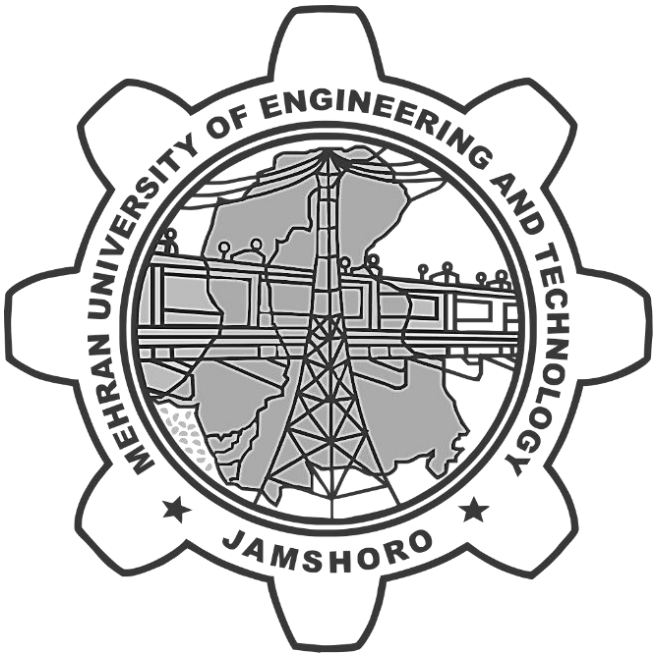
CURRICULUM

for the

M.E Mechatronic Engineering Program



MEHRAN UNIVERSITY OF ENGINEERING AND TECHNOLOGY,
JAMSHORO, SINDH, PAKISTAN
2018

MEHRAN UNIVERSITY OF ENGINEERING AND TECHNOLOGY, JAMSHORO
INSTITUTE OF INFORMATION AND COMMUNICATION TECHNOLOGIES

Title of Subject	: ADVANCED ROBOTICS **[MTS-601]**
Disciplines	: M.E. Mechatronic Engineering
Semester	: 1st
Effective	: 19 ME-MTS Batch & Onwards
Credit hours	: 03
Minimum Contact hours	: 42
Assessment	: 10% Sessional Work, 30% Mid Semester Examinations, 60% Final Examinations.
Marks	: 100

Aim: To develop kinematic and dynamic knowledge as applied to robots.

Objectives:

1. To develop comprehension of forward and inverse kinematics for robot manipulators
2. To introduce formulation necessary to develop dynamic models of manipulators
3. To understand force and motion control of robots

Contents:

Forward Kinematics
Rotation matrix, pose, Euler angles, Quaternion, transformation, Denavit-Hartenberg convention, kinematics of two-link, three-link, PUMA and Stanford manipulator, workspace

Inverse Kinematics
Introduction, Inverse kinematics of two-link and three-link robot manipulators

Differential Kinematics
Geometric Jacobian, Jacobian of two-link, three-link and PUMA manipulators, kinematic singularities, inverse kinematics Jacobian

Trajectory Planning
Path and trajectory, point-to-point motion, motion through sequence of points

Dynamics
Lagrange formulation, dynamic models of two-link Cartesian, planar and parallelogram arm, Newton-Euler formulations

Motion Control
Joint space control, torque feedforward control, centralized control

Force Control
Compliance control, impedance control, force control, constrained motion, hybrid force-motion control

Visual Servoing
Vision for control, image processing, pose estimation, camera calibration, position and image based visual servoing

Robot programming languages
Overview of robot programming languages, Introduction to Robot Operating System.

Recommended Books :

- Siciliano, B., Sciavicco, L., Villani, L., Oriolo, G, Robotics: Modelling, Planning and Control.. , Latest edition.
- Robert J. Schilling, Fundamentals of Robotics: Analysis and Control, Latest edition.
- 3. John J. Craig, Introduction to Robotics: Mechanics and Control, Latest edition.

Approval :	Board of Studies	Res. No. 3.1	Dated: 27-08-2018
	Advanced Studies and Research Board	Res.No.151.18(a)	Dated: 04-09-2018
	Academic Council	Res. No. 93.7(C)	Dated: 17-09-2018

MEHRAN UNIVERSITY OF ENGINEERING AND TECHNOLOGY, JAMSHORO
INSTITUTE OF INFORMATION AND COMMUNICATION TECHNOLOGIES

Title of Subject	: DATA ACQUISITION AND CONTROL **[MTS-602]**
Disciplines	: M.E. Mechatronic Engineering
Semester	: 1st
Effective	: 19 ME-MTS Batch & Onwards
Credit hours	: 03
Minimum Contact hours	: 42
Assessment	: 10% Sessional Work, 30% Mid Semester Examinations, 60% Final Examinations.
Marks	: 100

Aim : To provide knowledge of data acquisition and control necessary to develop a measurement and control system.

Objectives :

1. To develop an understanding of modern data acquisition techniques.
2. To give detailed explanation of passive and active electrical transducers, signal conditioning circuits along with digital interfacing techniques.
3. To provide an overview of digital control systems and digital controller design.

Contents :

Introduction to data acquisition:
Data acquisition fundamentals, needs, devices

Passive and active electrical transducers:
Passive: Principles and types of resistive, inductive and capacitive transducers.
Active: Piezoelectric, magnetostrictive , photoelectric transducers

Signal conditioning circuits:
Analog signal conditioning, digital signal conditioning

Digital interfacing:
Input/Output Subsystems and Registers, Input/Output Mapping, Interfacing Using Polling or Interrupts, The Parallel I/O Subsystem, Serial Systems, Analog/Digital I/O Subsystems, I/O Subsystem Registers, Interface Standards

Data communication and networks:
Data communications and networks for modern instrumentation and control, smart instrumentation systems, serial and parallel communications, error detection, Industrial protocols

ADC, DAC, timers and counters:
Sampling, quantization, dithering, analog to digital and digital to analog conversion

Digital measurements and control programming for real time systems:
Introduction to real time system hardware and software, digital measurement fundamentals, programming techniques to control real time systems

Introduction to digital control systems:
Close loop digital control systems, system time response, Stability analysis techniques

Digital controller design
Control system specifications, Compensation (Lag and Lead), PID Controller design, Design by root locus

Recommended Books :

- DVS Murty, Transducers and Instrumentation, Latest edition
- C. L. Phillips and H. T. Nagle, Digital control system analysis and design, Latest edition
- Curtis D Johnson, Process Control Instrumentation Technology, Latest edition
- Robert B. Northrop, Instrumentation and measurements, Latest edition.

Approval :	Board of Studies	Res. No. 3.1	Dated: 27-08-2018
	Advanced Studies and Research Board	Res. No.151.18(a)	Dated: 04-09-2018
	Academic Council	Res. No. 93.7(C)	Dated: 17-09-2018

MEHRAN UNIVERSITY OF ENGINEERING AND TECHNOLOGY, JAMSHORO
INSTITUTE OF INFORMATION AND COMMUNICATION TECHNOLOGIES

Title of Subject	: IMAGE PROCESSING FOR INTELLIGENT SYSTEMS **[MTS-603]**
Disciplines	: M.E. Mechatronic Engineering
Semester	: 2nd
Effective	: 19 ME-MTS Batch & Onwards
Credit hours	: 03
Minimum Contact hours	: 42
Assessment	: 10% Sessional Work, 30% Mid Semester Examinations, 60% Final Examinations.
Marks	: 100

Aim : To develop the image processing techniques for intelligent systems.

Objectives :

1. This course presents the theory and practice of digital image processing with Matlab. Numerous examples and practical hands-on exercises are included in the course.
2. One major topic of image processing is covered in every lecture, typically consists of a discussion of the basic theoretical concepts and some examples illustrating practical imaging problems.
3. The course will also deal with the application of the techniques in a simulated robot soccer environment.

Contents :

Introduction to Image Processing
Application areas of Image Processing, Components of Image Processing System

Image Processing Fundamentals
Image Sensing and Acquisition, Image Sampling and Quantization, Relationships between Pixels, Linear and Non-Linear Operations

Image Enhancement in Spatial Domain
Basic Grey Level Transformations, Histogram Processing, Enhancement using Arithmetic/Logic Operations, Smoothing Spatial Filters, Sharpening Spatial Filters

Image Enhancement in Frequency Domain
Introduction to Fourier Transform, Smoothing Frequency Domain Filters, Sharpening Frequency Domain Filters, Homomorphic Filtering

Image Restoration
Noise Models, Restoration in the Presence of Noise, Periodic Noise Reduction by Frequency Domain Filtering, Linear Position-Invariant Degradations, Estimating Degradation Function, Inverse Filtering, Minimum Mean Square Error Filtering, Constrained Least Squares Filtering

Geometric transformations: Spatial Transformations, Grey-Level Interpolation

Colour Image Processing
Colour Models, Colour Transformations, Smoothing and Sharpening, Colour Segmentation

Image compression
Image Compression Models, Elements of Information Theory, Lossy Compression, Lossless Compression

Case studies pertaining to intelligent systems
Edge Detection, Thresholding, Object Recognition

Implementation of techniques in Robot Soccer and manufacturing environment

Recommended Books :

- R. C. Gonzalez and R. E. woods, Digital Image Processing, Latest edition.
- R. C. Gonzalez,R. E. Woods and S.L. Eddins, Additional readings: Digital Image Processing using MATLAB, Latest edition.

Approval :	Board of Studies	Res. No. 3.1	Dated: 27-08-2018
	Advanced Studies and Research Board	Res. No.151.18(a)	Dated: 04-09-2018
	Academic Council	Res. No. 93.7(C)	Dated: 17-09-2018

MEHRAN UNIVERSITY OF ENGINEERING AND TECHNOLOGY, JAMSHORO
INSTITUTE OF INFORMATION AND COMMUNICATION TECHNOLOGIES

Title of Subject	: ADVANCED EMBEDDED SYSTEMS **[MTS-604]**
Disciplines	: M.E. Mechatronic Engineering
Semester	: 2nd
Effective	: 19 ME-MTS Batch & Onwards
Credit hours	: 03
Minimum Contact hours	: 42
Assessment	: 10% Sessional Work, 30% Mid Semester Examinations, 60% Final Examinations.
Marks	: 100

Aim: The course is intended to give detailed explanation of processor architecture and design, memory access, programming of embedded systems and integration of embedded systems in real time environment.

Objectives:
1. This course is designed to develop an understanding of modern embedded systems.
2. An overview of programmable logic devices and system on chip will also be given along with IC fabrication and design challenges.

Contents:

Introduction to embedded systems: Design challenge - optimizing design metrics
Hardware architecture for embedded systems: Processor technology, IC technology, Design Technology
Single purpose processors:
Transistors and logic gates, Flip-flops, Custom single-purpose processor design, RT-level custom single-purpose processor design
General purpose processors: Basic architecture, Operation, Programmer's view, Development environment,
Application specific processors: Application-specific instruction-set processors, Selection of Microprocessor
Programmable logic devices:
Programmable array logic (PAL) Programmable logic array (PLA), complex Programming logic device (CPLD)
Application Specific Integrated Circuits (ASIC):
Chip Design Styles, Macro Modules, Gate Arrays, FPGA, ASIC Flow, Front-end Verilog, Back-end, Clock Edge triggered Design
Field Programmable Gate Arrays (FPGA)
Software for embedded systems: Embedded Operating Systems, Resource Access Protocols, Embedded Linux, Middleware
Introduction to development environment: FPGA development kit (Spartan-III)
Introduction to Verilog
Synthesis and HDLs, Synthesis and Mapping for FPGA, Verilog Module, Verilog Registers, Case Statement, Advantages and Disadvantages of Verilog, Priority Logic
Development of various applications: Mux, Demux, counters, registers, ALU etc.

Recommended Books:
- Dr. David A. Patterson and Dr. Paul Hennessey, Computer Architecture, A Quantitative approach, Latest edition.
- Frank Vahid& Tony D. Givarigis, Embedded System Design: A unified Hardware/Software Introduction, Latest edition
- P. Marwedel, Embedded System Design. Hardware/ Software System, Latest edition.
- Pong P. Chu, FPGA prototyping by VHDL examples: Xilinx Spartan-3 version, Latest edition.

Approval :	Board of Studies	Res. No. 3.1	Dated: 27-08-2018
	Advanced Studies and Research Board	Res. No.151.18(a)	Dated: 04-09-2018
	Academic Council	Res. No. 93.7(C)	Dated: 17-09-2018

MEHRAN UNIVERSITY OF ENGINEERING AND TECHNOLOGY, JAMSHORO
INSTITUTE OF INFORMATION AND COMMUNICATION TECHNOLOGIES

Title of Subject	: INDUSTRIAL CONTROL TECHNOLOGY **[MTS-615]**
Disciplines	: M.E. Mechatronic Engineering
Semester	: 2nd
Effective	: 19 ME-MTS Batch & Onwards
Credit hours	: 03
Minimum Contact hours	: 42
Assessment	: 10% Sessional Work, 30% Mid Semester Examinations, 60% Final Examinations.
Marks	: 100

Aim : To teach the industrial controllers and controlling techniques.

Objectives :

1. To understand modern control technology and the theoretical fundamentals of process control, logic, binary operations, digital data conversion and discrete control.
2. To develop PLC programs and applications to solve practical control problems.

Contents :

Discrete control systems: introduction, fundamental concepts, relay control, PLC.

Fundamental logic: concepts connected to discrete control systems

Introduction to the linear control systems:

Discrete control systems with PLC: Discrete I/O Systems, Remote I/O Systems, PLC instruction and Types of Discrete inputs, Discrete Outputs, Discrete Bypass, and Interpreting.

PLC programming:

Ladder Diagram Format, Ladder Relay Instructions, Ladder Relay Programming, Instructions for Timers and Counters.

Lead and lag compensation: SCADA systems:

Supervisory Control and Data Acquisition, Sociological and Cultural Aspects, Threat Vectors, Application and Risk Management, SCADA economics

CNC Programming :

Cartesian Coordinate System, Machines Using CNC, Programming Systems, Point-to-Point or Continuous Path, Point-to-Point Positioning

Advanced CNC programming Functions

Milling and Drilling Programming, CNC Programming for Turning.

Concept of CIM, Automated Storage and Retrieval System, Programming of Industrial Robots

Recommended Books :

- L. A. Bryan, E. A. Bryan, Programmable Controllers Theory and Implementation, Latest Edition.
- Peng Zhang, Advanced Industrial Control Technology, Latest Edition.
- W. Bolton, Programmable Logic Controller (PLC), Latest Edition.
- John R. Hackworth, Frederick D. Hackworth, Jr., Programmable Logic Controllers: Programming Methods and Applications, Latest Edition.
- Frank D. Petruzella., Programmable Logic Controllers, Latest Edition.
- Stuart A. Boyer, SCADA: Supervisory Control and Data Acquisition, Latest Edition.

Approval	:	Board of Studies	Res. No. 3.1	Dated: 27-08-2018
		Advanced Studies and Research Board	Res. No.151.18(a)	Dated: 04-09-2018
		Academic Council	Res. No. 93.7(C)	Dated: 17-09-2018

MEHRAN UNIVERSITY OF ENGINEERING AND TECHNOLOGY, JAMSHORO

INSTITUTE OF INFORMATION AND COMMUNICATION TECHNOLOGIES

Title of Subject	: ADVANCED ACTUATORS **[MTS-641]**
Disciplines	: M.E. Mechatronic Engineering
Semester	: 1st
Effective	: 19 ME-MTS Batch & Onwards
Credit hours	: 03
Minimum Contact hours	: 42
Assessment	: 10% Sessional Work, 30% Mid Semester Examinations, 60% Final Examinations.
Marks	: 100

Aim : To impart the knowledge of working principles and performance of advanced actuators such as piezoelectric, electrostatic, fluid power, shape memory alloy, soft and micro actuators.

Objectives : At the end of this course, students will be able to:

1. Describe control methods and applications of advanced actuators.
2. Design advanced mechanical systems with wide variety of specifications selecting adequate actuators..

Contents :

Fundamentals of Advanced Actuators

Transducing Materials as a basis of Actuator Design, Role of Actuator in Control System, Concomitant Actuation and Sensing

Electrostatic Actuators

Pull-In Phenomena, Constant Charge Mode of Electrostatic Force, Constant Voltage Mode of Electrostatic Force, X-direction motion of Comb Drive Device, Force and Deflection (lateral motion), Z-direction motion of Comb Drive Device

Fluid Power Actuators

Fundamental Principles, Types of Control Valves, Speed Control, Actuator Synchronization, Linear and Rotary Actuators, Sequencing Applications

Shape Memory Alloy Actuators

Shape Memory Effect, Pseudoelasticity in SMA, Design of Shape Memory Actuators, Control of SMAs, Figures of Merit of SMA

Piezoelectric actuators

Piezoelectricity and Piezoelectric Materials, Constitutive Equations of Piezoelectric Materials, Resonant Piezoelectric actuators, Non-Resonant Piezoelectric actuators, Control Aspects of Piezoelectric Motors

Soft actuators

Micro-Actuators

Biological inspiration of Micro-Actuators, Mechanical Micro-Actuators with Different Energy Inputs, Characteristics of Mechanical Micro-Actuators, Electrostatic Comb-Drive

Recommended Books :

- Smart Actuator and Sensor Technologies: Design, Modeling, Fabrication, and Control for Mechatronic Systems by Kam K Leang, Kwang J Kim
- Soft Actuators: Materials, Modeling, Applications, and Future Perspectives edited by Kinji Asaka, Hidenori Okuzaki
- Emerging Actuator Technologies: A Micromechatronic Approach by By José L. Pons.

Approval :	Board of Studies	Res. No. 3.1	Dated: 27-08-2018
	Advanced Studies and Research Board	Res. No.151.18(a)	Dated: 04-09-2018
	Academic Council	Res. No. 93.7(C)	Dated: 17-09-2018

MEHRAN UNIVERSITY OF ENGINEERING AND TECHNOLOGY, JAMSHORO
INSTITUTE OF INFORMATION AND COMMUNICATION TECHNOLOGIES

Title of Subject	: LINEAR CONTROL SYSTEMS **[MTS-621]**
Disciplines	: M.E. Mechatronic Engineering
Semester	: 3rd
Effective	: 19 ME-MTS Batch & Onwards
Credit hours	: 03
Minimum Contact hours	: 42
Assessment	: 10% Sessional Work, 30% Mid Semester Examinations, 60% Final Examinations.
Marks	: 100

Aim: To impart the knowledge of the limitations on performance of control systems

Objectives :

1. Design of state-space controllers; estimation filters; dynamic output feedback
2. Model uncertainty and robustness

Contents :

Introduction
Basic root locus: analysis and examples
Frequency response methods: Control design using Bode plots
state-space models: Introduction, developing state-space models based on transfer functions, State-space models: basic properties, System zeros and transfer function matrices, State-space model features.
Controllability: Full-state feedback control, Pole placement approach
LQ servo: Introduction, Open-loop and closed-loop estimators, Combined estimators and regulators, Adding reference inputs
LQ servo: Improving transient performance, Deterministic linear quadratic regulator (LQR), Linear quadratic Gaussian (LQG)

Recommended Books :

- Franklin, Gene, J. David Powell, and Abbas Emami-Naeini, Feedback Control of Dynamic Systems, Latest edition.
- Astrom, Karl, and Richard Murray, Feedback Systems: An Introduction for Scientists and Engineers, Latest edition.
- Van de Vegte, John, Feedback Control Systems. , Latest edition.

Approval :	Board of Studies	Res. No. 3.1	Dated: 27-08-2018
	Advanced Studies and Research Board	Res. No.151.18(a)	Dated: 04-09-2018
	Academic Council	Res. No. 93.7(C)	Dated: 17-09-2018

MEHRAN UNIVERSITY OF ENGINEERING AND TECHNOLOGY, JAMSHORO
INSTITUTE OF INFORMATION AND COMMUNICATION TECHNOLOGIES

Title of Subject	: MACHINE LEARNING **[MTS-612]**
Disciplines	: M.E. Mechatronic Engineering
Semester	: 3rd
Effective	: 19 ME-MTS Batch & Onwards
Credit hours	: 03
Minimum Contact hours	: 42
Assessment	: 10% Sessional Work, 30% Mid Semester Examinations, 60% Final Examinations.
Marks	: 100

Aim : The course will give the student the ideas and intuition behind modern machine learning methods and formal understanding of how, why, and when they work.

Objectives :

1. This course provides a broad introduction to machine learning and statistical pattern recognition.
2. The underlying theme in the course is statistical inference as it provides the foundation for most of the methods covered.

Contents :

Supervised Learning
Basic Concepts, Review of Linear Algebra and Probability, Supervised Learning, Logistic Regression, Generative learning algorithms. Gaussian discriminant analysis. Naive Bayes, Support Vector Machines

Fine Tuning Supervised Learning
Bias/variance trade-off, Model selection and feature selection, Evaluating and debugging learning algorithms, Convex Optimization

Deep Learning
NN architecture, Forward/Back propagation, Vectorization and Other optimization techniques

Unsupervised Learning
Clustering, K-Means, Principal Component Analysis (PCA)

Reinforcement Learning
MDPs. Bellman equations, Value iteration and policy iteration, Linear quadratic regulation (LQR), Q-learning. Value function approximation, Generative Adversarial Networks (GANs), Adversarial machine learning

Recommended Books :

- Christopher M. Bishop, Pattern Recognition and Machine Learning, Latest edition.
- Kevin P. Murphy, Machine Learning A Probabilistic Approach, Latest edition.
- Ian H. Witten, Eibe Frank, Mark A. Hall, Christopher J. Pal ,Data Mining: Practical Machine Learning Tools and Techniques, Latest edition.
- Trevor Hastie, Robert Tibshirani and Jerome Friedman, The Elements of Statistical Learning, Latest edition.

Approval	:	Board of Studies	Res. No. 3.1	Dated: 27-08-2018
		Advanced Studies and Research Board	Res. No.151.18(a)	Dated: 04-09-2018
		Academic Council	Res. No. 93.7(C)	Dated: 17-09-2018