Department of Mechatronics, MIT, Manipal
M.Tech in Industrial Automation and Robotics
Course Structure (Applicable to 2019-20 admission onwards)

Year	FRIST SEMESTER						SECOND SEMESTER					
	Sub Code	**Subject Name**	**L**	**T**	**P**	**C**	**Sub Code**	**Subject Name**	**L**	**T**	**P**	**C**
	MAT 5162	Mathematics for Simulation and Modelling	4	0	0	4	MTE 5251	Embedded Systems for Automation	3	0	3	4
	MTE 5151	Robot Kinematics and Dynamics	4	0	0	4	MTE 5252	Fluid Power Systems and Factory Automation	3	0	0	3
	MTE 5152	Sensors, Drives and Actuators for Industrial Automation	4	0	0	4	MTE 5253	Motion Control and Path Planning	3	0	0	3
	MTE ***	Elective I	4	0	0	4	MTE ***	Elective III	4	0	0	4
I	MTE ***	Elective II	4	0	0	4	MTE ***	Elective IV	4	0	0	4
	HUM 5151	Research Methodology and Technical Communication	1	0	3	2	*** ****	Open Elective	3	0	0	3
	MTE 5161	Drives and Controls Lab	0	0	6	2	MTE 5261	Hydraulics and Pneumatics Lab	0	0	6	2
	MTE 5162	PLC and MPS Lab	0	0	3	1	MTE 5262	IIOT Lab	0	0	3	1
							MTE 5263	Robotics Lab	0	0	3	1
	TOTAL		**21**	**0**	**12**	**25**	**TOTAL**		**20**	**0**	**15**	**25**
II	**THIRD AND FOURTH SEMESTERS**											
	MTE 6098	Project Work							0	0	0	25
		Total							**0**	**0**	**0**	**25**

Programme Electives:

1. MTE 5001: Analog and Digital Electronics
2. MTE 5002 : Artificial Intelligence and Expert Systems
3. MTE 5003: Automated Manufacturing Systems
4. MTE 5004 : Digital Manufacturing
5. MTE 5005: Machine Vision and Image Processing
6. MTE 5006: Machines and Mechanisms
7. MTE 5007: Micro Manufacturing Systems
8. MTE 5008 : Signal Processing and Applications
9. MTE 5009 : Wireless Sensor Networks

Open Electives:

1. MTE 5051: Advanced Control systems
2. MTE 5052: Design Aspects of Industrial Automation
3. MTE 5053: Integrated Product Development
4. MTE 5054: Machine Learning

SEMESTER I

MAT 5162: MATHEMATICS FOR SIMULATION AND MODELLING [4 0 0 4]

Principles, Definitions of Mathematical Modelling and Simulation, State and System Parameters, Case studies: Modelling of inverted pendulum on moving cart. Basic theory, independence, Bayesian networks and other graph-theoretical models, Interference with Bayesian networks, Markov random fields, Matrix Representation of graphs – Incident matrix, Adjacency matrix, cycle matrix, cutset matrix, path matrix, Digraphs D, Matrix - tree theorem on number of spanning trees. Tournament. Directed Circuits and Shortest paths, Solution of linear and nonlinear system of equations: Direct methods – Gauss Jordon method, Crouts (LU decomposition) method, Cholesky Decomposition method and Thomas Algorithm for tridiagonal systems. Indirect Methods (Iterative methods) – Gauss Seidal and successive over relaxation. Newton Raphson method (system of non-linear equation), Birgevieta method, Bairstow's method, Eigen values and Eigen vectors using Power method. Concept of Finite Difference Method and Finite Element Method. Convex set, nonlinear constrained optimization: definition, basic concept, Lagrange Multipliers method, Kuhn-tucker theorem; Nonlinear unconstrained optimization: definition, basic concept, Steepest Descent method, Steepest Ascent method, Conjugate Gradient method, variable matrix method.

References:

1. Nielsen, Thomas Dyhre, and Finn Verner Jensen. *Bayesian networks and decision graphs*. Springer Science & Business Media, 2009.
2. Katsuhiko Ogata, "Modern control engineering" Prentice-Hall, 2002
3. Rao S.S., 'Optimization: theory and Practice', Wiley Eastern Limited, 2005.
4. Jain, Mahinder Kumar. Numerical methods for scientific and engineering computation. New Age International, 2003.
5. J. N. Kapur, "Mathematical Modelling", Wiley Estern, 1998.

MTE 5151: ROBOT KINEMATICS AND DYNAMICS [4 0 0 4]

Introduction to robotics- types and specification of robots, DoF, configurations, control resolution, spatial resolution, accuracy and repeatability, actuators and sensors, drives and transmission systems used in robotics. Kinematic analysis & coordinate transformation-Direct kinematic problem in robotics, homogeneous transformation matrices, joint space, and cartesian space, Denavit-Hartenberg method, Inverse manipulator kinematics solvability, robot kinematics constraints, robot workspace, holonomic robots, Jacobian matrix, Jacobian singularity. Trajectory generation- general considerations in path description and generation, joint-space schemes, cartesian-space schemes. Manipulator dynamics-Newton's equation, Euler's dynamic formulation, iterative vs. closed form. Mobile robot planning & navigation- Introduction, competences for navigation-planning & reacting, obstacle avoidance. Navigation architectures-modularity for code reuse & sharing, control localization, techniques for decomposition. Case studies.

References:

1. Lynch, Kevin M. "*Modern Robotics-Mechanics, Planning, and Control"*: Video supplements and software." (2017).
2. Murray, Richard M. "*A mathematical introduction to robotic manipulation"*. CRC press, 2017.
3. Craig, John J. "*Introduction to robotics: mechanics and control*". Vol. 3. Upper Saddle River, NJ, USA: Pearson/Prentice Hall, 2005.

4. Niku, Saeed. *"Introduction to robotics".* John Wiley & Sons, 2010.
5. Mittal, R. K., and I. J. Nagrath. *"Robotics and control".* Tata McGraw-Hill, 2003.

MTE 5152: SENSORS, DRIVES AND ACTUATORS FOR INDUSTRIAL AUTOMATION [4 0 0 4]

Data acquisition, signals conditioning, Sensors and transducers, Static characteristics, selection criteria, Units of measurements. Working Principle, operation, and applications of industrial sensors smart sensing, automation gadget sensors Actuators – Principle of operation of actuators, fundamental laws, classification, different types of motors and construction, torque- speed characteristics, applications, merits and demerits. Fundamentals of Electric drives - Components of electric drives, factors affecting choice of drives, fundamental torque equation, speed-torque conventions, steady state stability, multi-quadrant operation of electric drives, load torque components, load equalization, determination of motor power rating, motor duty cycles, electric braking, modes of operation, speed control and drive classification, closed loop control of drives, digital control. Power electronics – Power flow control switching, power electronic devices, power MOSFET, power BJT, SCR, V- I, turn on, turn off characteristics, triggering methods, PWM methods. DC drives- DC motor control, speed control, position control, proportional control, PID controllers. AC drives- Induction motor drives, synchronous motor drives, stepper motor drives, BLDC drivers, PMAC drivers, switched reluctance motors drives.

References:

1. A.K.Sawhney ,"*A course in Electrical and Electronic measurements and instrumentation*" Dhanpat Rai & Co.Publication, 2015.
2. Jacob Frden "AIP Handbook of modern sensors, physics, design and applications"American Institute of Physics-New York, 1993.
3. W.Bolton, "Mechatronics-Electronic control systems in mechanical and electrical engineering" Pearson Fourth edition, 2011.
4. Bimbra P.S., "Power electronics", 3/e, Khanna Publishers, 2003.
5. J.B.Gupta."A ourse in electrical technology"S.K.Kataria & sons, 2012.

HUM 5151: RESEARCH ME THODOLOGY AND TECHNICAL COMMUNICATION [1 0 3 2]

Mechanics of research methodology: basic concepts: types of research, significance of research, research framework case study method, experimental method, sources of data, data collection using questionnaire, interviewing, and experimentation. Research formulation: components, selection and formulation of a research problem, objectives of formulation, and criteria of a good research problem. Research hypothesis: criterion for hypothesis construction, nature of hypothesis, need for having a working hypothesis, characteristics and types of hypothesis, procedure for hypothesis testing; sampling methods: introduction to various sampling methods and their applications. Data analysis: sources of data, collection of data, measurement and scaling technique, and different techniques of data analysis. Thesis writing and journal publication: writing thesis, writing journal and conference papers, IEEE and Harvard styles of referencing, effective presentation, copyrights, and avoiding plagiarism.

References:

1. Dr. Ranjit Kumar, *"Research Methodology; A Step-by-Step Guide for Beginners",*SAGE. 2005.

2. Geoffrey R. Marczyk, David De Matteo& David Festinger, *"Essentials of Research Design and Methodology",* John Wiley &Sons, 2004.

3. John W. Creswel, *"Research Design: Qualitative, Quantitative, and Mixed Methods approaches",* SAGE. 2004.

4. Suresh C. Sinha and Anil K. Dhiman, *"Research Methodology (2Vols-Set)",* Vedam Books., 2006.
5. C. R. Kothari*, "Research Methodology; Methods & Techniques",*new age international publishers, New Delhi., 2008.

MTE 5161: DRIVES AND CONTROLS LAB [0 0 6 2]

Automation motors and their drivers and controls: Stepper motors, servo motors, linear motors etc. Configuring masters and slaves, synchronizing master & slave, making drives PLC enabled, restructuring encoders, running motors in translation and rotation mode, position & velocity control, PLC programming – pick and place operation, tracing drive parameters.

References:

1. *Drives and Control training system practice module*, BOSCH REXROTH manual Germany 2011
2. *PLC training practice module*,BOSCH REXROTHmanual Germany 2011
3. John W. Webb and Ronald A. Reiss, *Programmable logic controllers-Principle and applications, (5e)*, PHI.
4. Hackworth and Hackworth F.D, *Programmable logic controllers- Programming Method and applications*, Pearson, 2004.

MTE 5162: PLC AND MODULAR PRODUCTION SYSTEMS LAB [0 0 3 1]

Introduction of PLC, study of basic components, networking and different programming technique of PLC. Study of NO, NC and holding circuit programs, Implement of Simple Ladder program, to study basic functions of timers, counters, math, logical and program control instructions. Study different applications using ladder logic. Study hardware and software used in particular vendor PLC, develop a ladder program and implementation of distribution, process, handling, separating and buffer stations.

Introduction to the Mechatronics and Modular Production Systems(MPS), Brief study and understanding of Distribution station, Buffer station, Processing station, Handling station and Storage station along with demonstration and hands on experiment with PLC.

References:

1. *Mechatronics training practice module*, FESTO manual Germany 2011.
2. *Drives and Control training system practice module*, BOSCH REXROTH manual Germany 2011
3. *PLC training practice module*,BOSCH REXROTHmanual Germany 2011
4. John W. Webb and Ronald A. Reiss, *Programmable logic controllers-Principle and applications, (5e)*, PHI.
5. Hackworth and Hackworth F.D, *Programmable logic controllers- Programming Method and applications*, Pearson, 2004.

SEMESTER II

MTE 5251: EMBEDDED SYSTEMS FOR AUTOMATION [3 0 3 4]

Basic controller and processor – architecture and philosophy, Introduction to datatypes and variables, RISC and CISC – instruction set, architecture. Introduction to arm, processor architecture and organization, RISC and arm design philosophy, embedded system hardware, embedded system software, arm processor fundamentals, arm processor fundamentals, exceptions, interrupts and vector table, developmental tools, core extensions, arm processor families, arm 3 stage and 5 stage pipelining, instruction set, data processing instruction , FPGA & CPLD Architectures - FPGA Programming Technologies- FPGA Logic Cell Structures- FPGA Programmable Interconnect and I/O Ports - FPGA Implementation of Combinational Circuits - FPGA Sequential Circuits - Timing Issues in FPGA Synchronous Circuits, Real time operating systems based embedded system design, operating system basics, types of operating systems, multi-processing and multi-tasking, task scheduling-non pre-emptive and pre-emptive scheduling with examples, Design considerations, interfacing mixed signal circuits and sensors, EMI/EMC considerations, PCB layout guidelines, characteristics and quality attributes of embedded systems, examples of time-critical and safety-critical embedded system, applications in automation- automotive – aerospace - medical and manufacturing.

References:

1. K.J. Ayala,Dhananjay V. Gadre "The 8051 Microcontroller and Embedded systems", *CENGAGE Learning,2010*
2. Muhammad Ali Mazidi, Janice Gillipse Mazidi, Rolin D. Mckinlay, "8051 Microcontroller and Embedded Systems Using Assembly and C", Pearson Education, 2010.
3. Shibu K.V, "Introduction to Embedded sytems," *McGraw Hill, 2009*
4. Frank Vahid, Tony architectureGivargis " Embedded Systems", *Wiley India Edition, 2002*

MTE 5252: FLUID POWER SYSTEMS AND FACTORY AUTOMATION [3 0 0 3]

Hydraulic pumps and motor gears, vane, piston pumps-motors-selection and specification-drive characteristics. Linear actuator - types, mounting details, cushioning - power packs - construction. Reservoir capacity, heat dissipation, accumulators - standard circuit symbols, circuit (flow) analysis. Direction flow and pressure control valves-methods of actuation, types, sizing of ports-pressure and temperature compensation, overlapped and under lapped spool valves-operating characteristics- electro hydraulic system, electro hydraulic servo valves-different types characteristics and performance. Types of proportional control devices- pressure relief, flow control, direction control, hydraulic symbols, spool configurations, selection & sizing with reference to manufacturer's data, electrical operation, basic electrical circuits and operation, solenoid design, comparison between conventional and proportional valves. Typical industrial hydraulic circuits-design methodology. Example: paper industry, process industry, printing sawmill, woodworking, extrusion press, powder methodology press, continuous casting, food and packaging, injection moulding, solar energy and automobile.

References:

1. Antony Esposito, *Fluid Power with Applications*, 7th edition, Pearson Prentice Hall, 2013
2. S. Ilango, V. Soundararajan, *Introduction to Hydraulics and Pneumatics*, 2nd edition, PHI Learning, 2011.

3. R.Srinivasan*Hydraulic and Pneumatic Control*, 3rd edition, published by Vijay Nicole Imprints Private Ltd. 2004
4. Shizurou Konami, Takao Nishiumi, *Hydraulic control systems: Theory and Practice* , World Scientific Publishing, 2017.

MTE 5253: MOTION CONTROL AND PATH PLANNING [3 0 0 3]

Introduction: Classification of Robot (fixed, mobile), fixed- serial, parallel, Hybrid. Mobile-Ground (wheeled (omnidirectional, holonomic), tracked, legged), under water (submarine, fishlike), Surface (Ship like) and Aerial (Fixed wing, flapping wing, rotor based). Overview of motion planning, Configuration space, Degree of freedom, Definition, Introduction to Trajectory planning, General consideration in path description and Generation of motion, Joint space motions, Cartesian space motions, Point to point: Straight line path, Trapezoidal motion profile and S curve motion, Polynomial via point Trajectories. Application: Two axis /three axis planar mechanism Trajectory planning.Wheeled robots- over view of path planning, Algorithms – Analysis and complexity, running time, complexity, completeness. Visibility graph, Road Maps - Generalized Voronoi Graph (GVG) - definition, properties, Cell Decompostion – Trapezoidal decomposition, Morse cell decomposition – variable slice, sensor based coverage, complexity coverage, Visibility based decomposition. Control based planning, Manipulation planning, Optimal motion planning, Feedback motion planning, Randomised Kinodynamic Planning, Legged robots- Introduction, locomotion - key issues for locomotion, legged mobile robots, leg configurations & stability, Gait analysis, examples of legged robot locomotion. Case studies.

References:

1. H. Choset, K. M. Lynch, “Principles of Robot Motion: Theory, Algorithms, and Implementations”, 1/e, MIT Press, Boston, 2005.
2. Planning Algorithms, “Steven M. LaValle”, 1/e, Cambridge University Press, 2006.
3. Farbod Fahimi –“Autonomous Robots- Modeling, Path Planning, and Control”, 1/e Springer, 2009.

MTE 5261: HYDRAULICS AND PNEUMATICS LAB [0 0 6 2]

Operations of various valves like directional control valves, flow control valves, pressure control valves and switches like pressure switches, proximity switches. Operations of timers and counters.Rigging of manual pneumatic and electro-pneumatic circuits using above valves and switches. Working principles of hydraulic pumps, hydraulic motors, pressure switch, pressure reducing valve, accumulator, proximity switch, throttle valves, pressure compensated flow control valves and direction control valves. Rigging of manual and electro hydraulic circuits using above components.

References:

1. Practice for Professional Pneumatics Trainee’s manual, *BOSCH REXROTH manual* Germany 2011
2. Practice for Professional Electro-Pneumatics Trainee’s manual, *BOSCH REXROTH manual* Germany 2011.
3. Industrial Hydraulics Trainee’s manual, *BOSCH REXROTH manual* Germany 2011.

MTE 5262: IIOT LAB [0 0 3 1]

Operation of TwinCAT software, tools and usage. I/O accessing: Analog and Digital detection of sensors. Actuation on sensor detection using TwinCAT. HMI programming using TwinCAT. ADS communication in LAN. Actuation and programming of stepper and servo motors using TwinCAT. Communication using OPCUA with remote server. Creation of apps for usage and remote control of factory floor.

References:

1. *Beckhoff: New Automation Technology: Main Catalog, Volume 1, IPC, Motion, Automation,*Germany, 2018.
2. *Beckhoff: New Automation Technology: Main Catalog, Volume 2, I/O,* Germany, 2018.

MTE 5263: ROBOTICS LAB [0 0 3 1]

Programming and control of multi--axis robot, part recognition using robotic vision system, path and trajectory planning of multi-axis robotic manipulator. Building of Robotic manipulator by using stepper and servo drives. Implementation of sensors and control algorithms in robotic manipulators.

References:

1. John J. Craig, *Introduction to Robotics- Mechanics and Control, (3e),* Pearson Education International, 2004.
2. YoramKoren, *Robotics for Engineers*, McGraw Hill, 1992

SECOND YEAR

MTE 6098: PROJECT WORK [0 0 0 25]

Students are required to undertake innovative and research oriented projects, which not only reflect their knowledge gained in the previous two semesters but also reflects additional knowledge gained from their own effort. The project work can be carried out in the institution/ industry/ research laboratory or any other competent institutions. The duration of project work should be a minimum of 36 weeks. There will be a mid-term evaluation of the project work done after about 18 weeks. An interim project report is to be submitted to the department during the mid-term evaluation. Each student has to submit to the department a project report in prescribed format after completing the work. The final evaluation and viva-voice will be after submission of the report. Each student has to make a presentation on the work carried out, before the departmental committee for project evaluation. The mid-term & end semester evaluation will be done by the departmental committee including the guides.

ELECTIVES

MTE 5001: ANALOG AND DIGITAL ELECTRONICS [4 0 0 4]

Analog Circuits- Diode circuits, Transistors, Linear and non-linear applications of Operational amplifiers with positive and negative feedback. Special functions-ADC, DAC, IC555 Timer, Voltage regulator IC's 78XX & 79XX series - adjustable output voltage regulator LM 317. Number system, codes and combinational logic- BCD numbers (8421-2421), different binary codes and conversion, ASCII, EBCDIC codes, combinational circuits. Flip flop and timing circuit- Latches and different types of flip flops. Registers & counters- types and applications of counter, shift register, bi-directional register.

References:

1. Ananda Kumar, *"Switching Theory and Logic Design",* Prentice Hall of India, 2009.
2. R.L.Boylestad, L.Nashelsky, "Electronic Devices and Circuit Theory", PHI 8th edition. 2003.
3. Ramakant, Gayakwad. "Op-amps and linear integrated circuits." 4thEdition, PHI publication Lecture Laboratory 02perbatch Tutorial---Hours Marks Hours Marks (2000).
4. Roy, D. Choudhury. Linear integrated circuits. New Age International, 2003.

MTE 5002: ARTIFICIAL INTELLEGENCE AND EXPERT SYSTEMS [4 0 0 4]

Artificial intelligence-Overview and Historical Perspective, Applications in various domains.

Statistical and Probabilistic Reasoning- Symbolic reasoning under uncertainly, probability and Bayes' theorem, certainty factors and rule based systems, Linear Discrimination, Bayesian networks and Decision Theory, Dempster – Shafer theory. Machine learning- Introduction, regression and clustering, K-means algorithm, Hierarchical and Association Learning for Clustering, Support vector machines, Naïve Bayes, Decision Trees and Random Forest. Optimization Techniques-Introduction to optimization, Traditional optimization techniques with applications. Fuzzy Logic Systems-Crisp sets and relations, Fuzzy sets and relations. Fuzzy rule based systems, de-fuzzifications methods and applications. Knowledge, Reasoning and Planning-Logical Agents, Fundamental and Inference of First-Order Logic, Classical Planning, Knowledge Representation and Reinforcement Learning. Artificial Neural Network-Introduction, McCulloch-Pitts Neuron Model, Models of Artificial Neural Network, Learning and Adaption, Learning Rules, Winner-Take-All, Multilayer feedforward, Feedback Networks and Associative Memories.

References:

1. Khemani, Deepak. *A first course in artificial intelligence*. McGraw-Hill Education, 2013.
2. Rajasekaran, Sanguthevar, and GA Vijayalakshmi Pai. *Neural networks, fuzzy logic and genetic algorithm: synthesis and applications (with cd)*. PHI Learning Pvt. Ltd., 2003.
3. Russell, Stuart J., and Peter Norvig. Artificial intelligence: a modern approach. Malaysia; Pearson Education Limited, 2016.

MTE 5003: AUTOMATED MANUFACTURING SYSTEMS [4 0 0 4]

Development in machine tools, design consideration of CNC machines, control loops of CNC.Machine control unit - elements and their functions, principles, types and Stages of interpolation, requirements of interpolation algorithms, software interpolators. Tool path generation and control methods, CNC programming for turning and milling center by manual

method, adaptive control machining system, automated inspection and testing, analysis of material transport systems, engineering analysis of automated storage systems.Methods of improving machine accuracy and productivity, automatic identification and data capture, RFID in manufacturing, part classification and coding, production flow analysis, computer integrated manufacturing system, flexible manufacturing system, computer aided process planning, shop floor control.

References:

1. KorenYoram and Ben and Uri Joseph, *"Numerical Control of Machine Tools"*, Khanna Publishers, New Delhi, 2005.
2. GrooverMikell P., *"Automation, Production Systems, and computer Integrated manufacturing"* Prenice Hall of India, New Delhi., 2003.
3. GrooverMikell P. and Zimmers Emory W.,*"Computer aided design and manufacturing"*Prentice Hall of India , New Delhi., 2003.
4. Radhakrishnan P., *"Computer Numerical Control Machines"* New Central Book Agency (P) Ltd.,Kolkata., 2004.

MTE 5004: DIGITAL MANUFACTURING [4 0 0 4]

Introduction to manufacturing and web based manufacturing system- building blocks of automation, mechanization of parts handling, manufacturing systems, batch, mass, group, cellular systems, process planning and CAPP**,** computer network for manufacturing- integration of design and manufacturing, design assignment and practice based on process planning and CAPP.MEMS overview and working, design and manufacturing of electromechanical systems, application of MEMS, concurrent engineering- teamwork; interfacing of manufacturing and design, design for manufacturability; project management; design for assembly. Rapid manufacturing and prototyping technologies- generic process of product development, prototype tooling - process comparison, virtual prototyping, product architecture,design for manufacturing- industrial design and design for manufacturing, considerations, activity based costing; networking technologies.

References:

1. Syan, Chanan S., and Unny Menon, eds. Concurrent engineering: concepts, implementation and practice. Springer Science & Business Media, 2012.
2. Radhakrishnan, Pezhingattil, S. Subramanyan, and V. Raju. Cad/cam/cim. New Age International, 2008.
3. Tai Ran Hsu, MEMS and Microsystems- Design and manufacturing, Tata McGraw Hill, 2001.
4. Marc J. Madou, Fundamentals of microfabrication,2002.
5. Jerome H Fuchs, The illustrated handbook of Advanced Manufacturing methods, 2002.

MTE 5005: MACHINE VISION AND IMAGE PROCESSING [4 0 0 4]

Image acquisition and pre-processing: Vision and image sensors, vision system components, image digitization, image formats, image representation, and histogram. Color space, image analysis coding and representation of regions, dimensional analysis, Pixel brightness transformations, image de-nosing, image enhancement, visual image quality indexes, edge detection and morphological operations. Image segmentation and feature extraction-Manual threshold and optimal thresholding, splitting and merging, segmentation quality indexes, Feature extraction of images, Fourier transformations, discrete cosine transform. Motion estimation and object recognition-Optical flow estimation, object tracking with Kalman filtering, Classification principles, cluster analysis, k-mean and fuzzy c-means, and optimization techniques in recognition. 3D vision-Parallel and Perspective projection geometry, pinhole camera model, lens distortion, affine and metric geometry, geometrical transformations, camera parameters, calibration methods, stereovision, epipolar geometry, triangulation, stereo correspondence algorithms, 3d reconstruction. Case studies/application.

References:

1. 1. Sonka, Milan, Vaclav Hlavac, and Roger Boyle. Image processing, analysis, and machine vision. Cengage Learning, 2014.
2. Cyganek, Boguslaw, and J. Paul Siebert. An introduction to 3D computer vision techniques and algorithms. John Wiley & Sons, 2011.
3. Gonzalez, Rafael C., and Richard E. Woods. "Digital Image Processing, New Jersey." (2002): 626.
4. Davies, E. Roy. Machine vision: theory, algorithms, practicalities. Elsevier, 2004.
5. Jain, Ramesh, Rangachar Kasturi, and Brian G. Schunck. Machine vision. Vol. 5. New York: McGraw-Hill, 1995.

MTE 5006: MACHINES AND MECHANISMS [4 0 0 4]

Kinematic pairs, Kinematic diagram and inversions. Mobility and range of movements. Displacement, velocity and acceleration analysis of planar linkages, analytical methods. Dimensional synthesis for motion, function and path generation. Force analysis of planar mechanisms. Inertia forces and their balancing for rotating machines. Gyro-dynamics and effects on machines. Conveyors- types and applications, Bearings-types and applications. Gear types, selection and application, gear trains including compound epicyclic gears.

References:

1. Norton, Robert L. *Design of machinery: an introduction to the synthesis and analysis of mechanisms and machines*. 5/ed, McGraw-Hill, 2011.

2. Uicker, John Joseph, Gordon R. Pennock, and Joseph Edward Shigley. *Theory of machines and mechanisms*. Vol. 1. New York, NY: Oxford University Press, 2011..

3. Myszka, David H. *Machines and mechanisms*.Applied Kinematic Analysis. 4/e, Pearson Higher education, 2012.

MTE 5007: MICRO-MANUFACTURING SYSTEMS [4 0 0 4]

Introduction, working principles and process parameters, machine tools, applications of the micro manufacturing processes, challenges in meso, micro, and nanomanufacturing, industrial applications and future scope of micro-manufacturing processes. Different instruments related to micro manufacturing such as microsensors, microactuators, microsystems. Working principles, machine construction, and applications of micromachining, nanofinishing, microjoining, microforming, microcasting, micromolding, LIGA for micro/nano products and features, the diversified industrial applications of the micro-manufactured processes, and recent research trends in this area.

References:

1. Jain V. K., *Introduction to micromachining*,Narosa Publishing house Pvt. Ltd., 2010

2. Jain V. K., *Micromanufacturing*, CRC Press, 2012

3. Jain V. K., *Advanced machining processes*, Allied Publishers Pvt. Ltd., 2014

4. Mahalik N. P., *Micromanufacturing& Nanotechnology*, Springer Berlin Heidelberg, 2006

5. Jackson J. M., *Microfacbrication&Nanomanufacturing*, CRC Press, 2005.

MTE 5008: SIGNAL PROCESSING AND APPLICATIONS [4 0 0 4]

Fundamentals of signals and system-Introduction to signals, systems and its applications, Signal and systems classification, properties and operations, Impulse response of the system. Signal transformation and analysis-Z-transform, region of convergence, Inverse z transform, transfer function, poles and zeros, application of z transforms to discrete time systems, Sampling and aliasing. Frequency domain analysis of discrete time signals, Discrete Fourier transform (DFT), properties of DFT, linear convolution using DFT, Fast Fourier Transform. Filters-Introduction to filter, Finite Impulse Response (FIR), Infinite Impulse Response (IIR), Filter structures, Direct form I, II, Cascaded form, Lattice form. Problem solving/ Real time application of Signal processing-Image signal processing, Moving image (video) signal processing, Audio signal processing, Communication signal processing, Temperature signal processing.

References:

1. Simon Haykin, Barry Van Veen, *Signals and systems, (2e)*, John Wiley & Sons, 2007.
2. Proakis J.G. and D.G. Manolakis, *Digital Signal Processing: Principles, Algorithms and Applications, (3e)*, PHI, 2007.
3. Oppenheim A.V. and R.W. Schafer, *Discrete Time Signal Processing, (2e)*, Prentice-Hall, 2001.
4. Rabiner L.R and Gold D.J, *Theory and Applications of Digital Signal Processing*, Prentice Hall, 2007.
5. Mark Owen, "*Practical Signal Processing*", Cambridge University Press, 2007.

MTE 5009: WIRELESS SENSOR NETWORKS [4 0 0 4]

Challenges for wireless sensor networks, single node architecture , hardware components, energy consumption of sensor nodes, network architecture, types of sources and sinks, single hop versus multi-hop networks, multiple sinks and sources, wireless channel and communication fundamentals, frequency allocation, modulation and demodulation, MAC protocols , contention-based protocols, SMAC – BMAC, TRAMA, IEEE 802.15.4 MAC protocol, Q-MAC (Querry MAC), Q-MAC (QoS MAC). Routing challenges and design, SPIN COUGAR, ACQUIRE, LEACH, PEGASIS, GF, GAF, GEAR, aggregation techniques – TAG, tiny DB traditional transport control protocols. Wireless LANs: 802.11, 802.11a/b/g, 802.16-WiMAX, UWB communications, wireless personal area networks, BlueTooth, healthcare monitoring system using wireless sensor networks, remote home lighting and appliance control system, automatic speed control and vehicle tracking using GSM and GPS technologies.

References:

1. KazemSohraby, Daniel Minoli and TaiebZnati, *"Wireless Sensor Networks Technology- Protocols and Applications"*, John Wiley & Sons, 2007.
2. Holger Karl and Andreas Willig, *"Protocols and Architectures for Wireless Sensor Networks",* John Wiley & Sons, Ltd, 2005.
3. Swami, Ananthram, et al., eds. *Wireless sensor networks: signal processing and communications perspectives*. John Wiley & Sons, 2007.
4. Murthy, C. Siva Ram, and B. S. Manoj. *Ad hoc wireless networkd: Architestures and protocols*. Pearson Education India, 2006.

OPEN ELECTIVES

MTE 5051: ADVANCED CONTROL SYSTEMS [3 0 0 3]

Introduction, Control structures and performance measures, Time and frequency domain performance measures, Design of controller, Design of controller for SISO system, Controller design for TITO processes, Limitations of PID controllers, PI-PD controller for SISO system, PID-P controller

for Two Input Two Output system, Effects of measurement noise and load**.** Identification of dynamic models of plants, Relay control system for identification, Off-line identification of process dynamics, On-line identification of plant dynamics. State space based identification, State space analysis of systems, State space based identification of systems-1, State space based identification of systems -2, Identification of simple systems, Identification of FOPDT model 1 7 Identification of second order plus dead time model 1 8 Identification of SOPDT model 1 9 Steady state gain from asymmetrical relay test 1 10 Identification of SOPDT model with pole multiplicity.

References:

1. Ogata, Katsuhiko, and Yanjuan Yang. *Modern control engineering*. Vol. 4. India: Prentice hall, 2002.
2. Dorf, Richard C., and Robert H. Bishop. *Modern control systems*. Pearson, 2011.
3. Gopal, Madan. *Control systems: principles and design*. Tata McGraw-Hill Education, 2002.

MTE 5052: DESIGN ASPECTS OF INDUSTRIAL AUTOMATION [3 0 0 3]

Detailed study of P&ID, preparation of input / output list, listing of process range, list of instruments for hardwired control, list of field instruments. Preparation of specification sheets choosing of instruments, system study - examples categorization of operations, categorization of devices, deducing alarm limits, categorization of hard / soft alarms, categorization of input / output signals. Preparation of schemes, open loop schemes, closed loop schemes, power supply distribution schemes, hardwired control schemes, measurement schemes, marshalling schemes interface schemes, overview of input / output signal ranges, voltage input / output, current input / output, and pulse input RTD input, thermocouple input. power supply design, power requirements calculation, redundancy in power supply schemes, choice of circuit breakers - inrush current, interrogation power supply for inputs / outputs, panels & control desks, buffer termination / marshalling cabinets, power supply distribution in panels, control desks / panels, PLC/DCS panels.

References:

1. Terry Bartlet*, "Industrial Control Electronics Devices, Systems, & Applications"* 3rded, Delmar, 2006.
2. C. D. Johnson*, "Process Control Instrumentation Technology" ,* Prentice Hall, 2002.
3. J. W. Webb and R. A. Reis, "*Programmable Logic Controllers: Principles & Applications"*, Prentice Hall, 2002.
4. A D Srinivasan, D Michael Mcfarland**,** *Smart structures analysis and design Cambridge univ press*, 2000.

MTE 5053: INTEGRATED PRODUCT DEVELOPMENT [3 0 0 3]

Trend Analysis and Product Decision, Product Development methodologies – types of Product Development and Product Development life cycle – planning and management. Introduction to development process taxonomy (DPT), the front end process, adaptive generic product development process, Product Planning and steps for evolution – concept selection, concept testing, product architecture. Introduction to reverse engineering and value engineering, reverse engineering vs machine design, material identification techniques and process verification, geographical forms, Robust design & steps in design process, formulating objectives, development of experimental plan, methodologies of reflect and repeat, case study 1, case study 2, and case study 3. Engineering series industry, product development in industries vs institutions, Integration of mechanical, embedded & software systems, Intellectual property rights & confidentiality, security management.

References:

1. "Product Design and Development", by Karl T. Ulrich & Steven D. Eppinger, Mc Graw Hill, 2012.

2. “Reverse Engineering – Technology of Reinvention”, by Wego Wang, CRC Press, 2011.
3. “Methods in Product Design – New strategies in Reengineering” by Ali K. Kamrani, Maryam Azimi, and Abdulrahman M. Al-Ahmari, CRC Press, 2013

MTE 5054: MACHINE LEARNING [3 0 0 3]

Introduction- Introduction to Machine Learning, Supervised Learning, Unsupervised Learning, Mathematical Preliminaries. Classification and Regression: Bayesian decision theory, Maximum likelihood ratio, Parametric classification, Regression, Multivariate methods, K-nearest neighbor classification. Supervised learning- Setup, LMS, Logistic regression, Perceptron, Exponential family, Generative learning algorithms, Gaussian discriminant analysis, Naïve Bayes, Support vector machines, Model selection and feature selection, Evaluation and debugging learning algorithms. Unsupervised learning- Clustering, K-means, Hierarchical clustering, Competitive learning, Radial basis functions. EM, Mixture of Gaussians, Factor analysis, Principal Component Analysis, Independent Component Analysis. Application of unsupervised learning in anomaly detection and tactile manipulation. Deep Learning-Introduction to frameworks for deep learning, Convolutional neural networks-convolutional layer, pooling layer, normalization layer, fully-connected layer, conversion of fully-connected layer to convolutional layers. ConNet architecture-layer patterns, layer sizing patterns, case studies (LeNet/AlexNet/ZFNet/GoogLeNet). Generative adversarial network-Generator, Discriminator.

References:

1. Kevin P. Murphy, “Machine Learning: A Probabilistic Perspective”, MIT Press, 2012.
2. Ethem Alpaydin, “Introduction to Machine Learning”, 2nd edition, MIT Press, 2010.
3. Mehryar Mohri, Afshin Rostamizadeh and Amet Talwalkar, “Foundation of Machine Learning”, MIT Press 2012.
4. Daphne Koller and Nir Friedman, “Probabilistic Graphical Models: Principles and Techniques”, MIT Press, 2009.
5. Christopher M. Bishop, “Pattern Recognition and Machine Learning”, Springer, 2007.