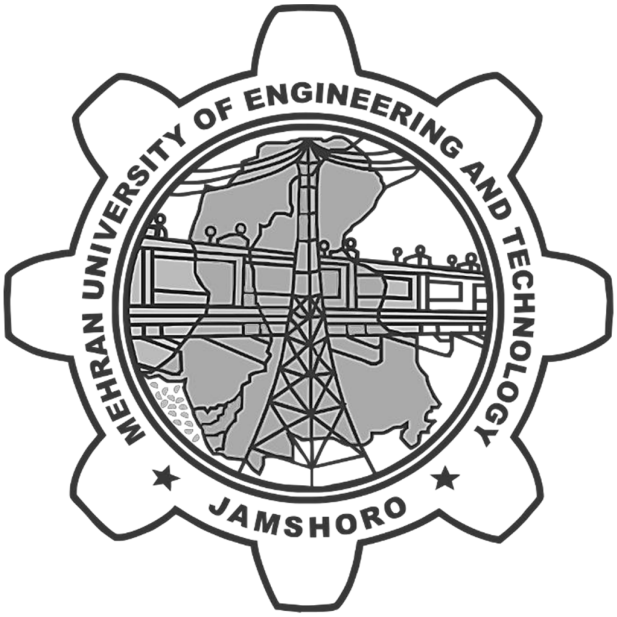
CURRICULUM

for the

PhD Mechatronic Engineering Program



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

PhD IN MECHATRONIC ENGINEERING PROGRAM

Number of weeks per semester:	18 (16 for teaching and 2 for examinations)
Total number of credit hours (Course work):	18
Dissertation/Thesis:	30
Number of credit hours per semester:	6
Core Courses:	6 Credit Hours
Elective Courses	12 Credit Hours

CORE COURSES

Sr. No.	Course Code	Course Title	CHs
1	MTH704	Mathematical Modelling and Simulation	03
2	RM860	Research Methodology	03

ELECTIVE COURSES

Sr. No.	Course Code	Course Title	CHs
1	MTS-801	Micro and Nano Fabrication	03
2	MTS-802	Photonic Devices	03
3	MTS-803	Non-Linear Control Systems	03
4	MTS-804	Advanced Topics in Control Systems	03
5	MTS-805	Advances in Manufacturing Technologies	03
6	MTS-806	Rapid Prototyping and Manufacturing	03
7	MTS-807	Advanced Information Systems for Manufacturing	03
8	MTS-808	Robotic Manipulation	03
9	MTS-809	Robot Motion Planning	03
10	MTS-810	Wearable Sensors	03
11	MTS-811	Advanced Mechatronics System Design	03
12	MTS-812	Pattern Recognition and Image Processing	03
13	MTS-XXX	Any other approved relevant course	

RESEARCH CREDITS

1	MTS-899	Dissertation	30

SCHEME OF STUDIES FOR
PhD IN MECHATRONIC ENGINEERING

Semester-1

S. No.	Subject Code	Subject Name	Credit Hours
1	MTH-850	Mathematical Modelling and Simulation	3
2	RM-860	Research Methodology	3

Semester-2

S. No.	Subject Code	Subject Name	Credit Hours
1	MTS-XXX	Elective-I	3
2	MTS-XXX	Elective-II	3

Semester-3

S. No.	Subject Code	Subject Name	Credit Hours
1	MTS-XXX	Elective-III	3
2	MTS-XXX	Elective-IV	3

Semester-4 & Onwards

S. No.	Subject Code	Subject Name	Credit Hours
1	MTS-899	Dissertation	30

PhD MECHATRONIC ENGINEERING

CORE COURSES

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

Title of Subject	: MATHEMATICAL MODELLING AND SIMULATION **[MTH-850]**
Disciplines	: PhD Mechatronic Engineering
Semester	: 1st
Effective	: 19 PhD-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 give the idea of converting the physical problems in mathematical Models and their simulations and its applications in Engineering field

Objectives: After completion of this course the student should be able to know the:

- Concept of modelling, types and nature of models
- Basic schemes of discretisation of PDE's
- Numerical solutions of the PDE's
- Estimations and hypothesis

Contents:

Linear Algebra: Matrix Theory; Computation of trivial and non-trivial solutions; linear and non-linear systems, Eigen valves and Eigen vectors, Approximation theory.

Mathematical models
Introduction to physical laws and representation of dynamical systems; interpolation, numerical differentiation and integration; solution of ordinary differential equations.

Introduction to simulation techniques
Finite difference Methods (FDM) and finite Element Methods (FEM). Problem formulation, Design of steady and time dependent algorithms. Solution of PDEs by employing FDM and FEM in one & two-dimensional problems.

Introduction to Inferential Statistics
Estimation of Parameters, test concerning means and variances; hypothesis test and goodness of fit; analysis and modeling of regression and correlation.

Recommended Books :

- Kai Velton, "Mathematical Modelling and Simulation: Introduction for scientists and engineers", latest edition.
- H. K. Dass, & Dr. Rama Verma, "Mathematical Physics", latest edition.
- Richard. Courant & David Hilbert, "Methods of Mathematical Physics", latest edition.

Approval :	Board of Studies	Res. No. 1.1	Dated: 16-06-2015
	Advanced Studies and Research Board	Res. No. 139.129	Dated: 10-11-2016
	Academic Council	Res. No. 90.11	Dated: 17-07-2017

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

Title of Subject	: RESEARCH METHODOLOGY **[RM-860]**
Disciplines	: PhD Mechatronic Engineering
Semester	: 1st
Effective	: 19 PhD-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 give the knowledge how to conduct the research.

Objectives: After completion of this course the students should be able to:

- Appreciate and understand the research tools and methods, and particularly geared for engineering research
- Choose a research problem, prepare and present a research proposal.
- Write technical/research report, research papers and thesis.

Contents:

Meaning of Research. Objectives of Research. Types of Research. Research Approaches.

Research Methods vs. Methodology. Research and Scientific Method. Research Process. Criteria of Good Research. Selecting and Defining the Research Problem. Necessity of Defining the Problem. Techniques for Defining a Research Problem. Review of Literature and its Uses. Sources of Information. Research Design and its Necessity. Features of a Good Research Design. Concepts Related to Research Design. Different Research Designs. Principles of Experimental

Designs. Sampling Design: Census and Sample Survey. Steps in Sampling Design. Criteria of Selecting a Sampling Procedure. Characteristics of a Good Sample Design. Different Types of Sample Designs. Selection of a Random Sample. Random Sample from an Infinite Universe.

Methods of Data Collection: Collection of Primary Data. Collection of Secondary Data. Selection of an Appropriate Method for Data Collection. Types of Data Analysis. Statistics in Research. Measures of Central Tendency. Measures of Dispersion. Measures of Asymmetry (Skewness). Measures of Relationship. Simple Regression Analysis. Multiple Correlation and Regression.

Procedure for Hypothesis Testing. Flow Diagram for Hypothesis Testing. Measuring the Power of a Hypothesis Test. Hypothesis Testing for Differences between Means. Hypothesis Testing for Comparing Two Related Samples. Interpretation and Report Writing: Meaning of Interpretation. Technique of Interpretation. Significance of Report Writing. Different Steps in Writing Report. Layout of the Research Report. Types of Reports. Oral Presentation. Mechanics of Writing a Research Report

Recommended Books:

- R.C.Kothari, Gaurav Garg, "Research Methodology : Methods and Techniques edition.
- Paul D. Leedy and Jeanne Ellis Ormrod, "Practical Research: Planning and Des edition.

Approval :	Board of Studies	Res. No. 1.1	Dated: 27-08-2018
	Advanced Studies and Research Board	Res. No. 151.17(a)	Dated: 04-09-2018
	Academic Council	Res. No. 93.7(d)	Dated: 17-09-2018

PhD MECHATRONIC ENGINEERING

ELECTIVE COURSES

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

Title of Subject	: MICRO AND NANO FABRICATION **[MTS-801]**
Disciplines	: PhD Mechatronic Engineering
Semester	: 2nd or onwards
Effective	: 19 PhD-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 Aim to provide a comprehensive overview of modern Micro- and Nano-fabrication techniques, and to establish the theoretical basis necessary to exploit these techniques towards fabrication of devices and structures.

Objectives:

1. To provide comprehensive knowledge of Micro and Nano fabrication tools and processes used in the modern industry.
2. To introduce deposition and etching methods used in Micro and Nano fabrication
3. To provide knowledge of various lithography-based techniques used in Micro and Nano fabrication

Contents:

Introduction: Importance of Micro and Nanofabrication methods in modern industry, typical examples of Micro and Nano fabrication technology, overview of vacuum technology

Deposition methods: Thermal physical vapour deposition, plasma and arc physical vapour deposition, Hybrid plasma vapour deposition, chemical vapour deposition, liquid phase deposition by spin coating, spray coating and dip coating

Etching Technologies: Wet chemical etching, dry etching, mechanical etching

Doping and surface modification
Doping by diffusion, doping by implantation, doping applications, silicon thermal oxidation

Lithography: Optical lithography, X-Ray lithography, laser and e-beam lithography, scanning probe lithography, Nanoimprint lithography, soft lithography, Lithography, Galvano forming, Affirming (Lithography, Electroplating, and Molding) (LIGA), LIGA infrastructure, LIGA fabrication, LIGA production samples, high aspect ratio Micro structures (HARMS)

Recommended Books :

- Micro and Nanofabrication: Tools and Application, by Hans H Gatzen and Volker Saile, Latest edition.
- Mark J. Jackson, Microfabrication and Nano-manufacturing, Latest edition.
- Shrestha Surendra, Fundamentals of Micro/ Nano fabrication, Latest edition.

Approval :	Board of Studies	Res. No. 1.1	Dated: 27-08-2018
	Advanced Studies and Research Board	Res. No. 151.17(a)	Dated: 04-09-2018
	Academic Council	Res. No. 93.7(d)	Dated: 17-09-2018

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

Title of Subject	: PHOTONIC DEVICES **[MTS-802]**
Disciplines	: PhD Mechatronic Engineering
Semester	: 2nd or onwards
Effective	: 19 PhD-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 provide an in-depth understanding of the design, operation and performance of advanced photonic devices

Objectives:

1. To understand working principle and practical application of photonic devices.
2. To provide concrete physical principles on which photonic devices work
3. To impart practical knowledge of optical, electro-optical and magneto-optical devices
4. To develop knowledge base laser based photonic devices

Contents:

Introduction
Need for studying photonic devices, Wave equations, power and orthogonality, waveguides

Optical fibers
Step-index fibers, weakly guiding fibers, graded-index fibres, attenuation and dispersion in fibers

Coupling of waves and modes
Coupled-wave theory, coupled-mode theory, two mode coupling, grating waveguide couplers, directional couplers, surface input and output couplers

Electro-optic devices
Electro-optic effects and modulators, guided-wave electro-optic modulators, travelling-wave modulators

Magneto-optic devices
Magneto-optic effects, Faraday Effect, optical isolators and circulators, magneto-optic modulators and sensors, magneto-optic recording

Acousto-optic devices
Elastic waves, photo-elastic effect, acousto-optic diffraction, acousto-optic modulators, acousto-optic deflectors, acousto-optic filter.

Non-linear optical devices
Optical nonlinearity, coupled wave analysis, phase matching, nonlinear optical modulators and switches, bi-stable optical devices, nonlinear optical interactions in wavelength

Lasers amplifiers and oscillators
Optical transitions, optical absorption and amplification, optical gain, laser amplifiers, laser oscillation, laser power, pulsed lasers, optical fiber lasers

Recommended Books :

- Jia-ming Liu, Photonic Devices, latest edition.
- Shun Lien Chuang, Physics of Photonic Devices, Latest edition.
- Alphan Sennaroglu, Photonics and Laser Engineering: Principles, Devices, and Applications , Latest edition.

Approval :	Board of Studies	Res. No. 1.1	Dated: 27-08-2018
	Advanced Studies and Research Board	Res. No. 151.17(a)	Dated: 04-09-2018
	Academic Council	Res. No. 93.7(d)	Dated: 17-09-2018

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

Title of Subject	: NON-LINEAR CONTROL SYSTEMS **[MTS-803]**
Disciplines	: PhD Mechatronic Engineering
Semester	: 2nd or onwards
Effective	: 19 PhD-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 analyse non-linear systems by means of describing functions and phase-plane diagrams.

Objectives:

1. To develop understanding of nonlinear systems and their control methods.
2. To provide various principles for stability of system
3. To comprehend nonlinear control methods for robotics
4. To introduce geometric methods for nonlinear control systems

Contents:

Nonlinear Systems
Introduction to nonlinear Systems, Nonlinear Models, Solutions to nonlinear systems, Linear vs. nonlinear

Stability Analysis
Notions of Stability, Lyapunov Functions, Invariance Principles, Converse Theorems

Control Design
Feedback Control, Design via Linearization, Gain Scheduling

Control Lyapunov Functions
Control Lyapunov functions, CLFs and feedback linearizations, Sliding Mode Control, Adaptive Control, Control barrier functions

Geometric Methods
Controllability concepts, Drift-free control systems**,** Nonholonomic systems

Recommended Books :

- Hassan K. Khalil, Nonlinear Systems, Latest edition.
- Shankar Sastry, Nonlinear Systems: Analysis, Stability, and Control, Latest edition.

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

Title of Subject	: ADVANCED TOPICS IN CONTROL SYSTEMS **[MTS-804]**
Disciplines	: PhD Mechatronic Engineering
Semester	: 2nd or onwards
Effective	: 19 PhD-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 subject provides depth knowledge of advanced topics in control systems and the control engineering application.

Objectives:
To provide knowledge about control systems and introduce various advanced techniques.
To provide a comprehensive knowledge of advanced topics in control systems
To design control systems using various advanced techniques
To introduce learning and variable structure control

Contents:

Introduction to digital control: Control system specifications, Distinct control vs digital control
Modeling of sampled-data systems: The z-transform and sampled-data systems, Properties and inverse of z-transform, Discrete models of sampled data systems, System identification
Sampling rate selection: Sampling theorem and aliasing, Selection based on smoothness of input and output, Disturbance rejection, Stability
Controller design with continuous systems: Comparison of emulation methods: numerical integration, pole-zero mapping, hold equivalence, Discrete PID control and Zeigler-Nichols tuning method, Continuous controller design using Bode plots
Direct digital design: Conversion of time domain specifications to the z-plane, Z-plane root locus, Direct digital design method of Ragazzini
Design considerations for robust control: Sensitivity to modeling errors, Relative stability, Effect of sensor noise
State space methods for control and estimation: Continuous time state-space plant model, Discrete time state-space model, Design of state space pole placement control, Estimator design
Optimal feedback control and optimal estimation: Time varying optimal feedback control, LQR steady state optimal feedback control, LQG control, Optimal estimation
Long range predictive control (LRPC): Tuning, Advantages and disadvantages
Adaptive control : Gain scheduling, Model-reference adaptive systems (MRAS), Self- tuning regulators (STRs), Recursive least- squares (RLS) estimation with exponential forgetting.
Dealing with actuator constraints: Modifying a continuous-time linear controller for anti-windup, State- variable feedback and anti-windup
Learning control : Iterative learning control (ILC), Convergence analysis, Linear discrete time SISO ILC
Fuzzy control: Fuzzy sets, Fuzzy Control, Fuzzy Rules
Variable structure control: Basic theory of sliding mode control (SMC), Equivalent control method, Implementation issues

Recommended Books:

- **Glad and Ljung, ``Control Theory - Multivariable and nonlinear methods, Latest edition.**
- **Slotine and Li, Applied Nonlinear Control, Latest edition.**
- **Hassan K. Khalil, Nonlinear Systems, Latest edition.**
- **Shankar Sastry, Nonlinear Systems: Analysis, Stability, and Control, Latest edition.**

Approval :	Board of Studies	Res. No. 1.1	Dated: 27-08-2018
	Advanced Studies and Research Board	Res. No. 151.17(a)	Dated: 04-09-2018
	Academic Council	Res. No. 93.7(d)	Dated: 17-09-2018

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

Title of Subject	: ADVANCES IN MANUFACTURING TECHNOLOGIES **[MTS-805]**
Disciplines	: PhD Mechatronic Engineering
Semester	: 2nd or onwards
Effective	: 19 PhD-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 students with the in-depth knowledge of methods, processes, and technologies related to the analysis and design of manufacturing systems.

Objectives:

1. To provide knowledge about manufacturing technologies and their latest techniques.
2. To provide understanding of Advances in manufacturing Technologies to support manufacturing operations.
3. To build and analyse models for the purpose of theoretical comprehension and related studies.
4. To apply proper advanced processes for fast production to save time and increase productivity and quality

Contents:

Additive Manufacturing Techniques: Design Methods and Standards, Modelling, Monitoring, Control, and Process Innovation, Materials Development and Evaluation, Integration of Variables and Their Implementation, Flexible Manufacturing System.

Laser Deposition Techniques: Process Modelling of Laser Deposition, Residual Stresses, Porosity in Laser-Deposited Materials, Solidification Microstructure in Laser-Deposited Materials, Laser-assisted Mechanical Micromachining, Advances in Modelling Solidification Microstructure

3D Printing Techniques: 3D Printing Design & Working, Materials for 3D Printing, Rapid Prototyping and 3D Printing Systems, fused deposition modelling, Scanning and Reverse Engineering, Present and Future Trends

Micro Assembly Technology and System: Miniaturization, MEMS & NEMS, coordinate measuring machine (CMM), System Integration and Motion Control, Micro Grippers, Precision Positioning.
Manufacturing, Internet of things: Case study of conditioning monitoring system.

Recommended Books :

- T.S. Srivatsan, T.S. Sudarshan, Additive Manufacturing: Innovations, Advances, and Applications, latest edition.
- Rafiq Noorani, 3D Printing Technology, Applications, and Selection, latest edition.
- Lihui Wang, Jeff Xi, Smart Devices and Machines for Advanced Manufacturing, latest edition.
- Stephen Beeby, Graham Ensell, Michael Kraft, Neil White, MEMS Mechanical Sensors, latest edition.

Approval :	Board of Studies	Res. No. 1.1	Dated: 27-08-2018
	Advanced Studies and Research Board	Res. No. 151.17(a)	Dated: 04-09-2018
	Academic Council	Res. No. 93.7(d)	Dated: 17-09-2018

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

Title of Subject	: RAPID PROTOTYPING AND MANUFACTURING **[MTS-806]**
Disciplines	: PhD Mechatronic Engineering
Semester	: 2nd or onwards
Effective	: 19 PhD-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 to provide state of the art development, knowledge and understanding of Rapid Prototyping and Manufacturing (RPM), and associated advanced technologies.

Objectives:

1. To impart the deeper knowledge of rapid prototyping and manufacturing.
2. To find the solution to save time and manufacture any part without any difficulty.
3. To control manufacturing process and obtain superior performance of productions.

Contents:

Design of Rapid Prototyping & Manufacturing (RPM) System: Design Potential of Rapid Manufacturing, Geometrical Freedom, Material Combinations, CAD and Rapid Manufacturing, Emerging Rapid Manufacturing Processes, Materials Issues in Rapid Manufacturing, Materials and Process Control for Rapid Manufacture.

RPM in Production: Production Economics of Rapid Manufacture, Management and Implementation of Rapid Manufacturing. Using Prototypes for Product Assessment, Orthogonal Arrays, Analysis of Variance, ANOVA, Quality Characteristic, Optimization of a Prototype Laser Deposition Process.

RPM in the Industry: Manual Manufacturing, Digital Manufacturing, Scanning, Electronic Detailing, Electronic Modelling, Fabrication, Equipment, Selective Laser Sintering (SLS), Stereolithography Apparatus (SLA), Raster-Based Manufacturing, Materials, Implementation, Analysis and Results.

Analysis of RPM: layer manufacturing processes, accuracy, Finishes, Secondary Operations, Speed, Cost, Strengths & Limitations, Materials

Case studies.

i- Rapid Prototyping Techniques in Manufacturing processes
ii- Rapid Prototyping in development of impeller pump
iii- Flow Visualization using rapid prototype models.

Recommended Books :

- Kenneth G. Cooper, Rapid Prototyping Technology Selection and Application, latest edition.
- L. L. Faulkner, Rapid Prototyping and Engineering Applications, latest edition.
- D.T. Pham, S.S. Dimov, Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, latest edition.
- Ian• Gibson•, David •Rosen, Brent •Stucker, Additive Manufacturing Technologies 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, latest edition.
- N. Hopkinson, R.J.M. Hague and P.M. Dickens, Rapid Manufacturing: An Industrial Revolution for the Digital Age

Approval	**:**	Board of Studies	Res. No. 1.1	Dated: 27-08-2018
		Advanced Studies and Research Board	Res. No. 151.17(a)	Dated: 04-09-2018
		Academic Council	Res. No. 93.7(d)	Dated: 17-09-2018

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

Title of Subject	: ADVANCED INFORMATION SYSTEMS FOR MANUFACTURING **[MTS-807]**
Disciplines	: PhD Mechatronic Engineering
Semester	: 2nd or onwards
Effective	: 19 PhD-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 to gather information and control manufacturing processes virtually with no human intervention.

Objectives:

1. To provide understanding of manufacturing information systems (MIS) that support, manage, optimize and assist the manufacturing industry.
2. To control multiple variables from inputs to machines, and personnel in real time to optimize production and eliminate inefficiencies.
3. To optimize the processes by generating current and historical maps for production equipment.

Contents:

Engineering Design System: technology of product design: product design analysis and process, Information processing technology, real-time information services,
Production management System: production decision making, production data acquisition, monitoring and control of machining, TQM, SIX Sigma, operations planning, Optimized material movements, equipment layout, material flow process, production plan, cost analysis and logistic, Data Model for Product Definition and Resource Management
Equipment Intelligent Systems: processing equipment, measuring equipment, auxiliary equipment, automatic machine tools, combined machine tools, NC machine tools, machining centres, distributed digital control, technique of manufacturing equipment.
Manufacturing Systems: Flexible manufacturing systems, flexible production lines, flexible manufacturing cell.
Enterprise Management Information System: collection, transmission, storage, processing, maintenance of management information, advanced management ideas and operation modes of enterprise,
E-commerce Systems: electronic technology for advertising, trading, transaction, payment and service, pervasive computing e-commerce,
Manufacturing Information System (MIS): MIS components, Inventory systems, Manufacturing-planning systems, Manufacturing-scheduling systems, Shop-floor Data Collection Systems, Manufacturing operations systems, Accounting Information Systems Documentation and Designing Requirements, Construction of the Product, Computer-Aided Flow Planning, Merging Consultancy Activities and IT Systems, Strategic Implications of MIS.
Case Studies: Emulsions and Synthetic Fiber Fabrics production / processes,

Recommended Books :

- Heiko Meyer,Franz Fuchs, Klaus Thiel, "Manufacturing Execution Systems, latest edition.
- Dr. Franjo Cecelja, "Manufacturing Information and Data Systems, latest edition.
- Michael McClellan, "Collaborative Manufacturing Using Real-Time Information, latest edition.

Approval :	Board of Studies	Res. No. 1.1	Dated: 27-08-2018
	Advanced Studies and Research Board	Res. No. 151.17(a)	Dated: 04-09-2018
	Academic Council	Res. No. 93.7(d)	Dated: 17-09-2018

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

Title of Subject	: ROBOTIC MANIPULATION **[MTS-808]**
Disciplines	: PhD Mechatronic Engineering
Semester	: 2nd or onwards
Effective	: 19 PhD-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 provide in-depth knowledge of manipulation through the study of mathematical models of manipulation and algorithms that use these models to plan manipulation tasks.

Objectives:

1. To provide deeper knowledge on mechanics of robot manipulator.
2. To develop comprehension of rigid body motion
3. To derive relationships for hand dynamics and control
4. To present nonholonomic behaviors and planning in robotic systems

Contents:

Rigid Body Motion
Rigid body transformation, Translation and rotation in three dimensional space, velocity of a rigid body, wrench and reciprocal screw

Manipulator Kinematics
Forward kinematics, Inverse kinematics, Manipulator Jacobian, Redundant and parallel manipulators

Robot Dynamics and Control
Lagrange's equation, Dynamics of open chain manipulators, Lyapunov Stability Theory, Position control and trajectory tracking , control of constrained manipulators

Multifingered Hand Kinematics
Introduction to grasping, Grasp statics, Force closure, Grasp planning, Gasp constraints, Rolling contact kinematics

Hand Dynamics and Control
Lagrange's equations with constraints, Robot hand dynamics, Redundant robot systems, Kinematics and statics of tendon actuation, Control of Robot hands

Nonholonomic Behavior in Robotic Systems
Controllability and Frobenius' Theorem, Examples and structure of nonholonomic systems, nonholonomic motion planning,

Recommended Books :

- R. M. Murray, Z. Li, S. S. Sastry, A Mathematical Introduction to Robotic Manipulation, Latest edition
- Marco Ceccarelli, Fundamentals of Mechanics of Robotic Manipulation, Latest edition
- Bruno Siciliano and Oussama Khatib, Springer Handbook of Robotics, Latest edition.

Approval :	Board of Studies	Res. No. 1.1	Dated: 27-08-2018
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MEHRAN UNIVERSITY OF ENGINEERING AND TECHNOLOGY, JAMSHORO
INSTITUTE OF INFORMATION AND COMMUNICATION TECHNOLOGIES

Title of Subject	: ROBOTIC MOTION PLANNING **[MTS-809]**
Disciplines	: PhD Mechatronic Engineering
Semester	: 2nd or onwards
Effective	: 19 PhD-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 of producing algorithms for solving the motion planning problems.

Objectives:

1. To provide understanding of the motion planning complexities
2. To develop mathematical concepts for robot motion among obstacles
3. To present various methods of motion planning under real life circumstances

Contents:

Introduction to motion planning
Basic motion planning problem, collision-free path, configuration space, computational approaches to motion planning, computational complexities of motion planning

Configuration space of rigid object
Translation and rotation among obstacles, Differential and topological structure of robot space, mapping obstacles within robot workspace, polygons and polyhedral obstacles

Basic motion planning techniques
Computational approaches for solving motion planning problems, roadmap method, exact cell decomposition, approximate cell composition, potential field methods,

Advanced motion planning methods
Motion planning under moving obstacles, motion planning for multiple robots, effect nonholonomic kinematic constraints, motion planning under uncertain condition, grasping of movable objects

Recommended Books:

- Jean-Claude Latombe, Robot Motion Planning, Latest edition
- Howie Choset and Kevin M. Lynch, Principles of Robot Motion: Theory, Algorithms, and Implementations, Latest edition
- Luigi Biagiotti and Claudio Melchiorri, Trajectory Planning for Automatic Machines and Robots, Latest edition

Approval :	Board of Studies	Res. No. 1.1	Dated: 27-08-2018
	Advanced Studies and Research Board	Res. No. 151.17(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	: WEARABLE SENSORS **[MTS-810]**
Disciplines	: PhD Mechatronic Engineering
Semester	: 2nd or onwards
Effective	: 19 PhD-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 to impart the knowledge of various wearable sensor technologies required to develop indigenous wearable sensor systems.

Objectives:

1. To convey theoretical and practical knowledge related to wearable sensing technology.
2. To derive necessary mathematical equations for development of inertial sensor technologies
3. To provide knowledge of textile sensor technologies
4. To impart knowledge required to develop electronic circuits for wearable sensors
5. To model the energy harvesting systems from human body

Contents :

Wearable sensor technology
Overview, challenges, opportunities
Wearable haptics
Need, force and vibration feedback devices, sensorimotor enhancement techniques
Wearable inertial sensors
Capacitive, gyroscopic and magnetic inertial sensors. Mathematical equations and modelling of inertial sensors
Textile knitted sensors
Development of textile sensors, physiological and biological sensing, smart fabrics, remote monitoring and rehabilitation
Flexible wearable sensors
Electronics of flexible sensors, Thin film sensors, implantable flexible sensors, case studies
Energy harvesting from human body
Energy from temperature gradient, foot motion energy, wireless energy transmission, energy from light
Wearable sensors for better life
Sensors for early detection of diseases, food intake detection sensors, sensors for assisted living.

Recommended Books :

- Edward Sazonov, Michael R Neuman, Wearable Sensors: Fundamentals, Implementation and Applications, latest edition.
- William S. Wong, Alberto Salleo, Flexible Electronics: Materials and Applications, latest edition.
- Kuniharu Takei, "Flexible and Stretchable Medical Devices", latest edition.
- Guozhen Shen, Zhiyong Fan, Flexible Electronics: From Materials to Devices, latest edition.
- Haider K Raad, Flexible and Wearable Electronics: Design and Fabrication Techniques, latest edition.

Approval :	Board of Studies	Res. No. 1.1	Dated: 27-08-2018
	Advanced Studies and Research Board	Res. No. 151.17(a)	Dated: 04-09-2018
	Academic Council	Res. No. 93.7(d)	Dated: 17-09-2018

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

Title of Subject	: ADVANCED MECHATRONIC SYSTEM DESIGN **[MTS-811]**
Disciplines	: PhD Mechatronic Engineering
Semester	: 2nd or onwards
Effective	: 19 PhD-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 this subject is to impart integrated knowledge required for designing a mechatronic engineering system.

Objectives:
1. To adopt a proper procedure to build the mechanical part of the system and choose the appropriate sensors and actuators that have to be used in the functioning of the mechatronic system.
2. To design the electronic circuit around Microcontrollers that will assure the functioning of the mechatronics systems.
3. To control and analyse the system under study and design the appropriate controller to get the desired performances by establishing an acceptable model that gives the relationship between the inputs and the output

Contents:

Modelling and simulation of physical systems: System Modelling with Structured Analysis, Modelling Paradigms for Mechatronic Systems, Modelling of Electromechanical systems, Rigid body models, Dynamic Models, Mechanical System Modelling.

Integration of systems: sequential tasks integration of several engineering systems, finite state machine-based design, direct problem, indirect problem, multi objective optimization problems, performance and robustness trade-offs, model-based compensators, and nonlinear effects.

Designing of mechatronics System: Design and Implementation of Mechatronic System, project management, project planning, project feasibility study, design selection, design costing and sizing, System Budgets, analysis and evaluation,

Case Studies: Balancing Robot Control, Magnetic Levitation System and Velocity & Position Control of the dc Motor Kit.

Recommended Books :

- El-Kebir Boukas, Fouad M. AL-Sunni, Mechatronic Systems Analysis, Design and Implementation, Latest edition
- Patrick Kaltjob, Mechatronic Systems and Process Automation Model-Driven Approach and Practical Design Guidelines, Latest edition
- Klaus Janschek, Mechatronic Systems Design, Methods, Models, Concepts, Latest edition
- Robert H. Bishop, The Mechatronics Handbook: Mechatronics System Control Logic and Data Acquisition, Latest edition
- Dean C. Karnopp, Donald L. Margolis, Ronald C. Rosenberg, SYSTEM DYNAMICS: Modeling, Simulation, and Control of Mechatronic Systems, Latest edition.

Approval :	Board of Studies	Res. No. 1.1	Dated: 27-08-2018
	Advanced Studies and Research Board	Res. No. 151.17(a)	Dated: 04-09-2018
	Academic Council	Res. No. 93.7(d)	Dated: 17-09-2018

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

Title of Subject	: PATTERN RECOGNITION AND IMAGE PROCESSING **[MTS-812]**
Disciplines	: PhD Mechatronic Engineering
Semester	: 2nd or onwards
Effective	: 19 PhD-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 to impart the in-depth knowledge of image processing and pattern recognition algorithms.

Objectives: The student will be able to:

1. understand the typical steps for solution of image processing/vision problems: pre-processing, segmentation, description, and recognition;
2. possess knowledge and understanding of some advanced methods for each step in the process
3. choose appropriate methods and implement solutions to small-scale image processing and vision problems

Contents:

Image Analysis Techniques
Image Segmentation, Edge Based and Region Based Segmentation, Edge Linking and Boundary Detection, Matching, Image Feature Extraction, Mathematical Morphology **Image Transforms**

Continuous Image Mathematical Characterization, Discrete Image Mathematical Characterization, Discrete Fourier Transform, Other Image Transforms, Object Recognition and Image Understanding, Knowledge representation, Pattern **Classification, Neural Nets**
Advanced Research Areas in Machine Vision, Geometry for 3D Vision, 3D Objects Representation and Modelling Techniques, Machine Vision, Industrial Application, Robot Vision,

Compressed Sensing
Conventional sensing versus compressed sensing, Application areas of compressed sensing: MRI, video, CT, hyperspectral images, Shannon's sampling theorem and its limitations, Candes' puzzling experiment, role of sparsity, Concept of sensing matrix, Softening to L1 norm: linear programming, Theorem by Candes, Romberg, Tao involving incoherence and sparsity

Tomographic Reconstruction
Concept of radon transform and its relationship to tomographic projections, Back-projection for tomography and its limitations, Applications of tomography, Beer's law, 1st to 4th generation CT, Tomography as a compressed sensing problem: empirical comparison to FBP, Limitations in theory: Radon matrix does not obey RIP, incoherence properties, Coupled tomographic reconstruction of similar slices.

Recommended Books:

- Aapo Hyvarinen, Jarmo Hurri, Patrick Hoyer, Natural Image Statistics, Latest edition
- Simon Foucart and Holger Rauhut, Birkhauser, A Mathematical Introduction to Compressive Sensing", Latest edition

Approval:	Board of Studies	Res. No. 1.1	Dated: 27-08-2018
	Advanced Studies and Research Board	Res. No. 151.17(a)	Dated: 04-09-2018
	Academic Council	Res. No. 93.7(d)	Dated: 17-09-2018