STRUCTURE & SYLLABI OF COLLABORATIVE MASTER OF TECHNOLOGY PROGRAMME IN MECHATRONICS

M.Tech.
(Mechatronics)

PROPOSED BY SCHOOL OF MECHATRONICS & ROBOTICS IN COLLABORATION WITH THREE CSIR LABORATORIES [CMERI (DURGAPUR), CEERI (PILANI) & CSIO (CHANDIGARH)] AND RECOMMENDED BY BOARD OF STUDIES

2007-2008
BENGAL ENGINEERING & SCIENCE UNIVERSITY, SHIBPUR
## M. Tech. (Mechatronics)- 2 year, 4 semester Course Structure

### 1st. Semester

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Subject</th>
<th>Course No.</th>
<th>Hours per week</th>
<th>Full Marks</th>
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<tr>
<td></td>
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<td>L  T  S  TO T</td>
<td>Theo  Sess  Total</td>
</tr>
<tr>
<td>1.</td>
<td>APPLIED ENGINEERING MATHEMATICS</td>
<td>MEC-101</td>
<td>3  1  0</td>
<td>100</td>
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<tr>
<td>2.</td>
<td>MECHATRONICS SYSTEM DESIGN</td>
<td>MEC-102</td>
<td>4  1  0</td>
<td>100</td>
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<tr>
<td>3.</td>
<td>SMART MATERIALS, SENSORS AND ACTUATORS</td>
<td>MEC-103</td>
<td>4  1  0</td>
<td>100</td>
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<tr>
<td>4.</td>
<td>ADVANCED CONTROL SYSTEMS</td>
<td>MEC-104</td>
<td>4  1  0</td>
<td>100</td>
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<tr>
<td>5.</td>
<td>ELECTIVE- I : Bridge Course*</td>
<td>MEC-105/n</td>
<td>4  1  0</td>
<td>100</td>
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<tr>
<td>6.</td>
<td>MECHATRONICS LABORATORY</td>
<td>MEC-151</td>
<td>0  0  4</td>
<td>50</td>
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<tr>
<td>7.</td>
<td>DIGITAL INTERFACING LAB</td>
<td>MEC-152</td>
<td>0  0  4</td>
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<tr>
<td>8.</td>
<td>MINI PROJECT AND SEMINAR</td>
<td>MEC-153</td>
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<td><strong>TOTAL</strong></td>
<td></td>
<td>19 5 10 34</td>
<td>500 150 650</td>
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</table>

* Bridge Course (MEC-105/1) for the students having ME, Prod, Met, Min, Automobile, C.E. background.
* Bridge Course (MEC-105/2) for the students having E.E., E. & TC., and C.S.T. background.

### 2nd. Semester **

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<thead>
<tr>
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<td>L  T  S  TO T</td>
<td>Theo  Sess  Total</td>
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<tr>
<td>1.</td>
<td>MICROPROCESSORS, MICROCONTROLLERS AND EMBEDDED SYSTEM DESIGN</td>
<td>MEC-201</td>
<td>3  1  0</td>
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<td>MEMS TECHNOLOGY</td>
<td>MEC-202</td>
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<td>3.</td>
<td>ROBOTICS</td>
<td>MEC – 203</td>
<td>3  1  0</td>
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<td>4.</td>
<td>DIGITAL SIGNAL PROCESSING AND APPLICATIONS</td>
<td>MEC – 204</td>
<td>3  1  0</td>
<td>100</td>
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<tr>
<td>5.</td>
<td>INSTRUMENTATION AND INDUSTRIAL CONTROL</td>
<td>MEC – 205</td>
<td>3  1  0</td>
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<td>6.</td>
<td>ROBOTICS LABORATORY</td>
<td>MEC – 251</td>
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<td>7.</td>
<td>SENSORS LABORATORY</td>
<td>MEC – 252</td>
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<td>8.</td>
<td>MEMS LABORATORY</td>
<td>MEC – 253</td>
<td>0  0  4</td>
<td>50</td>
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<td><strong>TOTAL</strong></td>
<td></td>
<td>15 5 12 37</td>
<td>500 150 650</td>
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**Contact hours per week for each subject denoted here correspond to 90 full academic working days i.e. 18 weeks. For reduced number of working days (crash course), this should be proportionately increased.
### 3rd Semester

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Subject</th>
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<td>ELECTIVE – II ***</td>
<td>MEC-301/n</td>
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<td>PROJECT &amp; THESIS</td>
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*** List of ELECTIVE – II subjects :

- MEC- 301/01 : NONLINEAR OSCILLATIONS (With special applications to MEMS)
- MEC- 301/02 : POWER ELECTRONICS AND MACHINE CONTROL
- MEC- 301/03 : ADVANCED COMPUTER ORGANISATION AND ARCHITECTURE
- MEC- 301/04 : ANALYSIS AND DESIGN OF ALGORITHMS
- MEC- 301/05 : MOBILE ROBOTICS
- MEC- 301/06 : NAVIGATION, GUIDANCE AND CONTROL
- MEC- 301/07 : NON-LINEAR CONTROL SYSTEM
- MEC- 301/08 : AUTOMATION AND INTELLIGENT SYSTEMS
- MEC- 301/10 : DIGITAL IMAGE PROCESSING
- MEC- 301/09 : HDL-BASED FPGA DESIGN
- MEC- 301/11 : OPTICAL ENGINEERING AND PHOTONICS
- MEC- 301/12 : SMART SYSTEMS
- MEC- 301/13 : MATERIAL CHARACTERIZATION & METROLOGY

### 4th Semester

<table>
<thead>
<tr>
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<tr>
<td>1.</td>
<td>THESIS</td>
<td>MEC – 451</td>
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<td>SEMINAR &amp; VIVA VOCE ON THESIS</td>
<td>MEC – 452</td>
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<td><strong>TOTAL</strong></td>
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**Syllabi**

**MEC-101 : APPLIED ENGINEERING MATHEMATICS**

Full Marks : 100          3L+ 1T+0S

**Linear Algebra:** Vector space; Linear dependence, basis, dimension, illustrations, subspace, direct sum, inner product space, orthonormal basis, Gram-Schmidt orthogonalising process.

**Introduction to Tensors:** Elementary concept only

**Linear Transformation:** Domain, range, image of a transformation, properties, rank, nullity, associative theorems, inverse transformation, matrix as linear transformation, eigen value, eigen vector, Cayley-Hamilton theorem.

**Integral Transformation:** General Theory.

**ODE & PDE:** Basic ideas, solution of PDE of the form Pp + Qq = R, classification of 2\textsuperscript{nd} order linear PDE, Wave, Heat, and Laplace equations, solution by transform methods, power series solution of ODE, solution of nonlinear ODE.

**Numerical Methods:** Concept of Finite Difference Method and Finite Element Method.

**Optimization:** 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 etc.

**MEC-102 : MECHATRONICS SYSTEM DESIGN**

Full Marks : 100          4L+1T+0S

**Review:** Review on classification of control systems, open-loop control, Laplace transform models, block diagrams, block diagram reduction and control performance analysis


**Electronics and hardware components for Mechatronics:** Computer interfacing, hardware for digital/analog interfacing, devices for data conversion

**REFERENCES:**


MEC-103: SMART MATERIALS, SENSORS AND ACTUATORS

Full Marks: 100 4L+1T+0S

**Smart Materials**: Structure dependent response of materials, Sensing and actuating, Property Specific activities of Smart Materials, Mechanically Smart Materials, Magnetic Smart Materials, Optically Smart Materials, Potential applications of Smart Materials, shape Memory application, Noise and Vibration Control.

**Sensors**: Analog and digital sensor: optical encoders, Hall – effect sensors, potentiometers, gyroscopes; Variable-capacitance transducers, piezoelectric sensors, capacitive acceleration sensor, CMOS microphone sensors; Micro-machined gyro sensor, ultrasound transducers, Magnetomechanic sensors, Angular sensor; Electromagnetic acoustic transducer

**Actuators**: Stepper motors, brushed dc motors, brushless dc motors, and hydraulic and pneumatic actuators; Bimorph actuators; Analog and digital chts, Microcontrollers, A/D & D/A circuits, Matlab, Simulink and the control systems.

Case Studies and Future Trends

MEC-104: ADVANCED CONTROL SYSTEMS

Full Marks: 100 4L+1T+0S

**Introduction to Control System**: Role of Controls in Mechatronics, role of Modeling in Mechatronics Design, Analog vs digital, open loop vs feedback control, continuous vs discrete time control. Signals and Systems. Transfer Functions and Laplace transforms.

**Control System Design**: Time domain and frequency domain analysis; Root Locus Method; Stability - absolute and relative; Industrial motion control – PID controllers, controller tuning; State Space Design.

**Digital Control**: Discrete time mathematics, z-transforms, sampling rates, zero and first order hold, time delays, computer control implementation concepts, state space realization.

**Advance Controller Design**: Kalman Filters as Dynamic System State Observers; LQ optimization – LQR, LQG, LTR design; $H_2$ and $H_\infty$ control; Adaptive and Nonlinear Control Design; Intelligent Control: Expert systems, fuzzy logic, artificial neural networks, evolutionary computing, and hybrid systems.

Future Trend

**TEST BOOKS**:
1. Cochin & Cadwallender: *Analysis and design of Dynamic Systems. 3e*, Addison Wesley
MEC-105/1 : ELECTIVE-I
(Bridge Course for students having ME, Prod, Met, Min, Automobile, C.E. background)
Full Marks : 100 4L+1T+0S


**Amplifiers:** Transistor as an amplifier, BJT, FET amplifier – single stage, multistage Power Amplifiers – class A, B, C and D Amplifiers.

**Operational amplifiers:** Introduction op-amp, Specification and characteristics, Application – Constant gain, Voltage summing, Voltage buffer, Instrumentation circuits, Active filters.

**Introduction to computing:** Number, system and code conversion, Logic gates, Boolean algebra, Combinational Logic circuits, Sequential Logic circuits – Latch, RS-, JK-, T-, D- Flip flops, Buffer Register, Counters, Shift registers.

**Qualitative Study & Interfacing Concepts:** Decoder, Encoder, MUX, DMUX, Memories – RAM, ROM, PROM, EPROM, EEPROM, Programmable logic devices.

**REFERENCES:**
3. *Electronic Devices*, Floyd, Pearson Education

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MEC-105/2 : ELECTIVE-I
(Bridge Course for students having E.E., E&TC. and C.S.T. background)
Full Marks : 100 4L+1T+0S

**Basic Mechanical Engineering:** Review of basic engineering mechanics; Stress-strain under different types of loading; Power and motion transmission systems (Shaft, Gear-train, coupling, belt, screw-nut mechanisms, various examples of four-bar mechanisms); Bearings; Springs; Fluid power systems and components – constructional features, operating principles and characteristics; Fundamentals of CNC machine tools

**Modelling and dynamic analysis of elastic machine components:** Lumped parameter modeling; Distributed parameter modeling of rod and beam like members; Response under dynamic loading

**REFERENCES:**
MEC – 151 : MECHATRONICS LABORATORY

Full Marks : 50 0L+0T+4S

Following Experiments will be performed :

- Pneumatic and Hydraulic Circuits: Simulate motion of pneumatic and hydraulic system using Automation studio software
- Development of control motion of pneumatic manipulator and hydraulic system using servo valves and PC interface
- Study of servo motors
- Robot modeling and simulation using Workspace software
- Micro-controller for motion control and path planning of BOE-BOT, HEXCRAWLER, ROBOT, Stair Climbing Vehicle
- Performance analysis of mechatronics system using Visual Nastran 4D software with MatLab interface, 20Sim, AMESim software
- Learn to apply concepts of Virtual Instrumentation using LabVIEW
- Path planning and programming for mobile robots using Webots software
- MEMS system analysis using ALGOR and COMSOL Multiphysics software

MEC-152 : DIGITAL INTERFACING LAB

Full Marks : 50 0L+ 0T+4S

Following Experiments will be performed :

- Study on the combinational and sequential logic circuits including interfacing between two logic families and driver circuits
- Study on display devices and opto-couplers including multi-channel DAS, ADC and DAC
- PLC programming practice using Fanuc PLC for Ladder Programming (AND, OR, NOT, NAND, NOR, XOR, Counter, ON and OFF delayed Timer etc.)
- Study stepper motor controlled mobile robot through PC interface
- Development of sensors and instrumentation
- Programming using microprocessor and micro-controller for motion control
- Learn to apply concepts of Virtual Instrumentation using LabVIEW
- Data Acquisition and Signal Processing using load cell, potentiometer, LVDT, accelerometer for vibration control
- Image Processing using IMAQ Vision and Matlab

MEC-153 : MINI PROJECT AND SEMINAR

Full Marks : 50 0L+ 0T+2S

As noted in the structure.
Introduction to embedded systems and architecture
System design using specification and modeling tools
Overview of embedded computing platforms; Microprocessors, Microcontrollers, DSP’s, FPGA’s and SoC’s
Hardware – Software codesign and partitioning
Design issues, consideration and trade-offs: Performance, memory, power, timing, cost, and development time
Memory hierarchy, System Interfaces and Communication with peripheral units, timers, counters
Introduction to Real-time systems and Real-time Scheduling
Real-time software development: High level languages (HLL) and Programming issues
Systems performance evaluation and optimization
Fault tolerance: Networked embedded systems
Case Studies and Future Trends.

TEXT BOOKS

REFERENCE BOOKS
5. J. Catsoulis, *Designing Embedded Hardware*, ORA, 2002
Material Properties; Crystal growth;  
Basic fabrication techniques – Doping, Diffusion, Oxidation, Deposition of films using CVD, LPCVD and Sputtering Techniques, chemical and Plasma Etching; Anisotropic Etching; Cleaning; Lithographic Process; Electro-plating;  
Surface and bulk Micro-machining; LIGA; Release of Micro-structures  
MEMS Design Principles and Tools  
MEMS Devices: Capacitive, Electrostatic, Piezo-resistive, Piezo-electric, Thermal, Magnetic transduction, Micro-fluidics  
MEMS Packing Technologies  
MEMS Design and Application Case Studies

**TEXT BOOK**

**REFERENCE BOOKS**


### MEC – 203 : ROBOTICS

Full Marks : 100  
3L+1T+0S

History of development of robots, basic components of robotic systems, Anatomy and structural design of robot, manipulation, arm geometry, drives and control (hardware) for motions, End effectors and grippers.

Translation, orientation of rigid bodies, Representation of links and joints, workspace, velocities, manipulator jacobian, singularities of robots and mechanisms, Kinematics for manipulators, election of coordinate frames, homogenous transformation, DH parameters, solution of kinematics.

Introduction to robot dynamics, Lagrange-Euler Dynamic formulation, Trajectory planning, position, velocity and force control, Introduction to computer vision.

Case Studies and Future Trend

**TEST BOOKS AND REFERENCES:**

1. *Robotics: Control, Sensing, Vision and Intelligence* by Fu, Gonzalez and Lee
3. *Robot Dynamics and Control* by Spong and Vidyasagar
4. *A Robot Engineering Testbook* : Mohsen Sahinpur
6. *Kinematic Analysis of Robot Manipulators* : Carl D. Crane and Joseph Duffy
8. *Robotics for Engineers* : Koren Y.

### MEC – 204 : DIGITAL SIGNAL PROCESSING AND APPLICATIONS

Full Marks : 100  
3L+1T+0S

**Introduction** : Elements of a Digital Signal Processing system, advantages of digital processing over analog processing, continuous time signals, discrete time signals, sampling of analog signals, sampling theorem, quantization of signals, coding, digital signals vs discrete time signals.

**Discrete time signals and systems** : Classification, block diagram representation, analysis of linear systems, response of LTI systems to arbitrary inputs, convolution, causal systems, stability, finite duration and infinite duration impulse response, recursive and non-recursive systems, description by difference equations, structures for realization, correlation of discrete-time signals.
Z transform: Direct and inverse Z transform, properties, poles and zeros, techniques of finding inverse Z-transform, analysis of LTI systems in z-domain.

Frequency Analysis: Fourier series of continuous and discrete-time signals, power density spectrum, Fourier transform, cepstrum, frequency-domain characteristics of LTI systems, LTI systems as filters.

Discrete Fourier Transform: Frequency domain sampling, properties of DFT, Linear filtering methods based on the DFT, frequency analysis of signals using DFT, FFT algorithms.

Design of digital filters: Characteristics of filters, design of FIR filters, design of IIR filters from analog filters, design of filters based on least-square method.

DSP Hardware: Introduction to DSP processors, their architecture, software development tools, emulators, floating point chipset, fixed point components.

A case study illustrating DSP applications.

MEC – 205: INSTRUMENTATION AND INDUSTRIAL CONTROL
Full Marks: 100          3L+1T+0S

Measurement systems: Performance terms, static and dynamic characteristics, system transfer function, system accuracy, sources of error, intelligent instruments.

Sensors and transducers: Resistive, inductive, capacitive, piezoelectric, optoelectronic, pressure, strain, torque, speed, chemical, temperature.

Signal conditioning and processing: Methods, instrumentation amplifiers, filter, A/D converters, sample and hold, multiplexers, data acquisition systems, virtual instrumentation and its advantages.

Closed-loop Controllers: Continuous and discrete processes, two step control, proportional control, derivative control, integral control, PID control, adaptive control, digital control, velocity control, distributed control, fuzzy control.

Data display: Display indicators, monitors, recorders, data loggers.

Programmable Logic Controllers: Construction, Types, Hardware, Programming and Applications

Practical instrumentation systems and their applications: Agro-based; Biomedical and prosthetic; Strategic and defense related; Disaster mitigation; Opto-electronic, Concept of SCADA

Case Studies and Future Trend

MEC – 251: ROBOTICS LABORATORY
Full Marks: 50          0L+0T+4S
Hands on working and training on following Robotics related Hardware and test-beds:
5 d.o.f. articulated robot; Wheeled Mobile Robot equipped with actuators and different sensors; Legged Mobile Robot equipped with actuators and different sensors; Mechanism development and robot kits

Testing and validation of developed algorithms related to navigation, guidance, obstacle avoidance and control, research platform Pioneer 3-DX of Active Media Robotics and AMRIA, developed by the laboratory can be used during experimentation with Software and Simulation Platforms.
e.g. C, C++ in windows and Linux working environment; Matlab with Simulink tool box for Programming, Simulation and Control design; IDEAS for 3D modeling, assembly and kinematic analysis.; ADAMS for Dynamic modeling and simulation of systems; Visual NASTRON & AutoCAD Inventor

including all measuring equipment and accessories as available in the Electronic Laboratory and using high end PC’s, workstations with relevant software codes available in Computational Laboratory.

MEC – 252: SENSORS LABORATORY

Full Marks: 50 0L+0T+4S

Experiments and Training on different tropics as mentioned in MEC – 205 “Instrumentation and Industrial Control”

MEC – 253: MEMS LABORATORY

Full Marks: 50 0L+0T+4S

1. MEMS Fabrication Unit Processes: Doping; Diffusion; Oxidation; Deposition of films using CVD, LPCVD and Sputtering Techniques; Chemical and Plasma Etching; Lithographic Process; Surface and Bulk Micro-machining.

2. MEMS Process Modelling.

MEC 301/01: ELECTIVE - II: NONLINEAR OSCILLATIONS

(With special applications to MEMS)

Full Marks: 100 4L+1T+0S

Phase plane and geometric theory of nonlinear oscillations; Harmonic balance and perturbation methods for nonlinear systems; Duffing and van der Pol oscillators; Mathieu's equation; Lyapunov theory of stability; Bifurcation and Chaos; Nonlinear models of MEMS; Nonlinear oscillations of MEMS.

TEXT & REFERENCES]

Power devices: Construction, rating, characteristics:-(Including SOA Rating) Power diode, Power BJT, Power MOSFET, SCR, TRIAC, IGBT

Drive Circuits: For BJT, MOSFET, SCR, IGBT; Isolation circuits using optocoupler / pulse transformer; Protection circuits: Snubbers, MOVs, di/dt inductor, semiconductor fuses.


A.C. phase control circuits: Single Phase AC voltage regulators and cycloconverters

Power Inverters: Single phase bridge, three phase bridge and PWM inverters: - Working, important waveforms, control circuits.

Drives: Selection of Motor, control and stability of electric drives, feedback control of drives,

D.C motor controllers: Armature voltage control of separately excited DC shunt Motor; single quadrant, two quadrant and four quadrant operation; field current control, torque-speed characteristics, micro controller based control circuit for motor control, (Block diagram and working)

A.C motor controller: Squirrel cage induction motor control – stator voltage control, V/F control, torque – speed characteristics, control of wound rotor motor, slip power recovery. D.C and AC servo motor controller; stepper motor controller; Brushless DC motor controllers; Electric Vehicles

TEXT BOOK
3. Lander, Power Electronics, McGraw Hill
4. Krein, Philip, Principles of Power Electronics, OUP
5. Dubey G.K, Electrical Drives, Narosa Press

MEC 301/03: ELECTIVE - II: ADVANCED COMPUTER ORGANISATION AND ARCHITECTURE
Full Marks : 100


Design Methodology: Introduction, the register level, processor level, design techniques. Processor Design: Processor organization, information representation, instruction sets, fixed point arithmetic, design.

Control Design: Instruction sequencing and interpretation. Hardware control, micro-programmed control, minimizing the microinstruction size, micro-programmed, nano-programmed Computers. Memory Organisation: Memory technology, Virtual memory, speed memories.

I/O Systems: Programmed I/O, DMA and interrupt, I/O processor bus control.

Types of parallel processors, performance consideration, introduction of pipeline structures, Vector Processor etc. Details about Pipelining Vector Processing: Principles of linear pipelining, Classification of pipelined processor, Design of pipelined instruction units, Arithmetic pipelined design, Multifunction and array pipelined, Principles of designing pipelined processor, Dynamic pipelining and reconfigurability, Characteristics of vector processing, Multiple vector task dispatching, Pipelined vector processing methods;

Vector Super Computers: Vectorization methods and vector super computers like STAR-100, CYBER-205, CRAY-1 etc.

Structure and Algorithms for Array Processors: SIMD Array Processors; SIMD inter-connection Networks (static versus dynamic, Mesh connected ILLIAC Network, Cube Inter-connection Network, Data manipulator shuffle-exchange and Omega networks; Parallel Algorithms for array processors; Associative array processing; SIMD Computers and Performance Enhancement.

MEC 301/04 : ELECTIVE - II: ANALYSIS AND DESIGN OF ALGORITHMS
Full Marks : 100 4L+1T+0S

Review of results from combinatorics, Data structure, Searching Algorithms in static and dynamic tables, Random binary search, Height-balanced binary trees, Implementation of dictionaries, priority queues: mergeable heap, concatenable queue.

Divide and Conquer, Dynamic programming, Greedy Algorithm with relevant examples.


Graph Algorithms: Transitive closure-depth, First search by connectivity, strong-connectivity, shortest paths minimum cost spanning trees.

Discrete Fourier Transform (DFT), Fast Fourier Transform (FFT), Application. Notion of NP-Completeness.

MEC 301/05 : ELECTIVE - II: MOBILE ROBOTICS
Full Marks : 100 4L+1T+0S

History of development of mobile robots, Types and Applications, Basic components of mobile robotic systems, Design considerations of mobile robots.

Sensors for mobile robots: Interceptive sensors, Exteroceptive sensors, Sensor for dead reckoning, Heading sensors, ground based beacons and GPS, Vision sensors, INS (Gyros and accelerometer), URF, LRF, Bumpers and Contact switches.

Modeling of Mobile robots: Degrees of freedom, constraints, Holonomic and Nonholonomic systems, Vehicle kinematics, Dynamics, example with two wheeled mobile robots.
Systems and methods for mobile robot positioning: Navigation and guidance, Odometry and other dead reckoning methods, Active beacon navigation system, Land mark navigation, Map based positioning, Vision based positioning, Pose estimation through Kalman Filter.

Motion control: Path planning, Obstacle avoidance, Classical control methods (PID, Feedback Linearization etc.), AI-based methods (Fuzzy Logic, ANN etc.)

Case Studies and Future Trend

TEXT BOOKS AND REFERENCES:

2. *Introduction to Autonomous Mobile Robots* by Roland Siegwart and Illah R. Nourbakhsh.
4. *Intelligent Mobile Robot Navigation: Cuesta Federico*
5. *Modern Navigation, Guidance and Control Processing* by Ching-Fang Lin

MEC 301/06 : ELECTIVE - II: NAVIGATION, GUIDANCE AND CONTROL
Full Marks : 100 4L+1T+0S

Fundamental concepts, State space formulations, Fundamental components of navigation, Guidance and control, Animal navigation, Robot navigation, Inertial technology used for guidance, Control and navigation, Interoceptive sensors, Exteroceptive sensors, Discussing in detail the principles, Operation and design of sensors, Gyroscopes and accelerometers, as well as the advantages and disadvantages of particular systems, Physical and mathematical principles forming the basis for inertial navigation, Approaches to map building and map interpretation, Case studies of navigating robots (planner motion), Path planning, Classical control methods (PID, Feedback Linearisation etc.), Evolutionary techniques of mobile robot navigation and control, The principles of guidance and control of 6-DOF motions, Modeling of land/underwater vehicles, Environmental Disturbances, Stability and control of Underwater Vehicles, the characteristics and noise models of sensors, Sensor fusion, Optimal Sensor Integration : The Kalman Filter Observer, the dynamic behavior of controlled and guided systems. Future Trend

TEXT BOOKS AND REFERENCES:

1. *Modern inertial technology, Navigation, Guidance, and control* by Anthony Lawrence
2. *Kalman Filtering by Theory and Practice*, M. S. Grewal, A. P. Andrews
5. *Navigating Mobile Robots: Systems and Techniques* by J. Borenstein, B. Everett and L. Feng
6. *Intelligent Mobile Robot Navigation: Cuesta Federico*
MEC 301/07: ELECTIVE - II: NON-LINEAR CONTROL SYSTEM

Full Marks: 100
4L+1T+0S

Review of classical control concepts Root locus technique; Frequency response analysis; Nyquist Criteria.

Mathematical models of physical system, DC motor modeling problem (linear); State space and state variables, state variable equations, Controllability, Observability, Solution of state equations. Evaluation of state transition matrix (STM). Simulation of state equation using MATLAB/SIMULINK program. Similarity transformation and invariance of system properties due to similarity transformations.

Feedback control, Various types of feedback, State feedback controller and observer design. Linear versus nonlinear systems, Fundamentals, Common nonlinearities (saturation, dead-zone, on-off non-linearity, backlash, hysteresis), DC motor modeling problem (nonlinear); Analysis of nonlinear systems, describing function and phase plane method. Disturbance issues in nonlinear control, non-linear control system design problem.


Feedback Linearization: Exact linearization, input-state linearization, input-output linearization.

TEXT BOOKS AND REFERENCES:

1. *Nonlinear Systems*: by Khalil, Hassan K.
2. *Nonlinear Control System*: by Alberto Isidori
3. *Introduction to Control Theory*: by O. L. R. Jacobs
4. *Control System Design*: by Goodwin, Graham C
5. *Applied Nonlinear Control*: by J. J. Slotine & E. W. Li
6. *Modern Control System theory and design*: Shinners, Stanley M.

MEC 301/08: ELECTIVE - II: AUTOMATION AND INTELLIGENT SYSTEMS

Full Marks: 100
4L+1T+0S

Introduction; Mathematical models of physical system, Basic principals of industrial automation. Role of mechanical handling in automation. Mechanical muscle power and control, Feedback characteristics of control systems; Control systems and components; Introduction to design; State variable analysis and design, Kinematic analysis and design of automatic machine, Application of robots and other intelligent machines in automation.

TEXT BOOKS AND REFERENCES:

1. *Autonomous Robots* by George A. Bekey
2. *Soft Computing & Intelligent Systems* by Sinha & Gupta
3. *Artificial Intelligence and Soft Computing* by Amit Konar

MEC 301/09 : ELECTIVE – II : HDL-BASED FPGA DESIGN

Full Marks : 100 4L+1T+0S

Overview of digital IC design and HDL-based design flow. 
Hardware design approaches and abstractions.
Introduction to HDLs and requirements.
Introduction to simulation concepts and event-driven simulation.
VHDL constructs for Behavioral, RTL, Data-flow and Structural Modeling.
Design of digital functional blocks using VHDL.
Basic synthesis methods and algorithms.
FPGA architectures and technology.
Design examples of VHDL synthesis for FPGA implementation

TEXT BOOK


REFERENCE BOOKS

**MEC- 301/10 : ELECTIVE-II : DIGITAL IMAGE PROCESSING**

**Full Marks : 100**

**4L+1T+0S**


**Image Segmentation** : Detection of Discontinuities, Edge Linking and Boundary Detection, Thresholding, Region-Oriented Segmentation, Use of Motion in Segmentation.

**Representation and Description** : Representation Schemes, Boundary Descriptors, Regional Descriptors, Morphology, Relational Descriptors.

**Object Recognition** : Modeling, Representation, Techniques

**Machine Vision & Intelligence** : Elements of a Machine Vision system, Selection of components, levels of processing, Performance Evaluation, Machine intelligence: Concepts & Methods

**RECOMMENDED BOOKS**


**MEC- 301/11 : ELECTIVE - II : OPTICAL ENGINEERING AND PHOTONICS**

**Full Marks : 100**

**4L+1T+0S**

**Spherical Optics** : Introduction to glass grinding and polishing, Fabrication of optical components like flats, prisms, spherical mirrors and lenses etc. Testing and measurements of spherical optical surfaces/elements/components and systems with the help of Twyman Green & Fizeau interferometer (Phase shift Interferometry).

**Optical System Design** : Paraxial Optics, Ray tracing, Aberrations analysis, Image evaluation, Optimisation techniques in lens design, Tolerance analysis and Introduction to zoom lenses.


**Application of Optical Instruments** : Optical instruments used in the field of Medical Sciences (Microscopes, Endoscopes, Medical LINAC, Direct & Indirect Ophthalmoscope, Surgical Microscope etc.), Societal Mission (Low Vision Aids, Night Driving Filters), Strategic (Precision Components & systems), Defense (Aerial & panoramic Camera), Security (Passport Camera etc.) and Avionics (Head up Displays &
other cockpit instrumentation), Industrial applications (Electrooptical systems for sorting, grading & packaging of different fruits & vegetables, Semi automatic optical inspection system for SMDs)

**Photonics**: Laser Systems and their application in data storage, communication and information technology, Fiber optics and its applications in security & telecommunication, Fiber optic sensors, Extrinsic Fabry Perot Interferometer EPFI Sensors for health monitoring studies of aerospace & civil structures, Fiber optics based fire detection & warning systems for aircraft, Fiber optics systems and holography, High security embossed holograms mastering techniques, Encoding anti counterfeit features in high security embossed hologram masters, Leak tight penetration assembly for fiber optic cables, Fiber Braggs gratings (FBG)/Long Period Gratings (LPG) writing, FBG based petrol leak sensor, Fiber optics beam delivery system for high power lasers, Fiber Optic based intrusion detection system, Integrated and Optoelectronic devices & their applications.

**MEC-301/12 : ELECTIVE - II : SMART SYSTEMS**

**Full Marks**: 100

**4L+1T+0S**


**Fuzzy Logic**: Fuzzy Sets vs Crisp Sets, Operations on Fuzzy sets, Fuzzy Arithmetic, Fuzzy relations, Fuzzy Pattern recognition, Fuzzy control, Engineering and other applications.

**Overview** of Genetic Algorithms; Recent Trend; A Few Case Studies

**RECOMMENDED BOOKS**


**MEC-301/13 : ELECTIVE - II : MATERIAL CHARACTERIZATION & METROLOGY**

**Full Marks**: 100

**4L+1T+0S**

**Materials characterization**: Definition, importance and application with case studies.

**Principles and General Methods of Computation, Strutural and Defect Characterization** – Techniques of X – ray, electron and neutron diffraction, EDAX

**Thermal Methods** - DTA, TGA, DSC, TMA and DMA.

**Electro Microscopy** - (TEM & SEM) and electron microprobe analysis

**Optical Spectroscopy** - UV, visible, IR and Raman spectroscopy, ESCA and Auger spectroscopy, SIMS

**Resonance Method** - NMR, ESR and Mossbauer techniques, particle size analysis, electrical and magnetic characterization techniques
Metrology : Limits, Fits and Tolerances : Concepts of interchangeability need for standards system of limits, fits and tolerances and its applications over design ISO system of tolerances. Precision and Accuracy; Methods of estimating accuracy and precision; their evolution; Types of errors in measurements; sources of errors; Systematic and random errors; statistical analysis of test-data and probable error / tabulation. Uncertainty measurement and control

Measuring and Gauging Instruments : Fundamental mechanical linear and angle measuring instruments like vernier calipers, Micrometers, dial gauges, bevel protectors, sine bars, spirit level, optical instruments and autocollimator. Application and uses of tool room microscope, comparators; Magnification principle, types of comparators, profile projectors, pitch measuring, Laser Interferometer, Coordinate measuring machine, types, construction and application, etc for the calibration of reference standards

Screw Threads and Gear Metrology : Elements of screw threads metrology and measurement of fundamental parameters like major, minor and effective diameters of external and internal screw threads, Elements of gear metrology and measurement of gear tooth profile, thickness, pitch and runout, gear rolling test and measurement.

Geometrical Metrology and Surface Roughness : Concepts of form errors; straightness, flatness, roundness errors and their measurements, concept of micro and macro errors, measurement of surface roughness, stylus method using, mechanical, optical, electrical magnification methodologies. Surface Roughness: Sources of surface irregularities in manufacturing, Different elements of surface roughness, Definition of centre line and related roughness parameters, Measurement Instruments, Profilometers, Analysis of roughness signal in frequency domain, Auto-correlation of surface roughness signals, Use of such analysis in identification of state of health of the manufacturing process

Transducers and Sensors : Transducers, types, governing principles of transducers; for displacement measurements, velocity measurement, linear and angular, study of velocity transducers. Mechanical, pneumatic, and hydraulic load cells; torque measuring devices; types of strain gauges and its measurements, fixing methods including applications. Pressure measurement, types of pressure transducer; measuring devices, performance characteristics; low and high pressure measurement techniques.

Industrial Inspection : Management of inspection and quality control, communication of specifications, selection of gauging equipments, kind of inspection, Application of statistical tools

BOOKS RECOMMENDED

- Engineering Metrology R.K.Jain, S Chand & Company
- Engineering metrology I. C. Gupta
- Mechanical Measurement & Control D.S.Kumar,
- Mechanical Measurement: Doebelin, Mc Graw Hill
- Dimensional Metrology by Miller
MEC – 351 : PROJECT & THESIS

Full Marks : 300

A part of dissertation comprising theoretical and / or experimental studies focussed on some topics related to the discipline to enable students to build up confidence to attack an unknown problem related to the field comprehensively and competently. This will be submitted for evaluation by internal and external examiners.

MEC – 451 : THESIS

Full Marks : 500

The complete dissertation of the topics chosen earlier during the third semester on the subject MEC – 351: “Project & Thesis” to be submitted for evaluation by internal and external examiners

MEC – 452 : SEMINAR & VIVA-VOCE ON THESIS

Full Marks : 500

A seminar followed by a viva voce examination on the submitted thesis to be conducted jointly by the internal and external examiners.