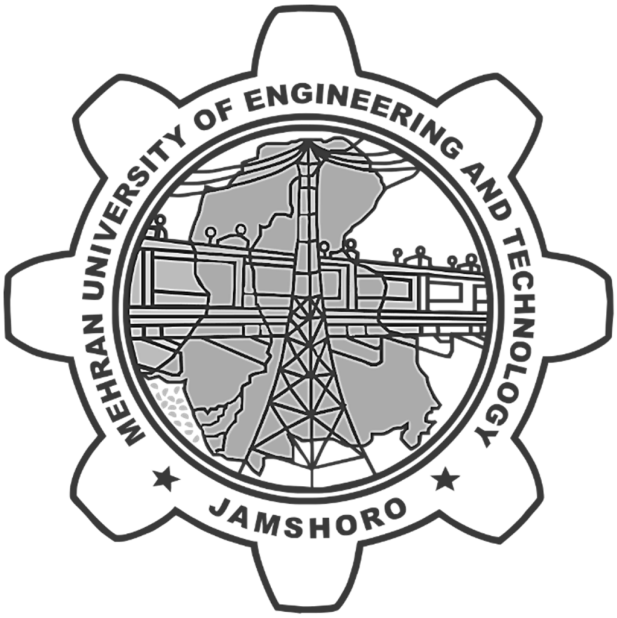
CURRICULUM

for the

M.E Mechatronic Engineering Program



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

INTRODUCTION PG PROGRAM

Mechatronics refers to a flexible, multi-technological approach for integration of mechanical engineering, computer engineering, electronics and information sciences. Mechatronics is essential in the design of intelligent products. It allows engineers to transform their virtual concepts into real life applications. It is a relatively new concept relating to the design of systems, devices and products aimed at achieving an optimal balance between basic mechanical structure and its overall control. The programme involves research and coursework that will push the frontiers of technology in intelligent product design and development. The research activities involve design and control of intelligent robotic systems and automated machines. Modern state-of-the-art industries have changed rapidly from pure mechanical-, manufacturing-, and process-controlled type to electro-mechanical, fully automated and computerized. It has become the requirement for people working on those processes and production lines to have knowledge of all the related systems.

Considering the need of the time most of the state of the art industries in the world have changed from pure mechanical, manufacturing or process controlled to the ones where the processes are more of electromechanical, fully automated and mostly controlled by computers. To achieve the quality products even the most simple production lines and production processes in the industries have a blend of computers in them. It has become the requirement for people working on such processes and production lines to have knowledge of all the related systems. Graduates should have a strong command on engineering principles as well as a sound capability of converting concepts to reality. They could find themselves in industry engaged with maintenance and operation of plant equipment such as boilers, compressors, turbines, instrumentation, automation and control of advanced industrial processes using such tools as PLC and microcontroller-based control systems, process simulation for plant modifications, defense and R&D applications, engineering management, or a variety of similar areas.

PROGRAM OBJECTIVES

The main objectives of Masters in Mechatronics Engineering programme are as below:-

- Enables the students to pursue a rigorous post doctorate / research programme in Mechatronics Engineering.
- Improve the marketability of our students in the local industry, public sector and R & D organizations.
- Provide technical confidence and financial guidance needed to start a small-scale industry to graduates interested in self-employment.

MECHATRONICS PROGRAMME – EDUCATIONAL OBJECTIVES

The broad objectives of the Postgraduate program in Mechatronics Engineering are to instill in its students a solid foundation of mathematical, scientific and engineering knowledge in addition to developing the intellectual skills essential for prosperity and success in their careers. The program is structured in such a manner that the students are provided a firm theoretical foundation with opportunity to strengthen their knowledge through research assignments, practical training and projects. graduates from the programme should:

- Be effective, innovative and research oriented mechatronics engineers having strong quantitative and analytical skills.
- Be practically sound and able to use engineering tools to enhance their productivity.
- Be able to design, analyze, and solve complex problems and develop effective processes that encapsulate multi domain technologies.
- Be effective leaders with high morals and professional ethics.

PROGRAM LEARNING OUTCOMES

Program Learning Outcomes should demonstrate that our graduates have the following abilities:

- **Engineering Knowledge**: Apply multidisciplinary engineering knowledge to formulate and solve real world problems.
- **Problem Analysis:** Identify and formulate solutions to complex problems by performing extensive research and application of concepts gained throughout the program.
- **Design/Development of Solutions:** Design processes, components and solutions by keeping in view the requirements of the society and environment.

- **Investigation:** Investigate specific engineering problems, analyze and interpret the resultant data by tools learnt during the coursework and synthesize the data to come to a meaningful conclusion.
- **Modern Tool Usage:** Handle and use state of the art equipment to experimentally validate the theoretical concepts.
- **Engineer and the Society:** Asses societal problems and devise solutions.
- **Environment and Sustainability:** Become aware of the need for sustainable development and realize their role for making the environment livable.
- **Ethics:** Apply professional ethics to all engineering practices and recognize civic duties and engage in activities to accomplish them.
- **Individual and Teamwork:** Work on technically diverse team-based projects.
- **Communication:** Develop basic technical presentation skills, written and oral, to effectively express ideas and knowledge.
- **Project Management:** To make effective use of time, resources and skills during team-based projects, which involves integrating knowledge and technical skills from diverse subjects?
- **Research and Life Long Learning:** Obtain lifelong skills of analytical thinking, problem analysis and optimized solution formulation to contribute to uplifting and growth of the society at large and recognize the importance of continued learning

M.E. IN MECHATRONIC ENGINEERING PROGRAM

Duration:	2-4 years
Number of semesters:	4-8
Number of weeks per semester:	18 (16 for teaching and 2 for examinations)
Total number of credit hours:	30
Number of credit hours per semester:	6-9
Core Courses:	12 Credit Hours
Elective Courses:	12 Credit Hours
Research Work	6 Credits Hours

STREAMS OF M.E. IN MECHATRONIC ENGINEERING PROGRAM

M.E in Mechatronic Engineering program is offered in two streams:

1- **Robotics and Industrial Automation Stream**
2- **Smart Electromechanical Systems Stream**

SCHEME OF STUDIES FOR
M.E IN MECHATRONIC ENGINEERING

Semester-1

S. No.	Subject	Credit Hours
1	Core 1	3
2	Core 2	3
3	Elective-I	3

Semester-2

S. No.	Subject	Credit Hours
1	Core 3	3
2	Core 4	3
3	Elective-II	3

Semester-3

S. No.	Subject	Credit Hours
1	Elective-III	3
2	Elective-IV	3

Semester-4

S. No.	Subject	Credit Hours
1	Thesis Research	6

M.E in Mechatronic Engineering
(Robotics and Industrial Automation Stream)

All courses: 3 Credit Hour
COMPULSORY (CORE) COURSES

S.No	SEMESTER	Course Code	Course Name
1	First	MTS-601	Advanced Robotics
2	First	MTS-602	Data Acquisition and Control
3	Second	MTS-603	Image Processing for Intelligent Systems
4	Second	MTS-604	Advanced Embedded Systems

ELECTIVE COURSES

Each student will select one subject from each group of following subjects:

S.No.	SEMESTER	Course Code	Course
1	First (Elective-I)	MTS-610	Advanced Manufacturing Design Techniques
		MTS-613	Precision Manufacturing Systems
		MTS-623	Computer Integrated Manufacturing
		MTS-627	Laser Material Processing
		MTS-628	Rapid Prototyping, Tooling and Automation
		MTS-641	Advanced Actuators
2	Second (Elective-II)	MTS-609	Motion Planning for Mobile Robots
		MTS-614	Optimization of Engineering Systems
		MTS-615	Industrial Control Technology
		MTS-618	Kinematics of Mobile Robotic Systems
		MTS-619	Cognitive Robotics
3	Third (Elective-III)	MTS-616	Fuzzy Control Systems
		MTS-617	Optimal Control
		MTS-621	Linear Control Systems
		MTS-624	Robust Control
		MTS-625	Adaptive Control
		MTS-629	Digital Control Systems
4	Third (Elective-IV)	MTS-611	Machine Vision
		MTS-612	Machine Learning
		MTS-620	Computational Geometry
		MTS-622	Advanced Measurement Techniques
		MTS-626	Micro-Electro Mechanical Systems
		MTS-630	Filtering and Tracking
5	Fourth	MTS-699	Thesis Research

M.E in Mechatronic Engineering
(Smart Electromechanical Systems Stream)

All courses: 3 Credit Hour
COMPULSORY (CORE) COURSES

Sr.No.	SEMESTER	Course Code	Course
1	First	MTS-601	Advanced Robotics
2	First	MTS-602	Data Acquisition and Control
3	Second	MTS-603	Image Processing for Intelligent Systems
4	Second	MTS-604	Advanced Embedded Systems

ELECTIVE COURSES

Each student will select one subject from each group of following subjects:

Sr.#	SEMESTER	Course Code	Course
1	First (Elective-I)	MTS-626	Micro-Electro Mechanical Systems
		MTS-605	Sensor and Sensing Technology
		MTS-638	Smart Materials and Structures
		MTS-641	Advanced Actuators
2	Second (Elective-II)	MTS-606	Stochastic Systems
		MTS-621	Linear Control Systems
		MTS-636	Fuzzy Logic Hybrid Systems
3	Third (Elective-III)	MTS-608	Artificial Intelligence
		MTS-631	Paradigms of Artificial Intelligence
		MTS-634	Artificial Neural Networks
		MTS-639	Pattern Recognition and Analysis
4	Third (Elective-IV)	MTS-633	Programming of Embedded Systems
		MTS-614	Optomechatronic Systems
		MTS-637	Natural Language Processing
		MTS-632	Real Time Systems
5	Fourth	MTS-699	Thesis Research

M.E. MECHATRONIC ENGINEERING
CORE COURSES

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.

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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.

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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.

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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.

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

Title of Subject	: ARTIFICIAL INTELLIGENCE **[MTS-608]**
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 design a knowledge-based system,

Objectives:
1. To Categorize an AI problem based on its characteristics and its constraints and implement search and adversarial algorithms.
2. To understand mathematical models such as belief networks and Markov decision processes and apply them to a range of AI problems.

Contents :

Introduction

Introduction to Artificial Intelligence and its Scope.

Machine Learning: Linear Regression, Logistic Regression, Loss Minimization, Stochastic Gradient Descent,Features and Non-Linearity,Neural Networks, Nearest Neighbors, Generalization, Unsupervised Learning, K-Means, Recurrent Neural Networks

Search Algorithms: Tree Search, Dynamic Programming, Uniform Cost Search, A*, Consistent Heuristics

Markov Decision Process

Policy evaluation, policy improvement, Policy iteration, value iteration, Reinforcement learning, Monte Carlo, SARSA, Q-learning, Exploration/exploitation, function approximation, Deep reinforcement learning

Game Playing

Minimax, expectimax, Evaluation functions, Alpha-beta pruning, Temporal Difference Learning, Game Theory

Constraint Satisfaction Problems:

Factor graphs, Backtracking search, Dynamic ordering, arc consistency, Beam search, local search, Conditional independence, variable elimination

Bayesian Networks: Bayesian inference, Marginal independence, Hidden Markov models, Forward-backward, Gibbs sampling, Particle filtering, Learning Bayesian networks, Laplace smoothing, Expectation Maximization

Logic: Syntax versus semantics, Propositional logic, Horn clauses**,** First-order logic, Resolution**.**

Recommended Books :

- Stuart Russell, Peter Norvig, Artificial Intelligence: A Modern Approach, Latest edition.
- Daphne Koller and Nir Friedman, Probabilistic Graphical Models: Principles and Techniques, Latest edition.
- Richard S. Sutton and Andrew G. Barto, Reinforcement Learning: An Introduction, Latest edition.
- Trevor Hastie, Robert Tibshirani, and Jerome Friedman, he Elements of Statistical Learning: Data Mining, Inference, and Prediction, Latest edition,
- Edward Tsang, Foundations of Constraint Satisfaction, Latest edition..

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

Title of Subject	: SENSORS AND SENSING TECHNOLOGY **[MTS-605]**
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 imart the knowledge required for developing sensing systems.

Objectives:

1. Introduces the fundamental issues in sensing and various sensor technologies including motion sensors, velocity sensors, GPS sensors, acoustic sensors, light and image sensors, and range sensors.
2. Also demonstrates sensor technologies using a system approach to show how they can be integrated into a complete digital system.

Contents :

Measurements: combining multiple signal and noise sources
Measurements involving multiple sensor inputs, effect of noise on measurements, noise identification and filtration techniques, sensor characteristics.
Data acquisition: getting signals to computers
Sensors, signals and systems, data acquisition software and hardware
Light and image sensors: Photodiodes, phototransistor, photo resistors, CCD and CMOS imaging sensors
Sound sensing: Resistive, condenser, fiber-optic, piezoelectric , electret microphones, solid-state acoustic detectors
Touch sensing: Switch sensors, piezoelectric sensors, piezo-resistive sensors, MEMS sensors, Capacitive touch sensors, Acoustic touch sensors
Navigation sensing: Sensors used for navigation, sensor fusion for navigation
Sensing and security: Sensors used for security, home and personal security sensors, Multi-component security systems
People sensing: Optoelectronic motion detectors, optical presence sensors, pressure gradient sensors.

Recommended Books :

- Sen Gupta, Smart Sensors and Sensing Technology, Latest edition.
- Krzysztof Iniewski , Optical, Acoustic, Magnetic, and Mechanical Sensor Technologies, Latest edition.
- Jacob Fraden, Handbook of modern sensors: physics, design and applications, Latest edition.
- Jon S. Wilson,Sensor Technology Handbook , Latest edition.
- Ghenadii Korotcenkov, Chemical Sensors Comprehensive Sensor Technologies, Latest edition.

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

Title of Subject	: STOCHASTIC SYSTEMS **[MTS-606]**
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 and evaluate stochastic models.

Objectives:
1. To analyse the transient and steady state behaviour of stochastic systems.
2. To evaluate the performance of a variety of queueing systems.

Contents:

Introduction: Stabilizing populations, The traps of reinforcement, Surfing Google's waves, Pinging hackers, Signal processing and population dynamics, the theory of speculation.

Stochastic simulation: Inversion and rejection technique, Bayesian inference, Laplace's rule of successions, Fragmentation and coagulation, Conditional probabilities, Gaussian updates, Conjugate priors, Spatial Poisson point processes, Monte Carlo integration, Markov chain model.

Stochastic illustrations: Stochastic processes, Markov chain models, Black-box type models Boltzmann-Gibbs measures, Ising model, Sherrington-Kirkpatrick model, The traveling salesman model, Filtering and statistical learning, Bayes' formula, Singer's radar model.

Discrete time processes: Markov chains, Functional Analysis, Stochastic Analysis, Martingales, Topological aspects, Parameter Estimation, Markov Chain Monte Carlo methods, Nonlinear filtering models, Markov chain restrictions, Kalman-Bucy filters.

Continuous time processes: Poisson processes, Morkov Chain embeddings, Jump Processes, Piecewise deterministic processes, Diffusion processes, Linear and Non-linear jump diffusion processes, Stochastic Analysis, Path space measures**,**

Processes on manifolds: Differential geometry and Projection operators, Stochastic differential calculus on manifolds, Parametrizations and charts, Stochastic calculus in chart spaces, analytical aspects, Prototype manifolds, Random walk on (lattices, graphs, and circle), Iterated random functions, Molecular dynamics simulation, Newton's second law of motion, Langevin diffusion processes. Dynamic population models, Gambling, ranking and control, Mathematical Finance**.**

Recommended Books :

- M. Scott, Applied Stochastic Processes in science and engineering, Latest Edition
- Kaddour Najim, Enso Ikonen, Ait-Kadi Daoud, Stochastic Processes Estimation, Optimization and Analysis, Latest Edition.
- Athanasios Christou Micheas, Theory of Stochastic Objects Probability, Stochastic Processes and Inference, Latest Edition.
- Syouji Najamurs, Toshio Nakagawa, Stochastic Reliability Modeling, Optimization and Applications, Latest Edition.
- L. L. Faulkner, "Stochastic Processes from Applications to Theory, Latest Edition

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

Title of Subject	: MOTION PLANNING FOR MOBILE ROBOTS **[MTS-609]**
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 motion planning systems for mobile robots.

Objectives :

1. This course is designed to study and enable the mobile robots to automatically compute their motions from high-level descriptions of tasks and models acquired through sensing.
2. It will deal primarily with algorithmic issues and discuss how we can approach the three key issues in mobile robotics i.e. mapping, localization and path planning.

Contents :

An overview of concepts in robot motion planning.
Sensor-Based Motion Planning Algorithms, The "Bug" algorithms, the Tangent-Bug algorithm and Implementation
The classical motion planning paradigms: The potential functions, The roadmaps, The cellular decompositions
The sampling-based algorithms: The probabilistic roadmaps, Single query sampling-based planners
Map making and SLAM: The Kalman filter, The SLAM problem, The Bayesian approaches to map making
Non-holonomic drive systems: The types of drive systems, the legged robots, the crawling robots, Trajectory planning for non-holonomic systems
Motion planning for multiple robots
Notion of configuration x time space, Mapping of moving obstacles in configuration x time space, Centralized vs. decoupled planning
Decoupled planning techniques:
Velocity tuning, coordination diagram, prioritized planning.

Recommended Books :

- Howie Choset, Kevin Lynch, Seth Hutchinson, George Kantor Wolfram Burgard, Lydia Kavraki, and Sebastian Thrun, Principles of Robot Motion, Theory Algorithms and Implementations, Latest Edition.
- Sebastian Thrun, Probabilistic Robotics, Latest Edition.
- Spyros G. Tzafestas, Introduction to Mobile Robot Control, Latest Edition.
- Nasser Sadati, Guy A. Dumont, Kaveh Akbari Hamed and William A. Gruver, Hybrid Control and Motion Planning of Dynamical Legged Locomotion, 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 MANUFACTURING DESIGN TECHNIQUES **[MTS-610]**
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: This course will take a detailed look at most of the Advanced Manufacturing Techniques that have emerged to achieve higher quality and productivity.

Objectives:
1. It will enable the students to integrate a wide range of manufacturing methods, technologies, equipment and people in a flexible manner to accommodate the rates of change to be predicted.
2. It will fulfil the need to exploit developing technologies, advanced manufacturing processes and computer-based techniques with efficient operation and effective management.

Contents:

Introduction
Automation and Control Technologies overview, Industrial Control Systems, Continuous versus Discrete Control, Computer Process Control, Sensors, Actuators and other control components, Digital to Analogue Converters and vice versa, Computer Numerical Control, Engineering Analysis of NC Positioning Systems, Discrete Control using PLCs and PCs

CIM: Elements of CIM, Elements of Manufacturing, Implementation of CIM

Material Handling and Identification Technologies: Overview of Material handling Equipment, Material Transport Systems (Industrial Trucks, AGVs, Monorails), Automated Storage Systems, Automatic Data Capture

Manufacturing Systems: Single Station manufacturing cells, Group Technology, Flexible Manufacturing Systems

Automated Assembly Systems: Advanced Inspection Technologies
a. Optical Inspection techniques, b. Machine Vision

Manufacturing Support Systems:
a. Uses of CAD/CAM in the production system,
b. Process Planning and Concurrent Engineering , Lean Production and Agile Manufacturing d. Advanced Manufacturing Techniques
e. Micro/ Nano Fabrication
f. Rapid Prototyping/Tooling , g. Virtual Manufacturing , h. Intelligent Manufacturing Systems

Recommended Books :
- Mikell P. Groover, Automation, Production Systems and Computer Integrated Manufacturing, Latest Edition.
- Mikell P. Groover, Fundamentals of Modern Manufacturing, Materials, Processes, and Systems, Latest Edition.
- Yusuf Altintas, Manufacturing Automation, Latest Edition.
- Geoffrey Boothroyd, Assembly Automation and Product Design, 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 VISION **[MTS-611]**
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 understand algorithms for automated computer vision.

Objectives:

1. To create mathematical models of images and objects and using these to perform inference.
2. To learn how to use these models to automatically find, segment and track objects in scenes, perform face recognition and build three-dimensional models from images.

Contents:

Introduction

Image Formation and Filtering

Geometric Transformations, Photometric Image Formation, Digital Camera Sampling and Aliasing, Point Operators, Linear Filters, Weiner Filter,

Grouping and Fitting: Hough transform, RANSAC, Alignment, image stitching

Image segmentation: Acitve Contours, Region Splitting, Region Merging, Mean Shift and Mode Finding

Texture analysis: Texel-Based Texture Descriptions, Quantitative Texture Measures, Texture Segmentation,

Shape from shading

Object Modelling

Common Representations, True 3D Models versus View-Class Models, Physics-based and Deformable Models

Visual Servoing

Camera Positioning, Direct/Indirect Visual Servoing, Poisition based and Image based Visual Servoing, Features, Robot Differential Kinematics

Recognition

Object Detection, Face Recognition, Instance Recognition, Context and Scene Understanding, Optical Flow

Multi-frame Motion Estimation: Stereo Vision

Structure from Motion: Line Based and Plane Based Techniques

Activity Recognition: Case studies pertaining to intelligent systems, Simulation of techniques on manipulators and mobile robots and Manufacturing

Recommended Books :

- Richard Szeliski ,Computer Vision: Algorithms and Applications, Latest edition
- Jean Ponce, Computer Vision a Modern Approach, Latest edition.

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		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	: PRECISION MANUFACTURING SYSTEMS **[MTS-613]**
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 the knowledge of various techniques used in precision manufacturing systems.

Objectives :

1. To gain an in-depth understanding of micro and Nano scale conventional manufacturing techniques, material properties, scaling laws, latest characterization and measurement techniques.
2. To be conversant with state-of-the-art equipment and processes used in fabrication.

Contents :

Manufacturing engineering in microelectronics: Micro electro mechanical, nano, opto and micro scale manufacturing, Examination of systems design, equipment, process and operational issues and linkages to business strategies

Thin film deposition processes and patterning

Sputtering, Evaporation, Physical Vapor Deposition, Chemical Vapor Deposition

Removal processes

Micro-machining Processes, Wet Bulk Micro-Machining, dry etching, wet etching, Plasma etching, ion-enhanced etching, Vacuum engineering, creating vacuum, Vacuum Deposited Coatings, Pressure Measurement, Pumping, Leaks, Water Vapor.

Characterization techniques

Scattering Techniques, Diffusion and Mass Transfer, Calorimetric Techniques, Combination of In Situ and Ex, Situ Techniques, Imaging, metrology and profiling techniques, Packaging, assembly, and self-assembly

Contamination control and Clean room practices

Contaminants Testing methods, Cleanrooms and clean zones, Cleaning and decontamination, Personal hygiene and personal responsibility

Recommended Books :

- Marc J. Madou, Microfabrication and Nanotechnology, Latest Edition.
- M. Koc and T. Ozel, Micro-Manufacturing: Design and Manufacturing of Micro-Products, Latest Edition.
- Koji Sugioka, Michel Meunier, Alberto Piqu, Laser Precision Microfabrication, Latest Edition.
- Charles A. Bishop, Jr., Vacuum Deposition onto Webs, Films, And Foils, Latest Edition.
- Nick Kanellopoulos, Nanoporous Materials Advanced Techniques for Characterization, Modeling, and Processing, 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	: OPTIMIZATION OF ENGINEERING SYSTEMS **[MTS-614]**
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 provide the knowledge of optimized techniques for manufacturing systems.

Objectives:
1. Student can apply off-the-shelf software to solve problems, analyse and algorithms with a number of case studies.
2. The student will able to develop solution of simultaneous equations and non-linear optimization problems.

Contents:

Introduction

Problems, algorithms and solutions, Decision vector, simultaneous equations, Optimization, Direct and Iterative Algorithms, Solution of Simultaneous equations and optimization problem, Sensitivity and large channel analysis, Transformation of problems: Transformation of objective, Penalty and Barrier functions, Constraints,

Linear simultaneous equations

Case studies: Analysis of Direct Current Linear Circuit, Control of Discrete-Time Linear System, Algorithms: Inversion of coefficient matrix, solution of Triangular systems, Solution of Square Non-Singular systems, Symmetric coefficient matrix, Sparsity techniques, Ill-conditioning, Non-square systems.

Non-linear simultaneous equations

Case Studies: Analysis of Non-linear DC circuit, Analysis of electric power system, Algorithms: Newton-Raphson method, Variations of Newton-Raphson method, Local convergence of iterative methods, Globalization procedures, Sensitivity and large change analysis **Unconstrained optimization:** Case studies: Multi-variate linear regression, Power system state estimation, Algorithms, Optimality conditions, Approaches to finding minimizers, Sensitivity, Solution of the case studies.

Equality-constrained optimization

Case studies: Least-cost production, Power system state estimation with zero injection buses, Algorithms for linear constraints: Optimality conditions, Convex problems, Approaches to finding minimizers, Sensitivity, Solution of the least-cost production case study, Algorithms for non-linear constraints: Geometry and analysis of constraints, Optimality conditions, Finding Minimizers,

Inequality-constrained optimization

Case studies: Least-cost production with capacity constraints, Optimal routing in a data communications network, Least absolute value estimation, Optimal margin pattern classification, Sizing of interconnects in integrated circuits, Optimal power flow

Algorithms for non-negativity constraints: Optimality conditions, Convex problems, Approaches to finding minimizers: active set method, Approaches to finding minimizers: interior point algorithm,

Recommended Books :
- Ross Baldick, Applied Optimization: Formulation and Algorithms for Engineering Systems, Latest edition.
- S.S Rao, Engineering Optimization: Theory and Practice, Latest edition.

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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.

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

Title of Subject	: FUZZY CONTROL SYSTEMS **[MTS-616]**
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 construct of nonlinear controllers for challenging real-world applications.

Objectives:
1. To gain fundamental understanding of the dynamics of fuzzy control systems
2. To implement properties (e.g., stability) and verified mathematically before implementation.
3. To evaluate the performance and comparative analysis with conventional control methods.

Contents :

Introduction: Conventional Control System Design, Fuzzy Control System Design

Fuzzy Control:

Choosing Fuzzy Controller Inputs and Outputs, Putting Control Knowledge into Rule-Bases, Fuzzy Quantification of Knowledge, Determining Conclusions, Converting Decisions into Actions, Graphical Depiction of Fuzzy Decision Making, Fuzzy Sets, Fuzzy Logic, and the Rule-Base, Fuzzification, The Inference Mechanism, Defuzzification, Design Example: The Inverted Pendulum, Real-Time Implementation Issues

Case studies in Design and Implementation

Vibration Damping for a Flexible Robot, Balancing a Rotational Inverted Pendulum, Machine Scheduling, Fuzzy Decision-Making Systems

Nonlinear Analysis

Parameterized Fuzzy Controllers, Lyapunov Stability Analysis, Absolute Stability and the Circle Criterion, Analysis of Steady-State Tracking Error, Limitations of the Theory

Fuzzy Identification and Estimation

Fitting Functions to Data, Least Squares Methods, Gradient Methods, Extracting Rules from Data

Perspectives on Fuzzy Control

Fuzzy Versus Conventional Control, Relationships Between Fuzzy Systems and Neural Networks, Genetic Algorithms for Fuzzy System Design and Tuning

Recommended Books :
- Kevin M. Passino and Stephen Yurkovich, Fuzzy Control, Latest edition.
- Guanrong Chen, Trung Tat Pham, Fuzzy Sets, Fuzzy Logic and Fuzzy Control Systems, Latest edition.
- Zdenko Kovacic, Stjepan Bogdan, Fuzzy Controller Design: Theory and Applications, 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
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MEHRAN UNIVERSITY OF ENGINEERING AND TECHNOLOGY, JAMSHORO
INSTITUTE OF INFORMATION AND COMMUNICATION TECHNOLOGIES

Title of Subject	: OPTIMAL CONTROL **[MTS-617]**
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 understand different forms of performance measures as applied to variety of optimal control problems.

Objectives :

1. Have complete familiarity with Calculus of Variation and Pontryagin's minimum principle
2. Understand Dynamic Programming and Hamilton-Jacobi-Bellman
3. Apply computational procedure to solve optimal control problems.

Contents :

System Description and Performance Evaluation:
Introduction, Problem formulation, State variable representation of systems, Performance Measure

Dynamic Programming:
Dynamic Programming, Optimal Control Law, Principle of Optimality, Dynamic programming applied to Routing problem, Optimal Control System, Interpolation, Computational procedure for solving control problems, Hamilton-Jacobi-Bellman equation, Continuous Linear Regulator problems

Calculus of Variations and Pontryagin's Minimum Principle
Calculus of Variations, Functional of single variable, Functions involving several independent variables, Constrained extrema, Variational Approach to Optimal Control Problems, Necessary conditions for Optimal Control, Pontryagin's Minimum Principle and State Inequality constraints, Minimum Time problems, Minimum Control Effort problems

Iterative Techniques for Optimal Control
Numerical Determination of Optimal Trajectories, Two-point boundary value problems, Method of Steppest Descent, variation of Externals, Quasilinearization

Recommended Books :

- Donald E. Kirk¸Optimal Control Theory: An Introduction , Latest edition.
- Eduardo D. Sontag, Mathematical Control Theory: Deterministic Finite Dimensional Systems, Latest edition.
- Robert F Stengel, Stochastic Optimal Control: Theory and Application , Latest edition.
- Michael Athans, Peter L. Falb, Optimal Control: An Introduction to the Theory and Its Applications, 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	: KINEMATICS OF MOBILE ROBOTIC SYSTEMS **[MTS-618]**
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 knowledge related to key localization techniques.

Objectives :

1. To impart knowledge of basic locomotion methods.
2. To teach kinematics of legged and wheeled robots
3. To study the use of various sensors for perception and extract the features from the sensor data.

Contents :

Introduction

Typical applications, key issues for locomotion

Locomotion with legs and wheels

Leg configurations and stability, examples of legged robot locomotion, design space and case studies for wheeled locomotion

Mobile Robots Kinematics

Kinematics models and constraints, mobile robot maneuverability and workspace, openloop and closed loop kinematic control

Perception

Sensors for mobile robots: wheel, heading, beacon, ranging, motion and vision sensors

Uncertainty Representation: Statistical representation of uncertainty, error propagation

Feature extraction Laser, ultrasonic and vision-based sensor feature extraction, image based feature extraction

Localization

Introduction, odometry, Map representation, introduction to probabilistic map-based Markov localization, Kalman filter localization, autonomous map building.

Recommended Books :

- Roland Siegwart and Illah Nourbakhsh, Introduction to Autonomous Mobile Robots, Latest edition.
- George Bekey, Autonomous Robots, latest edition.

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

Title of Subject	: COGNITIVE ROBOTICS **[MTS-619]**
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 apply cognition techniques to robots

Objectives :

1. This course is designed to study cognitive robotics that addresses the emerging field of autonomous systems possessing artificial reasoning skills.
2. To design a system and apply algorithms and autonomy models

Contents :

Introduction to Cognitive Robotics: Learning Objectives, Remote Explorers, Model-based Programming

Robots that Deftly Navigate: Kinodynamic and Randomized Path Planning, Review of Configuration Spaces, Visibility Graphs, Voronoi Diagrams, Potential Fields, and Cell Decomposition, Kino-dynamic Planning, Planning with Moving Obstacles, Probabilistic Roadmaps (PRMs), Rapidly Exploring Random Trees (RRTs)

Introduction to Simultaneous Localization and Mapping (SLAM)

Localization, SLAM, Kalman Filter, Large Scale SLAM, Vision Based SLAM, Topological Maps, Hidden Markov Models (HMM), SIFT, Vision-based Localization

Deducing State and Diagnosing Failure: Model-based Diagnosis and Mode Estimation,Consistency-based Diagnosis: Candidates, Conflicts, Diagnoses, and Kernel Diagnoses, Conflict Extraction and Candidate Generation, Mode Estimation and Probabilistic Diagnosis, Active Probing

Solving Optimal CSPs through Conflict-Learning

Optimal Constraint Satisfaction Problems, Constraint-based A*, Conflict-directed A*, Conflict Extraction

Planning Complex Missions

Mission-level Task Planning, Partial Order Planning, Constraint-based Interval Planning, and Simple Temporal Networks (STNs), Dynamic Plan Execution Under Uncertainty, STNS, Dispatchable Networks and Dispatching Execution, STNUs, Strong and Dynamic Controllability, Mixed Human Robotic Exploration

Robots that Plan on the Fly: Hidden State and Model-based Reactive Planning, Universal Planning, Structure Decomposition for Model-based Reactive Planning (MRP), Binary Decision Diagrams, Symbolic MRP, Continuous, Incremental Path Planning and Exploration, Single Source Shortest Path, D*, LRTA*

Cognitive Game Theory: Alpha-Beta and its Extensions, An Evolutionary Algorithm Applied to Chess, Inductive Adversary Modeler, Particle Filters and their Applications, Particle Filters in SLAM in Fault Diagnosis

Sensing and Manipulating at the Cognitive Level: Visual Interpretation using Probabilistic Grammars, Statistical Parsing, Image Segmentation, Monte Carlo Methods, Language Learning

Human Robot Interaction: Working with and Learning from Humans as Partners, Multi-modal Communication, Human-robot Teamwork, Socially Guided Learning

Recommended Books :

- Patnaik, Srikanta , Robot Cognition and Navigation - An Experiment with Mobile Robots Series, Latest edition.
- Ronald Brachman and Hector J. Levesque, Knowledge Representation and Reasoning, Latest edition
- Raymond Reiter, Knowledge in Action: Logical Foundations for Specifying and Implementing Dynamical Systems, Latest edition.

Approval	:	Board of Studies	Res. No. 3.1	Dated: 27-08-2018
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MEHRAN UNIVERSITY OF ENGINEERING AND TECHNOLOGY, JAMSHORO
INSTITUTE OF INFORMATION AND COMMUNICATION TECHNOLOGIES

Title of Subject	: COMPUTATIONAL GEOMETRY **[MTS-620]**
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 :
On completion of course, student will be able to implement libraries of geometric data structures and algorithms efficiently/accurately.

Objectives :
1. The course will contain review of basic algorithms and discussion of active research topics in the design and analysis of efficient algorithms and data structures for geometric problems with applications.
2. To carryout point location search.

Contents :

Polygon Triangulation
Art Gallery Theorems, Triangulation, Area of Polygons, Segment Intersection, Trapezoidalization

Convex hulls in two and higher dimensions
Naïve Algorithms for Extreme Points, Graham's Algorithm, Incremental Algorithm

Proximity problems
closest pair, closest point queries

Voronoi diagrams, Delaunay diagrams
Definitions and Basic Properties, Delaunay Triangulations, Connection to Convex Hull, Geometric minimum spanning trees, traveling salesman problem
Arrangements of lines, hyperplanes; geometric duality, Intersection problems; Bentley-Ottmann sweep

Point location search
Point Location and Trapezoidal Maps, Randomized Incremental Algorithm, Degenerate Cases

Parametric search, randomization.
Selected research topics in computational geometry, Selected application areas, one or two selected from computer graphics, manufacturing, robotics, GIS, geometric optimization

Recommended Books :
- Joseph O'Rourke ,Computational Geometry in C, Latest edition.
- Mark de Berg, Marc van Kreveld, Mark Overmars, and Otfried Cheong, Computational Geometry: Algorithms and Applications, Latest edition.

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

Title of Subject	: ADVANCED MEASUREMENT TECHNIQUES **[MTS-622]**
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 develop the advanced measurement systems.

Objectives :

1. To help students to gain an in-depth understanding of basic measurement theory, operating principle of modern measurement techniques,
2. To be capable for practical measuring machines and their applications in advanced manufacturing.

Contents :

Basics of measurement
Measurement uncertainty, data analysis and modeling
Displacement measurement
capacitive, inductive and magnetic sensors, Linear scales,
Interferometry
heterodyne and homodyne, their calibration,
Surface metrology
stylus and optical Instrumentation, profile and areal Characterisation, Calibration,
Scanning probe microscopy
SPM dimensional metrology, Calibration,
Materials metrology
General materials metrology, Energy beam techniques, Analytical techniques,
Low force and mass measurement
Measurement methods for low forces, techniques to measure low mass
Coordinate measuring machines
Structure, probes, multisensory measuring system

Recommended Books :

- Connie L Dotson, Fundamentals of Dimensional Metrology, Latest edition.
- Nobou Suga and Peter Rollings, Metrology Handbook: The Science of Measurement , Latest edition.
- John F.W. Galyer and C. Shotbolt , Metrology for Engineers, Latest edition.
- Anand K. Bewoor and V. A. Kulkarni , Metrology and Measurements, Latest edition

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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	: COMPUTER INTEGRATED MANUFACTURING **[MTS-623]**
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: The objective of this course is to develop an understanding of classical and state-of-the-art production systems, control systems, management technology, cost systems, and evaluation techniques.

Objectives:

1. To develops an understanding of computer-integrated manufacturing (CIM) and its impact on productivity, product cost, and quality.
2. To overview of computer technologies including computers, database and data collection, machine control, etc., as they to apply to factory management and factory floor operations.
3. To integrate the manufacturing activities into a complete system and helps to enhance performance of manufacturing systems by applying different CIM concepts and tools.

Contents :

Introduction
Overview of computer integrated manufacturing (cim), importance of cim.

Business perspectives for cim
Business characteristics of cim systems, justifying investments.

Human resource requirements
Quality issues, implementation difficulties / analysis of manufacturing operations.

Computers in manufacturing
Peripherals, factory information systems (fis), group technology/ coding systems.

Cellular manufacturing
Facility layout, flexible manufacturing systems (fms).

Product design
Computer aided process planning (capp).
Structure, probes, multisensory measuring system

Recommended Books :

- S Kant Vajpayee, Principles of Computer Integrated Manufacturing, Latest edition.
- Mikell P. Groover, Automation, Production Systems and Computer Integrated Manufacturing , Latest edition.
- Alan Weatherall , Computer Integrated Manufacturing, from fundamentals to implementation, Latest edition.
- K C Jain & Sanjay Jain, Principles of Automation and Advanced Manufacturing Systems, Latest edition.

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

Title of Subject	: ROBUST CONTROL **[MTS-624]**
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 aim of this subject is to teach the advanced concepts of multivariable robust control.

Objectives:
1. To effectively design and develop robust control
2. To carry model validation,
3. To solve mixed μ problem.

Contents:

Review of Linear Algebra: Linear subspaces, Eigenvalues and Eigenvectors, Matrix Inversion Formulas, Invariant Subspaces, Vector Norms and Matrix Norms, Singular Value Decomposition

Review of Linear Systems: Controllability and Observability, Observers and Observer-Based Controllers, Operations on Systems, Multivariable System Poles and Zeros

H_2 and H_∞ Spaces: Hilbert Spaces, H_2 and H_∞ Spaces, Computation of L_2 and H_2 Norms, Computation of L_∞ and H_∞ Norms,

Internal Stability, Performance Specifications and Limitations

Feedback Structure, Well-Posedness of Feedback Loop, Coprime Factorization over RH_∞, Weighted H_2 and H_∞ Performance, Selection of Weighting Functions, Analyticity Constraints

Uncertainty and Robustness: Lyapunov Equations, Model Reduction by Balanced Truncation, Frequency-Weighted Balanced Model Reduction, Model Uncertainty, Small Gain Theorem, Stability under Unstructured Uncertainties, Robust Performance, Skewed Specifications

mu and mu Synthesis: General Framework for System Robustness, Structured Robust Stability and Performance, Overview of μ Synthesis

Controller parametrization: Existence of Stabilizing Controllers, Parameterization of All Stabilizing Controllers, Coprime Factorization Approach

H_2 Optimal Control and H_∞ Control: Introduction to Regulator Problem, Standard and Extended LQR Problem, Guaranteed Stability Margins of LQR, Stability Margins of H 2 Controllers, Simplified H ∞ Control Problem, Optimality and Limiting Behavior, Minimum Entropy Controller, General H_∞ Solutions, H_2 and H_∞ Integral Control, H_∞ Filtering.

H_∞ Loop Shaping: Robust Stabilization of Coprime Factor, Loop-Shaping Design, Justification and Guidelines for H_∞ Loop Shaping

Recommended Books :
- Kemin Zhou, Essentials of Robust Control, Latest edition.
- Geir E. Dullerud and Fernando G. Paganini, A Course in Robust Control Theory: a convex approach, Latest edition.
- Sigurd Skogestad and Ian Postlethwaite, Multivariable Feedback Control Analysis and Design, Latest edition.

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

Title of Subject	: ADAPTIVE CONTROL **[MTS-625]**
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 aim of this course is to impart the knowledge of design methods of adaptive control.

Objectives :
1. To discuss peripherals of adaptive control.
2. To apply adaptive control including parameter identification as the core, intelligent control as the extension, and robust control as the complementary of adaptive control.

Contents :

Introduction
Identifier and Non-identifier based Adaptive Control

Parameter Identification: Continuous Time
Persistence of Excitation and Sufficiently Rich Inputs, Gradient Algorithms based on Linear Model, Least Square Algorithms, Parameter Identification based on DPM. Parameter Identification based on B-SPM, Robust Parameter identification, State-space identifiers, Adaptive Observers

Continuous-Time Model Reference Adaptive Control
Simple MRAC Schemes, MRC for SISO Plants, Direct MRAC with Unnormalized Adaptive Laws, Direct MRAC with Normalized Adaptive Laws, Indirect MRAC, Robust MRAC

Continuous-Time Adaptive Pole Placement Control
APPC schemes without Normalization, APPC Scheme: Polynomial Approach, APPC Scheme: State-Space Approach, Adaptive Linear Quadratic Control

Adaptive Control of Non-linear Systems
Feedback Linearization, Control of Lyapunov Functions, Backstepping, Adaptie Backstepping with Tuning Functions, Neuroadaptive Control

Recommended Books :
- Petros Ioannou, Baris Fidan, Adaptive Control Tutorial, Latest edition.
- Karl J. Astrom and Dr. Bjorn Wittenmark, Adaptive Control, Latest edition.
- Landau, I.D., Lozano, R., M'Saad, M., Karimi, A, Adaptive Control Algorithms, Analysis and Applications, Latest edition.

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

Title of Subject	: MICRO ELECTRO MECHANICAL SYSTEMS **[MTS-626]**
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 : This course deals with the fundamentals of Micro and nano electro mechanical systems.

Objectives :

1. To discuss challenges in fabrication using the proper grasp of dominant physical, chemical, and biological principles acting on the devices.
2. The course offers insight in MEMS design principles, detailed fabrication techniques, and detailed analysis of processes involved in MEMS system implementation.
3. To discuss about micro sensors, micro actuators and their modelling techniques are also part of this course.

Contents :

Introduction to microfabrication: History of mems development, characteristics of mems-miniaturization - micro electronics integration, devices: sensors and actuators.

Overview of microfabrication: Overview of microfabrication, frequently used microfabrication processes, microelectronics fabrication process flow, packaging and integration.

Thermal sensing and actuation: Introduction: thermal sensors and actuators, thermal couples, thermal resistors, applications.

Electrical and mechanical concepts: Overview, conductivity of semiconductors, crystal planes and orientations, stress and strain, torsional deflections, dynamic systems, resonant frequency.

Electrostatic sensing and actuation: Parallel plate capacitors and applications, interdigitated finger capacitors, comb drives.

Piezoresistive sensing: Sensor materials, sensor mechanical analysis, applications of piezoresistive sensors.

Piezoelectric sensing and actuation: Introduction, properties of piezoelectric materials, applications.

Magnetic actuation: Essential concepts and principles, fabrication of micro magnetic components, case study of mems magnetic actuators.

Bulk micromachining and silicon anisotropic etching

Introduction, dry / wet etching and deep reactive ion etching (drie), gas-phase etchants.

Surface micromachining: Basic processes, structural and sacrificial material, stiction/anti stiction methods.

Microfluidic applications: Motivation for microfluidics, essential biology concepts, basic fluid mechanics, design and fabrication of selective components.

Recommended Books :

- Chang Liu, Foundation of MEMS, Latest edition
- Marc J. Madou, Fundamentals of microfabrication: The science of miniaturization, Latest edition.

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

Title of Subject	: LASER MATERIAL PROCESSING **[MTS-627]**
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 : This course is designed to study the laser technology and the physics in laser-based manufacturing and materials processing techniques.

Objectives :

1. To apply the different analytical and numerical models that capture the physics in material processing techniques. On completion of this course student will be able:
2. To select the appropriate laser techniques for manufacturing and materials process.
3. To improve the metal properties by applying proper laser techniques.

Contents :

Introduction to laser
processing, challenges for the future and its industrial applications, Interaction of optical energy with matter, Characteristics of optical energy, Range of current industrial applications and Future trends, The challenges ahead for laser macro, micro, and nano manufacturing.

Laser cutting and Machining
Principles of fusion laser cutting, laser cutting of difficult materials and its improvement, Laser-assisted glass cleaving, The multiple laser system, Numerical simulation, Numerical results and discussions, Crack propagation in laser cleaving. Laser machining of silicon, Conventional laser dicing of silicon wafer, Laser-silicon interaction, Laser machining of carbon fibre-reinforced plastic composites.

Laser welding
Laser spot welding results, Continuous wave (CW) laser welding, formation mechanisms and suppression procedures of welding defects, Keyhole formation and dynamics, Melt pool dynamics, Micro welding of copper and aluminium, Enhancing laser welding capabilities.

Laser surface engineering
Laser annealing and hardening, Pulsed laser annealing technology for nanoscale fabrication, Surface treatment, coating and materials deposition using lasers, Micro- and nano-parts generated by laser-based
Solid Freeform Fabrication, Laser-assisted additive fabrication of micro-sized coatings,

Recommended Books :

- J. Lawrence, J. Pou, D. K. Y. Low and E. Toyserkani, "Advances in laser materials processing", Latest Edition.
- Esther Titilayo Akinlabi, Rasheedat Modupe Mahamood, Stephen Akinwale Akinlabi, "Advanced Manufacturing Techniques Using Laser Material Processing", Latest Edition.
- John C. Ion eur. ing., ceng, fimmm, Laser Processing of Engineering Materials Principles, Procedure and Industrial Application, Latest Edition.
- Elijah Kannatey-Asibu, Jr., Principles of Laser Materials Processing, Latest

Edition.

- John Michael Dowden, The Mathematics of Thermal Modeling: An Introduction to the Theory of Laser Material Processing, Latest Edition.

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

Title of Subject	: RAPID PROTOTYPING, TOOLING AND AUTOMATION **[MTS-628]**
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 : This course is designed to study the principles and application areas in Rapid Response Manufacturing Techniques.

Objectives :
1. To apply RRMT concepts in support of developing new products.
2. To evaluate the capabilities of various rapid prototyping (RP) processes,
3. To develop techniques for accelerating the product and manufacturing development process.

Contents :

Introduction

Product Prototyping, its Impact and Product Developments, Physical Prototype Design Procedure, Prototype Planning and Management, Project Vision in Project Management, Project Risk Management, Product and Prototype Cost Estimation, Prototype Design Methods, Design Tools, Paper Prototyping.

Modelling and Virtual Prototyping

Rapid Prototyping Data Formats, Modelling of Physical Systems, Product Modelling, Virtual Reality and Virtual Prototyping, Prototyping Materials, Modelling of Material Properties, Modelling and Design of Materials and Structures, Direct Digital Prototyping and Manufacturing

Rapid tooling techniques,

new materials development, Bi-metallic parts, Re-manufacturing, Rapid Soft Tooling, Rapid Bridge Tooling, Rapid Production Tooling, Composite Tooling, Rapid Tooling in Investment-Casting Applications

Rapid Prototyping Processes

Liquid-Based Rapid Prototyping Processes, Solid-Based Rapid Prototyping, Processes, Powder-Based Rapid Prototyping Processes.

Prototyping of Automated Systems

Actuators, Sensors, Controller and Analyzer, Applications and Selection of Mechanisms, Using Prototypes for Product Assessment, Orthogonal Arrays, Analysis of Variance, ANOVA, Quality Characteristic, Optimization of a Prototype Laser Deposition Process.

Recommended Books :

- L. L. Faulkner, Rapid Prototyping and Engineering Applications, Latest Edition.
- Chua C. K., Leong K. F., Lim C. S., Rapid Prototyping: Principles and Applications, Latest Edition.
- Adedeji B. Badiru, Additive Manufacturing, Latest Edition.
- Peter D. Hilton, Paul F. Jacobs, Rapid Tooling Technologies and Industrial Applications, Latest Edition.

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

Title of Subject	: DIGITAL CONTROL SYSTEMS **[MTS-629]**
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 :

Have in-depth knowledge and critical understanding of the theory and principles of digital control systems and their applications

Objectives :

1. Analyze the behaviour of a discrete system in time domain and in frequency domain
2. Design and synthesize controllers that will be implemented using digital hardware.
3. Apply digital control systems' principles and techniques to discrete or continuous time systems

Contents :

Introduction

Digital Control Systems, Quantizing and Quantization Error, Data Acquisition, Conversion and Distribution System

z-Transform

z-transforms of Elementary Functions, Properties and Theorems of z-transform, Inverse z-transform, z-Plane Analysis of Discrete Time Control Systems, Impulse Sampling and Data Hold, Obtaining z-Transform by Convolution Integral, Reconstruction of Original Signal from Sampled Signals, Pulse Transfer Function, Realization of Digital Controllers and Digital Filters

Design by Conventional Methods

Mapping between s-Plane and z-Plane, Stability Analysis of Closed Loop System in z-plane, Transient and Steady-State Response Analysis, Design Based on Frequency Response

State-Space Analysis

State-Space Representation of Discrete Time Systems, Pulse Transfer Function Matrix, Lyapunov Stability Analysis

Pole Placement and Observer Design

Controllability and Observability, Design via Pole Placement, State Observers, Servo Systems

Quadratic Optimal Control

Steady-State Quadratic Optimal Contro

Recommended Books :

- Katsuhiko Ogata, Discrete-Time Control Systems, Latest edition.
- Gene F. Franklin, J. David Powell, Michael L. Workman, Digital Control of Dynamic Systems, Latest edition.
- M. Sami Fadali Antonio Visioli, Digital Control Engineering, Latest edition.
- Landau, Ioan Doré, Zito, Gianluca, Digital Control Systems: Design, Identification and Implementation, Latest edition.

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

Title of Subject	: FILTERING AND TRACKING **[MTS-630]**
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 to solve linear and nonlinear filtering problem and understand the optimal solution to the filtering problem

Objectives :

1. Understand all the main filter algorithms such that they know when and how to apply them
2. Perform model selection in time varying settings
3. Design suitable measurement and motion models when given a new real-world problem

Contents :

Positioning: Complementary Filtering for Navigation, Inertial Navigation Systems, Models For Inertial Navigation Systems, Accuracy of GPS positioning, state-space models for GPS, GPS navigation with IMM estimator, integrated navigation

Constant velocity models: Optimal/conceptual solutions to general filtering problems

Kalman filters: The Kalman-Bucy Problem, State Estimation for Vehicle Collision Avoidance**,** Particle filters

Extended and Unscented Kalman filters: Approximation of the Nonlinear Estimation Problem, stability,

MMSE and LMMSE estimators: Least Squares and Minimum Mean Square Error Estimation, MMSE vs. MAP Estimator in Gaussian Noise. Linear MMSE Estimation for Vector Random Variables.

Model selection in time varying settings: Selection of noise levels, IMM algorithm, choice of the transition probabilities.

Interacting Multiple Model filters: Complexity reduction using merging and pruning

Recommended Books :

- Branko Ristic, Sanjeev Arulampalam, Neil Gordon, Beyond the Kalman Filter: Particle Filters for Tracking Applications, Latest edition.
- Yaakov Bar-Shalom, X. Rong Li, Thiagalingam Kirubarajan , Estimation with Applications to Tracking and Navigation, Latest edition.
- Fredrik Gustafsson, Statistical Sensor Fusion, Latest edition.
- Phil Kim, Lynn Huh, Kalman Filter for Beginners : with MATLAB Examples, Latest edition.

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

Title of Subject	: PARADIGMS OF ARTIFICIAL INTELLIGENCE **[MTS-631]**
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 develop the concepts of artificial intelligence, intelligent machines and differences between natural and artificial intelligence.

Objectives :

1. To understand the fundamental concepts of neural networks, neuro-modelling, several neural network paradigms and its applications.
2. To understand the concepts of fuzzy sets, fuzzy logic control and its applications.
3. To be able to create software for intelligent agents using these techniques.

Contents :

Introduction to Artificial Intelligence: Foundations of AI, Intelligent Agents, Agents and Environments, Good Behaviour, Nature of Environments, Structure of Agents

Problem Solving: Solving Problems by Searching, Problem Solving Agents, Uninformed Search Strategies, Informed (Heuristics) Search Strategies, Heuristic Functions

Adversarial Search: Optimal Decisions in Games, Alpha-Beta Pruning, Stochastic Games, Partially Observable Games,

Knowledge, Reasoning and Planning, Logical Agents
Knowledge-Based Agents, Propositional Logic, Agents Based on Propositional Logic

First-Order Logic and Inference: Syntax and Semantics of First-Order Logic, Knowledge Engineering in First-Order Logic, Unification and Lifting, Forward and Backward Chaining

Classical Planning: Algorithms for Planning as State-Space Search, Planning Graphs

Knowledge Representation: Ontological Engineering, Categories and Objects, Events

Uncertain Knowledge and Reasoning: Probabilistic Reasoning, Semantics of Bayesian Networks, Efficient Representation of Conditional Distribution, Exact and Approximate Inference in Bayesian Networks

Probabilistic Reasonig over Time
Inference in Temporal Models, Hidden Markov Models, Kalman Filters, Dynamic Bayesian Networks

Learning: Supervised Learning, Learning Decision Trees, Evaluating and Choosing Best Hypothesis, Regression and Classification with Linear Models, Artificial Neural Networks, Support Vector Machines

Reinforcement Learning: Passive and Active Reinforcement Learning, Policy Search, Applications of Reinforcement Learning

Communication Perceiving and Acting: Natural Language Processing, Language Models, Text Classification, Information Retrieval, Information Extraction

Perception: Image Formation, Object Recognition by Appearance, Object Recognition from Structural Information
Robotics: Robot Hardware, Robotic Perception, Planning to Move, Planning Uncertain Movements, Robotic Software Architecture
merging and pruning

Recommended Books :

- Tom M. Mitchell, Machine Learning, Latest edition.
- Laurene Fausett, Fundamentals of Neural Networks: Architectures, Algorithms and Applications, Latest edition.
- Jun Yan, Michael Ryan and James Power, Using Fuzzy Logic, Latest edition.
- Achim Hoffman, Paradigms of Artificial Intelligence: A Methodological and Computational Analysis, Latest edition

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

Title of Subject	: REAL TIME SYSTEMS **[MTS-632]**
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 aim of the course is to bring students up to a point that they understand the motivation, theoretical background, and some of the work that has been done in the field of real-time systems.

Objectives :

1. To apply advanced techniques, such as rate monotonic analysis, to practical problems without any further study.
2. To develop the concepts of scheduling of tasks.

Contents :

Introduction to real-time systems

Overview control systems, real-time systems and embedded systems, classification of real-time systems.

Typical real time applications: Overview of real-time applications, digital controls, high level controls, signal processing, other real time applications.

Hard versus soft real time applications: Jobs and processors, release times, deadlines and timing constraints, hard and soft timing constraints, hard real time systems, soft real time systems.

Uniprocessor scheduling (static/dynamic/state priority scheduling): Scheduling preemptable and independent tasks: Fixed-Priority Schedulers, Dynamic-Priority Schedulers, Comparing Fixed and Dynamic-Priority Schedulers, Scheduling Nonpreemptable Taskes: Scheduling nonpreemptable sporadic tasks, Nonpreemptable tasks with precedence constraints, Periodic tasks with critical sections

Clock driven scheduling

Notations and assumptions, static and timer driven scheduler, general structure of cyclic schedules, scheduling sporadic jobs, practical considerations and generalizations, procs and cons of clock-driven scheduling

Priority driven scheduling of periodic tasks

Static assumption, fixed-priority versus dynamic-priority algorithms, schedulability test for fixed-priority tasks with short and arbitrary response times, practical factors, pre emptive/non-pre emptive systems.

Resource sharing: Assumptions on resources and their usage, Effects of resource contention and resource access control, Basic Priority-inheritance protocol, Basic Priority-Ceiling protocol, Stack based, priority ceiling protocol, use of priority-Ceiling protocol in Dynamic-Priority systems, Preemption ceiling protocol, Controlling accesses to Multiple-Unit Resources, Controlling concurrent accesses to data objects

Multiprocessor and distributed systems: Model of Multiprocessor and distributed systems, Task assignment, Multiprocessor priority-ceiling protocol, Elements of scheduling algorithms for end-to-end periodic tasks, Schedulability of fixed priority end to end periodic tasks, End-to-End tasks in Heterogeneous systems, Predictability and validation of Dynamic Multiprocessor systems

Recommended Books :

- Jane Liu, Real Time Systems, Latest edition.
- Phillip A. Laplante, Real-time systems design and analysis, Latest edition.
- Alan Burns and Andy Wellings,Real-Time Systems and Programming Languages, Latest edition
- Alan C. Shaw,Real-Time Systems and Software , Latest edition.

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

Title of Subject	: PROGRAMMING FOR EMBEDDED SYSTEMS **[MTS-601]**
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 : Develop embedded systems based on real time operating systems.

Objectives :

1. Develop embedded software of high quality using high level programming in e.g. C.
2. Develop software on hardware platforms taking limitations such as memory size, processor capacity, and bandwidth into account.
3. Develop reliable software taking fault tolerance and recovery into consideration.
4. Develop correct and efficient software using fault detection and other test systems.

Contents :

Introduction to Hardware
Embedded Design Example, C Language, Hardware Basics, Processor and Peripherals Communication

Simple Embedded Program
Hello, World!, Blinking LED Program, Infinite Loop

Compiling, Linking, Locating and Debugging:
Building the Blinking LED Program, Remote Debuggers, Emulators, Memory, Types of Memory, Direct Memory Access, Memory Testing, Validating Memory Contents, Using Flash Memory

Peripherals: Control and Status Registers, Device Driver Philosophy and Design

Interrupts: Interrupt Map, Interrupt Service Routine

Operating Systems: Scheduler, Task Synchronization, Message Passing, Interrupt Handling

Embedded Linux Examples: Accessing Hardware in Linux, Task Mechanics, Mutex Task Synchronization, Semaphore Task Synchronization

Optimization Techniques:
Increasing Code Efficiency, Decreasing Code Size, Reducing Memory Usage, Power Saving Techniques

Recommended Books :

- Michael Barr, Anthony Massa, Programming Embedded Systems: With C and GNU Development Tools, Latest edition.
- Mark Siegesmund, Embedded C Programming: Techniques and Applications of C and PIC MCUS, Latest edition.
- Jack Ganssle, The Art of Programming Embedded Systems, Latest edition.Alan C. Shaw,Real-Time Systems and Software , 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	: ARTIFICIAL NEURAL NETWORKS **[MTS-634]**
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: Implement ANN algorithms to achieve signal processing, optimisation, classification as well as process modelling

Objectives:
1. explain the function of artificial neural networks (ANN) of the type Back-prop, Hopfield, RBF and SOM
2. explain the difference between supervised and unsupervised learning
3. account for assumptions and derivations behind the ANN algorithms that are brought up in the course
4. give examples of design and implementation for small problems

Contents :

Introduction to Neural Networks: Perceptrons and the LMS Algorithm, Backpropagation Learning

Visually-Guided Robot Control: Overfitting, Cross-Validation, and Early Stopping

Simple Recurrent Networks: Language Processing Models, Pattern Classification, Radial Basis Functions, The EM (Expectation-Maximization) Algorithm

Neural Networks for Control: Support Vector Machines, Time Series Prediction, Shared Weight Networks

Competitive Learning and Kohonen Nets: Hebbian Learning and Principal Components Analysis, Hopfield Nets and Boltzmann Machines, Mean Field Approximation, Helmholtz Machines; Minimum Description Length

Bayesian Networks: Computational Learning Theory, Connectionist Symbol Processing, Reinforcement Learning, Neurophysiology for Computer Scientists

Recommended Books :
- John Hertz, Anders Krogh, Richard G. Palmer, Introduction to the Theory of Neural Computation, Latest edition.
- Bishop, C. M. , Neural Networks for Pattern Recognition, Latest edition

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

Title of Subject	: OPTOMECHATRONIC SYSTEMS **[MTS-614]**
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 develop the advanced concepts of Optomechatronic systems.

Objectives :

1. To understand the importance of Mechatronics elements in the field of Optomechatronic system.
2. To familiarize the students with various micro-fabrication techniques in the field of Optomechatronics.
3. To familiarize the students with various software used in the design and simulation of MEMS/MOEMS.implement ANN algorithms to achieve signal processing, optimisation, classification as well as process modelling

Contents :

Optomechatronic Technology

Historical Background of Optomechatronic Technology, Optomechatronics: Definition and Fundamental Concepts

Fundamental Functions of Optomechatronic Systems

Principles of Optics

a. Reflection and Refraction
b. Lenses, Multiple Lens Systems, Aperture Stops and Pupils
c. Optical Aberrations
d. Polarization, Coherence, Interference and Diffraction
e. Optical Fiber Transmission
f. Gaussian Beam Optics

Mechatronics Elements of Optomechatronic System

a. Optomechatronic Actuation
b. Optomechatronic Sensing
c. Optical Scanning, Optical Switching
d. Zoom Control, Visual Auto focusing
e. Optical Signal Transmission and Display
f. Dynamic Systems and Control

Visual (Optical) Information Feedback Control

Micro-fabrication Techniques

a. Bulk micromachining b. Surface micromachining

CMOS-compatible MEMS and MOEMS

Compound-semiconductor-based MEMS and MOEMS

Technologies for continuous surface profiles

Optomechatronic Systems in Practice,

Adaptive Optics: Adaptive Optics Imaging Systems, Beam Propagation Systems**,** MEMS/MOEMS CAD and Simulation, FEM Simulation using COMSOL Multiphysics, Micro-fabrication, Design and Simulation

Case Studies

Laser Printers, Optical Storage Disk, Atomic Force Microscope, Confocal Scanning Microscope, Projection Television and Visual Tracking System,

Recommended Books :	• Hyungsuck Cho, Optomechatronic: Fusion of Optical and Mechatronics Engineering, Latest edition • M. Edward Motamedi, MOEMS: Micro-opto-electro-mechanical Systems, Latest edition • Marc J Madou, Fundamentals of Microfabrication and Nanotechnology, Latest edition. • Mark A. Mentzer,, Applied Optics Fundamentals and Device Applications Nano, Moems, and Biotechnology, Latest Edition.

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

Title of Subject	: FUZZY LOGIC HYBRID SYSTEMS **[MTS-636]**
Disciplines	: M.E. Mechatronic Engineering
Semestre	: 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 covers the main aspects of fuzzy systems together with their applications.

Objectives :

1. To teach of hybrid systems (neuro-fuzzy, and fuzzy-genetic), hybrid intelligent systems and examples to problem solving using hybrid intelligent systems.
2. To apply various hybrid system to intelligent systems.

Contents :

Introduction to fuzzy logic
Case for Imprecision, Utility of Fuzzy Systems, Limitations of Fuzzy Systems
Fuzzy logic applications
Aerospace, Automotive, Defence, Finance, Manufacturing
Introduction to fuzzy sets and fuzzy operations
Properties of Fuzzy Sets, Noninteractive Fuzzy Sets, Fuzzy Set Operations
Fuzzy logic control design
Rule-Base, Fuzzification, The Inference Mechanism, Defuzzification
Neuro-fuzzy systems
Adaptive Neuro-Fuzzy Inference System, Simulation
Fuzzy-Genetic systems
Genetic Algorithm and Fuzzy Fitness Finder
Application of fuzzy logic to robots and intelligent machines and hybrid fuzzy systems to robotics and intelligent machines, Type-2 fuzzy systems

Recommended Books :

- J.S.R. Jang, C.T. Sun, and E. Mizutani, Neuro-Fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence, Latest edition.
- D. Nauck, F. Klawonn, R. Kruse, Wiley, Chichester, Foundations on Neuro-Fuzzy Systems, Latest edition.
- T.J. Ross, Fuzzy Logic with Engineering Applications, Latest edition.
- K.M. Passino, S.Yurkovich, Fuzzy Control, Latest edition.
- Lin, Neural Fuzzy Systems: A Neuro-Fuzzy Synergism, Latest edition.
- G.J. Klir and T.A. Folger, Fuzzy Sets, Uncertainty, and Information, Latest edition.

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		Advanced Studies and Research Board	Res. No.151.18(a)	Dated: 04-09-2018
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MEHRAN UNIVERSITY OF ENGINEERING AND TECHNOLOGY, JAMSHORO
INSTITUTE OF INFORMATION AND COMMUNICATION TECHNOLOGIES

Title of Subject	: NATURAL LANGUAGE PROCESSING **[MTS-637]**
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 make models to understand, interpret and manipulate human language.

Objectives:
1. To fill the gap between human communication and computer understanding.
2. To use techniques for interpreting free text to analyse.

Contents :

Introduction
Regular Expressions, Text Normalization, Minimum Edit Distance

N-gram Language models
N-grams, Evaluating Language Models, Generalization and Zeros, Kneser-Ney Smoothing

Naive Bayes and Sentiment Classification
Naive Bayes Classifiers, Optimizing for Sentiment Analysis, Naive Bayes for other text classification tasks, Test sets and Cross-validation,

Logistic Regression
Classification: the sigmoid, The cross-entropy loss function, Gradient Descent, Regularization,

Vector Semantics
Lexical and Vector Semantics, Cosine for measuring similarity, TF-IDF: Weighing terms in the vector, Bias and Embeddings

Neural Networks and Neural Language Models
The XOR problem, Feed-Forward Neural Networks, Neural Language Models

Part-of-Speech Tagging
Penn Treebank Part-of-Speech Tagset, HMM Part-of-Speech Tagging, Maximum Entropy Markov Models, Bidirectionality

Syntactic Parsing
Ambiguity, CKY Parsing, Partial Parsing

Statistical Parsing
Probabilistic Context-Free Grammars, Probabilistic CKY Parsing of PCFGs, Ways to Learn PCFG Rule Probabilities, Probabilistic Lexicalized CFGs, Probabilistic CCG Parsing, Human Parsing

Information Extraction
Named Entity Recognition, Relation Extraction, Extracting Times, Template Filling

Dialog Systems and Chatbots
Knowledge-based Question Answering, Chatbots, Frame Based Dialog Agents

Recommended Books :

- Chris Manning and Hinrich Schütze, Foundations of Statistical Natural Language Processing, Latest edition.
- Brian Roark, Richard Sproat , Computational Approaches to Morphology and Syntax, Latest edition.
- Daniel Jurafsky and James H. Martin, An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition , Latest edition.

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

Title of Subject	: SMART MATERIALS AND STRUCTURES **[MTS-638]**
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 comprehensive knowledge and modelling methods for various smart materials and structures.

Objectives :
1. To provide comprehensive knowledge of various smart materials.
2. To present engineering applications of smart materials and structures along with modelling techniques.

Contents :

Introduction: Smart materials, smart structures, dependence of properties on structure, recent applications of smart materials, smart material properties

Piezoelectric Materials:
Electromechanical coupling in piezoelectric devices, physical basis for electromechanical coupling in Piezoelectric materials, constitutive equations for linear piezoelectric material, common operating modes of a piezoelectric transducer, dynamic force and motion sensing, operating mode of a piezoelectric device, Derivation of the piezoelectric constitutive relationships, approximation methods for static analysis Of piezolectric material systems, piezoelectric beams, piezoelectric material systems: dynamic analysis, spatial filtering and modal filters in piezoelectric material systems, piezoelectric plates, electrostrictive materials

Shape Memory Materials: Properties of Thermally Activated Shape Memory Materials, Physical Basis for Shape Memory Properties, Constitutive Modeling, Multivariant Constitutive Model, Actuation Models of Shape Memory Alloys, Electrical Activation of Shape Memory Alloys, Dynamic Modeling of Shape Memory Alloys for Electrical Actuation

Magnetostrictive Materials: Basics of Magnetostriction, Magnetosrtictive Materials Applications, modelling of magnetostrictive materials

Electrorheological Fluids: Electrorheological material properties, classification, applications, ER fluid composition and theory, ER fluid vibration damping

Magnetorheological fluids
MR fluid composition, applications, properties of MR Actuators, Design and modelling of MR fluid Systems

Active polymers: Fundamental Properties of Polymers, Dielectric Elastomers, Conducting Polymer Actuators, Ionomeric Polymer Transducers, Input–Output Transducer Models, Actuator and Sensor Equations, Material Properties of Ionomeric Polymer Transducers

Design, modeling and applications of smart materials systems
Motion Control Applications: Mechanically Leveraged Piezoelectric Actuators, Position Control of Piezoelectric Materials, Frequency-Leveraged Piezoelectric Actuators, Motion Control Using Ionomers, Passive and Semiactive Damping: Passive Damping, Piezoelectric Shunts, Multimode Shunt Techniques, Semiactive Damping Methods, Switched-State Absorbers and Dampers,Passive Damping Using

Shape Memory Alloy Wires, Parametric Study of Shape Memory Alloy Passive Damping Active Vibration Control: Second-Order Models for Vibration Control, Examples, Dynamic Output Feedback, Self-Sensing Actuation, Distributed Sensing, State-Space Control Methodologies

Recommended Books :

- M.V. Gandhi and B.S. Thompson , Smart materials and structures, Latest edition.
- Donald J.Leo, Engineering Analysis of Smart Material Systems, Latest edition
- M. Schwartz , Smart Materials, Latest edition..

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

Title of Subject	: PATTERN RECOGNITION AND ANALYSIS **[MTS-639]**
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 aim of this subject is to teach most widely used techniques and methodologies for pattern recognition tasks.

Objectives :
1. To provide knowledge of generic pattern recognition methods.
2. To impart knowledge of advanced techniques pattern recognition methods.

Contents :

Introduction to Pattern Recognition: Feature Detection, Classification

Review of Probability Theory:, Conditional Probability and Bayes Rule

Random Vectors:, Expectation, Correlation, Covariance, Review of Linear Algebra, Linear Transformations

Decision Theory: ROC Curves, Likelihood Ratio Test, Linear and Quadratic Discriminants, Fisher Discriminant

Sufficient Statistics: Coping with Missing or Noisy Features, Template-based Recognition, Feature Extraction, Eigenvector and Multilinear Analysis

Training Methods: Maximum Likelihood and Bayesian Parameter Estimation, Linear Discriminant/Perceptron Learning, Optimization by Gradient Descent, Support Vector Machines

K-Nearest-Neighbor Classification: Non-parametric Classification, Density Estimation, Parzen Estimation

Unsupervised Learning: Clustering, Vector Quantization, K-means, Mixture Modeling, Expectation-Maximization, Hidden Markov Models, Viterbi Algorithm, Baum-Welch Algorithm.

Linear Dynamical Systems: Kalman Filtering, Bayesian Networks, Decision Trees, Multi-layer, Perceptrons, Reinforcement Learning with Human Interaction, Genetic Algorithms, Combination of Multiple Classifiers "Committee Machines

Recommended Books :

- R. O. Duda, P. E. Hart, and D. G. Stork, Pattern Classification., Latest edition.
- T. Hastie et al., The Elements of Statistical Learning., Latest edition.
- K. Murphy, Machine Learning: A probabilistic Perspective, Latest edition.
- Theodoridis, K. Koutroumbas, Pattern recognition, Latest edition.

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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.

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