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

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<tr>
<th>Year</th>
<th>Sub Code</th>
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<tr>
<td>I</td>
<td>MAT 5162</td>
<td>Mathematics for Simulation and Modelling</td>
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<td>MTE 5251</td>
<td>Embedded Systems for Automation</td>
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<td>MTE 5151</td>
<td>Robot Kinematics and Dynamics</td>
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<td>MTE 5252</td>
<td>Fluid Power Systems and Factory Automation</td>
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<td>MTE 5253</td>
<td>Motion Control and Path Planning</td>
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<td>HUM 5151</td>
<td>Research Methodology and Technical Communication</td>
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<td>MTE 5261</td>
<td>Hydraulics and Pneumatics Lab</td>
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<td>MTE 5262</td>
<td>IIOT Lab</td>
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|     | MTE 6098 | Project Work |   |   |   |   |     |              |   |   |   |   |
|     | Total    |              |   |   |   |   |     |              |   |   |   | 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
**SEMMESTER I**

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


**References:**

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


**References:**


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


**References:**


**HUM 5151: RESEARCH METHODOLOGY 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:**


**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:**


**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:**

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-preemptive and non preemptive 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

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:

**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- overview of path planning, Algorithms – Analysis and complexity, running time, complexity, completeness. Visibility graph, Road Maps - Generalized Voronoi Graph (GVG) - definition, properties, Cell Decomposition – 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:**

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


**References:**

**MTE 5262: IIOT LAB [0 0 3 1]**

References:


**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:


**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:

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

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

References:

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.
**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:**

**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 denoising, 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:**

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


References:


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:
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:

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 (Query 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:

**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

References:

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:

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:
MTE 5054: MACHINE LEARNING [3 0 0 3]


References: