basic concepts heat transfer mechanism such as heat conduction, force and natural convection, and thermal radiation.
MCTA 1101	Mechatronics Workshop	This course is designed to introduce students to the concept of Mechatronics systems. Students are exposed to hardware and software integration which enables them to have basic skills in handling mechatronics components and systems. This course covers: Use of microprocessors and microcontrollers in mechatronics systems; Skill development through the use of programming and circuit design software such as Matlab, Scilab, Phyton, Eagle, etc; Circuit development and fabrication; Practical exposure to mechatronics systems with various sensing and actuating elements; Integration of hardware and software to build simple mechatronics systems.
MCTA 2102	Mechatronics Systems Lab	This course covers experiments on the characteristics of ac and dc motors and generators, stepper motor, transformers; flow measurements of fluids, friction losses in pipes, heat pump performances, heat engine performances, heat transfer through different modes; and structural and kinematics data extraction from mechanisms within machine components and analysis of kinematics and kinetics data. Students in groups also design and build systems integrating electrical machines,

		mechanisms and thermofluid systems for analyses of performances of integrated systems.
MCTA 2231	System Dynamics	Modeling of elementary mechanical, electrical and thermal systems. Modeling of mixed systems using bond graph method. Time response of linear systems, computer simulation of dynamic systems.
MCTA 2311	Electrical Machines	The course teaches the basic principles of electrical machines, which include AC and DC motors, AC and DC generators and transformers. Additionally, specialized and emerging motors and introduction to industrial motor control are also included in the study. The fundamental physics underlying the working principle is given in addition to the modelling and characteristics of various types of AC and DC machines. Performance analysis of the machines is introduced in the course.
MCTA 2312	Digital Systems Design and Microprocessor	Introduction to digital design, number systems and codes, digital circuits, combinational logic design principles and practices, sequential logic design principles and practices. Overview of hardware and software aspects of microprocessors and microcontrollers. Introduction to practical applications of microcontrollers in variety of control systems design and interfacing, real industrial on board controller problems.
MCTA 2313	Power Electronics and Drives	Characteristics of power electronic devices, switching characteristics of devices, power losses and thermal design. Classes of power converters and their operations: rectifiers; AC-AC Converters; DC-DC Converters; Inverters. Voltage and current source converters. Advanced energy-efficient motor drives: review of motor theory, power electronic control principles, vector and servo drives (stepper, DC, induction, brushless PM and switched-reluctance).
MCTA 2314	Signal and System Analysis	Classification of signals and systems. System modeling concepts. Laplace transforms. Fourier series and Fourier transform. Discrete-time signals and systems. Analog filter design. Introduction to analog communication systems.
MCTA 2315	Instrumentation and Measurements	Measurements and error analysis. Analog and digital. ADC and DAC. AC and DC Meters. AC and DC bridge circuits. Oscilloscopes. Signal conditioning circuit and processing. Data acquisition system. Transducers. Sensors. Emerging Sesors.
MCTA 2332	Mechanisms and Machine Design	Kinematic and dynamic analysis of linkage mechanisms, Synthesis of the linkage mechanisms, Kinematic design of CAM, Gear, Gear train, Vibration analyses balancing of machines, flywheel design. Design against stress, deflection and fatigue by analytical and FEA method. Design of beam, column, shaft, spring, gear using analytical and FEA method.
MCTA 3104	Mechatronics Control and Automation Lab	Review of classical and industrial forward type control systems. Classical control method Continuous-time

		response and performance specifications with additional control using Industrial Revolution 4.0 components. PLC and pneumatic based control via Internet of Things (IoT) platform. Instrumentation. Projects based on problems drawn from Mechatronics and Manufacturing.
MCTA 3203	Mechatronics System Integration	Exposure to different level of mechatronics interfacing systems, their elements, standards and protocols; various sensing elements and actuating elements; exposure to motor, pneumatic and hydraulic systems; use of microprocessors, PLC and microcontrollers in mechatronics systems; skill development through use of various software; integration of IoT and mechatronics systems to build system at different level of complexity.
MCTA 3300	Integrated Design Project	Integrated Design Project (IDP) provides students with an understanding of the design process where it allows students to apply what they have learned toward the solution of a real-world problem, through a team-based project experience. Students apply their knowledge and skills to gain significant experience in developing, designing, analysing, prototyping, and verifying their design, together with a basic business plan. Each integrated design project is executed by a group of approximately five students. A faculty advisor is assigned to each design project to supervise and guide the project throughout its duration. The lecture component provides students with key concepts in the design process, specific knowledge and skills on design and project management whereas the laboratory component allows students to brainstorm, propose ideas, design, evaluate performance of the proposed design, and verify the attainment of design objectives.
MCTA 3331	Engineering Design and Reliability	Problem definition and need identification, concept generation, decision making and concept selection, embodiment design, detail design, design for sustainability and environment, design for manufacturing, safety issues. Types of failures, Failure analysis (FMEA). Stochastic process, Design for reliability, Dependability: Reliability of simple and complex systems. Fault tree analysis (FTA), Event tree analysis (ETA), Risk assessment and management (Procedure of risk assessment, Step-by step guide to Risk Management, Maintenance strategy, case studies), and Reliability Management (Standards for Reliability, Quality, Safety and ethical responsibilities).
MCTA 3332	Fundamentals of Robotics	Overview of robotics system and components. Robot kinematics analysis. Robot path and trajectory analysis. Robot dynamic analysis. Robotics control scheme. Autonomous mobile robot.
MCTA 3351	Control Systems 1	Mathematical modelling. Model representation using transfer function, block diagram and state space variable systems. SISO. MIMO. Simulation of dynamics systems. Controllability. Observability. Control System types and

		effects of feedback. System analysis: transient response, steady-state error, sensitivity and stability. Root-locus analysis and design. Frequency response analysis of linear systems. Bode diagrams. Control design techniques.
MCTA 3352	Industrial Automation	Overview of industrial automation, basic concepts and components. CNC machines and programming. Pneumatic logic and sequence control. Programmable logic controllers. Ladder diagrams. PLC addressing and instructions. Timers and counters. I/O modules and wiring, Automation systems installation, maintenance, and troubleshooting. Plant floor communication, industrial networks, SCADA, DCS, Internet of Things (IoT) and Basic Industrial IoT (IIoT) Controller, web and mobile application design, programming and project implementation.
MCTA 3353	Control Systems 2	Elements of digital control systems. Discrete-time systems and z transform. Sampled data and reconstruction. Open loop and closed loop discrete-time systems. System time response. Stability analysis. Digital controller design in time domain by root locus. Bode diagrams. Compensator design in frequency domain. State variable analysis and digital controller design.
MCTA 3371	Computational Intelligence	This course provides extensive computational algorithms offered by fuzzy logic, artificial neural network and genetic algorithm. Introduction to Computational Intelligence; soft computing vs. hard computing, knowledge-based system and expert system. Concept of fuzzy logic control; architecture, components and design. Application of fuzzy logic for real-world problems. Concept of artificial neural networks. Single layer networks, multilayer network, supervised and unsupervised networks. Application of artificial neural network for real-world problems. Concept of evolutionary computation and genetic algorithm. Hybrid systems; Neuro-Fuzzy integrated architectures and Integration of Neural Networks, Fuzzy Logic and Genetic Algorithms. Applications of hybrid systems for real-world problems.
MCTA 4105	Mechatronics Robotics Lab	Introduction to practical aspects of robotics system.
MCTA 4200	Final Year Project 1	Implementation of knowledge gathered through theoretical and laboratory courses, expose the students to the contemporary problems and issues related to engineering project cycle (design, development, operation, simulation, data collection and analysis), technical report writing and presentation.
MCTA 4400	Final Year Project 2	Implementation of the engineering knowledge learnt in the theoretical and practical classes. Literature review, formulation, analysis, design and construction to develop products or system. Formulation of problem statement, objectives, scope of work and plan for engineering projects with consideration to society, social, cultural, global and environment.

MCTA 3500	Engineering Industrial Training	The Engineering Industrial Training Programme is to expose the students to the actual working environment at a relevant organization or industry. This exposure will develop students' skills in applying engineering knowledge, solving problems, work ethics, communication, management, and teamwork. The programme will also help to establish a close relationship between the industry and university.
ELECTIVE COURSES		
MCTA 4351	Electronic Instrumentation and Design	Overview of instrumentation principles, the physical principles and electrical characteristics for common instrument transducers, electronic signalconditioning circuits, operational amplifier imperfections, noise, grounding, decoupling, shielding and PCB layout, noise control techniques , carrier signal techniques, signal averaging techniques.
MCTA 4361	Natural Language Processing	This course will cover the foundations of natural language processing (NLP) from textual content processing to corpus understanding. It is designed to introduce the computational techniques for analyzing and understanding textual content. In addition, the course will also introduce significant application areas of NLP.
MCTA 4371	Autonomous Robotic Systems	Mobile robots, autonomous systems, mobile robot locomotion: wheeled, legged, kinematic models and constraints, manoeuvrability, mobile robot workspace, motion control, sensor for mobile robotics, performance measures, statistical representation, map representation, probabilistic map-based localization, autonomous web building, planning and navigation, control localization.
MCTA 4352	Industrial Instrumentation	This course will introduce industrial instrumentations principles used in biomedical applications, process measurements and manufacturing industry. Along with an overview of instrumentation principles, the physical principles and electronic characteristics for several common sensors and transducers are studied. Sensors, signal conditioning, recording and control will also be explained for both analog and digital instrumentations. The course will also expose the students to the safety standards that are implemented in the areas of biomedical, process control, assembly and manufacturing industries.
MCTA 4362	Machine Learning	This course covers on the three types of machine learning algorithms, viz. supervised, unsupervised and reinforcement learning algorithms. Introduction to Machine Learning. Supervised Learning: Linear Regression (with one variable and multiple variables) and Classification (Naive Bayes Classifier, Logistic Regression, KNearest Neighbors, Random Decision Forests, and

		Support Vector Machines). Regularization of Linear and Logistic Regression, Unsupervised Learning (K-Mean Algorithm). Dimensionality Reduction (Principal Component Analysis (PCA)). Reinforcement Learning. Machine Learning Model Evaluation.
MCTA 4372	Underwater and Aerial Robotics	Complete overview of the theory, design, and applications of Underwater and Aerial Robotics. It covers the basics, including definitions, attributes, locomotions, manned vs. unmanned, design considerations, architecture, components, payload, communications, and ground control stations. Additional chapters will cover types of sensors and characteristics, alternative power, human machine interface, sense and avoid systems, navigation, autonomous control, swarming, future capabilities and ethics in unmanned systems.
MCTA 4381	Electrical Power System Analysis	The course deals with fault level calculation, power flow, power system stability and economic operation. Power systems are modeled both at the distribution and transmission levels. The course covers long-distance transmission of electric power with emphasis on admittance and impedance modeling of components and system, power-flow studies and calculations, symmetrical and unsymmetrical fault calculations, circuit protection. Emphasis is on applications of computer-based methods to power-system problems.
MCTA 4353	Modern Control Design	Advanced classical control method. MIMO dynamic systems. Observer design. Lyapunov stability. Optimal Control. Linear Quadratic Regulator. Kalman Filter. Linear Quadratic Gaussian, Nonlinear systems. Feedback linearization.
MCTA 4363	Deep Learning	Introduction to Deep Learning and Machine Vision, Fundamentals of Deep Neural Networks, Training Deep Neural Networks for Image Classification, Convolutional Neural Networks (CNN), Training CNN for Image Classification (Random Initialization, Pre-Training, Transfer Learning, fine-tuning), Applying Deep Learning to Datasets, Deep Learning Applications: Object Detection and Semantic Segmentation, Deep Learning on Embedded Platforms, Autoencoders and Generative Models, Applications of Deep Learning in Mechatronics Engineering.
MCTA 4373	Manufacturing Mechatronics	Different manufacturing processes and machineries (conventional and non-conventional). Mechatronics aspects of different manufacturing machines. Design of different drive mechanism. Ball screw drive and lead screw drive, hydraulic drive, and pneumatic drive. Measurement errors and Geometrical Dimensioning & Tolerances (GD&T). Sensor assisted manufacturing processes. Introduction to automated manufacturing systems.
MCTA 4382	Microelectronics	The topics covered include: modeling of microelectronic devices, basic microelectronic circuit analysis and design,

		physical electronics of semiconductor junction and MOS devices, relation of electrical behavior to internal physical processes, development of circuit models, and understanding the uses and limitations of various models.
MCTA 4354	System Modeling and Identification	Principles for modeling of physical systems. Models of mechanical system, electrical system, thermal system, fluid system and mixed system. Model representations using differential equations, transfer functions, and difference equations. Experimental modelling of dynamical systems using input-output data. Identification using black box models. Experiment design for identification based on measured data and model validation. Modeling and identification using computer software.
MCTA 4364	Machine Vision	Machine vision concepts, image acquisition, image formation, image conversion, camera and vision sensors, image processing and analysis, filtering and edge detection, image representation and feature descriptors, bag of features, intro to machine learning, three-dimensional machine vision techniques, image enhancement, 3D vision
MCTA 4374	Smart Infrastructure	Definition of smart infrastructure, different level of smart systems, principle of smart infrastructure, Importance of Data, Performing Smart Analysis, Feedback: fundamental in smart systems, Adaptability, Redundancy and Maintainability of Smart System. Different application of smart systems. Barriers to implementing a smart system.
MCTA 4383	Robotic Operating System	Overview of the ROS framework, building models of complex robots, simulation and interfacing robots using the ROS, motion planning library and ROS navigation stacks. ROS packages to embrace robot models.
MCTA 4384	Thermal and Fluids Machineries	Introduction to thermodynamics and fluid mechanics, properties of steam and different refrigerants, vapor cycles, Carnot cycle, Rankine cycle, refrigeration cycles, Spark Ignition (SI) and Compression Ignition (CI) engines, Otto cycle, Diesel cycle, Steam turbines, impulse and reaction turbines, compounding of steam turbines, gas turbine, Brayton cycle, reciprocating and centrifugal compressor, hydraulic turbines, centrifugal pump, reciprocating pump.
MCTA 4385	Biomechatronics	Mechatronic principles and techniques for measuring, assisting, augmenting and mimicking biological systems. Brain machine interfaces, biomechanics and motion control, biomechanical modeling (Kane's method, neural network modelling), anthropomorphic designs, wearable and assistive devices, modelling and control of mechatronics for medical application, soft robotic technologies, safety/ethical aspects, and biomechatronic design principles.
MCTA 4386	Random and Nonlinear Vibration	Characterization and transmission of random vibration; response of simple single and two-degree-of-freedom

		systems to stationary random excitation, classification of nonlinear problems; exact, graphical and approximate solutions, singular points, stability, self-excited vibrations, failure due to random vibration, fatigue failure due to random excitation
MCTA 4387	Fluid Power Systems	Fundamental Concept of Fluid Power Transmission, components, symbol and circuits of fluid power systems. Mathematical models for hydraulic and pneumatic control components and systems including hydraulic pumps, motors, and spool valves. The application of electrohydraulic servomechanisms for position and velocity control.
MCTA 4388	Remote Sensing	Course will explain the fundamental engineering technology and the operating characteristics of remote sensing systems used for various applications. Introduction to remote sensing. Electromagnetic radiation. Scattering. Spectral signature. Satellite systems. Digital satellite imagery. Satellite image enhancement, transformation, and classification. Optical and microwave remote sensing systems. Lidar remote sensing.
MCTA 4389	Microelectromechanical Systems	This course covers the concept and technology of microelectromechanical systems (MEMS); multidisciplinary nature of microsystems design and manufacturing; microsystems fabrication processes and techniques; MEMSbased sensors and actuators; working principles of microsystems with microactuators, microaccelerometers and microfluidics; packaging, MEMS design techniques and applications.
MCTA 4391	Real Time Systems	Real-time Applications and Computation Model, Hard and Soft timing constraints, Task and computational model, Performance metrics, Prediction of Execution Time, Source code analysis, Micro-architecture level analysis, Task assignment and Scheduling, Task allocation algorithms, Single-processor and multiprocessor task scheduling, Clock-driven and priority-based scheduling algorithms, Programming Languages and Tools, Characteristics of real-time languages Run-time support, Complier optimization, Realtime Databases, Transaction priority and concurrency control issues, Real-Time Communication, Real-time networks, Communication protocols, Fault-Tolerance Techniques, Faults types and detection techniques, Redundancy management Integration issues, Prediction of Execution Time, Case studies
MCTA 4392	Embedded Systems	Cyber-physical systems and embedded computing, Design Methodology, Reliability, Safety and Security. Comparing Processor, Processor memory Hierarchy, Encoding and Security Code Generation and back end Compilation, Memory Oriented Optimizations, Program performance analysis, Model of Computation and Programming , Process Scheduling, Operating Systems, Performance

		Estimation, Hardware/software co-synthesis, Electronic System Level Design, Thermal -aware design, Reliability, Control theory and systems, Control / Computing co-Cyber-physical Systems: Network control system, Design Methodologies, Embedded System in Mechatronic Applications (Case studies) : Audio Record/Playback System, Home Monitoring System, Autonomous Robot
MCTA 4393	Vibration Analysis and Control	Fundamental concepts on vibration of mechanical systems. Behavior of simple mechanical vibrating systems and their responses to harmonic excitation. Analysis of multidegree of freedom system (MDOF). Determination of natural frequencies and mode shapes. Modal analysis. Vibration measurement and control.
MCTA 4394	Big Data Analytics	Introduction to big data, characteristics of big data and dimensions of scalability, big data modeling and management systems, big data storage concepts, big data storage technology, big data integration and processing, big data analysis techniques, scaling up machine learning with big data, modern data analytics technologies like hadoop and MapReduce, and applications of big data in engineering
MCTA 4395	Industrial Robotics	Related standards for Industrial Robot, Review of Kinematics, Jacobian, Position Sensing, Actuators, Robot control system, servo control, IO Control. Communication, Sensor Interface, Software Interface, low level Interface, IO Digital Signal, PLC Software, PC Software Data Protocols and Connections: Remote Procedure Calls (RCP), TCP-IP, Posts, UDP Robotic Programming: Techniques, Methods, Algorithms. Programming Execution Interface Device and System, Case studies
MCTA 4396	Biomedical Instrumentation	Generation and nature of bioelectric potentials; electrodes and other transducers; principles of instrumentation; electrical safety; neuromuscular and cardiovascular instrumentations; ultrasonic and other medical imaging