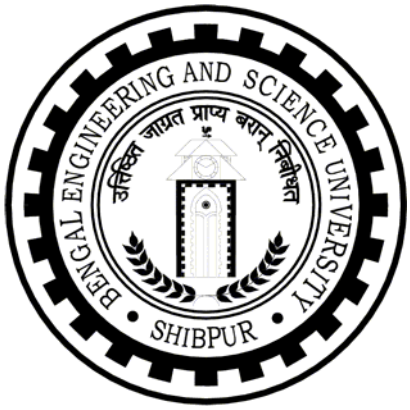
STRUCTURE & SYLLABI
OF
COLLABORATIVE
MASTER OF TECHNOLOGY
PROGRAMME IN MECHATRONICS

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

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

* 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 **

Sl. No.	Subject	Course No.	Hours per week				Full Marks		
			L	T	S	TOT	Theo	Sess	Total
1.	MICROPROCESSORS, MICROCONTROLLERS AND EMBEDDED SYSTEM DESIGN	MEC-201	**3**	1	0		**100**		
2.	MEMS TECHNOLOGY	MEC-202	3	1	0		100		
3.	ROBOTICS	MEC – 203	3	1	0		100		
4.	DIGITAL SIGNAL PROCESSING AND APPLICATIONS	MEC – 204	3	1	0		100		
5.	INSTRUMENTATION AND INDUSTRIAL CONTROL	MEC – 205	3	1	0		100		
6.	ROBOTICS LABORATORY	MEC – 251	0	0	4			50	
7.	SENSORS LABORATORY	MEC – 252	0	0	4			50	
8.	MEMS LABORATORY	MEC – 253	0	0	4			50	
	TOTAL		15	5	12	37	500	150	650

**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

Sl. No.	Subject	Course No.	Hours per week				Full Marks		
			L	T	S	TOT	Theo	Sess	Total
1.	ELECTIVE – II ***	MEC-301/n	**4**	1	0		**100**		
2.	PROJECT & THESIS	MEC – 351	0	0	30			300	
	TOTAL		4	1	30	35	100	300	400

***** 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

Sl. No.	Subject	Course No.	Hours per week				Full Marks		
			L	T	S	TOT	Theo	Sess	Total
1.	THESIS	MEC – 451	**0**	0	35			**400**	
2.	SEMINAR & VIVA VOCE ON THESIS	MEC – 452	0	0	0			100	
	TOTAL		0	0	35	35		500	500

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^{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

Overview of Mechatronics : What is Mechatronics? Instrumentation and Control Systems, An Introduction to Micro- and Nanotechnology.

Sensors and Actuators : Introduction to Sensors and Actuators, Sensor and Actuator Characteristics, Different types of Sensors, Actuators: Electro-mechanical Actuators, Electrical Machines, Piezoelectric Actuators, Hydraulic and Pneumatic Actuation Systems.

Mathematical Modeling of Physical Systems : Modeling Electromechanical Systems, Structures and Materials, Modeling of Mechanical Systems for Mechatronics Applications, Fluid Power Systems, Modeling and Simulation for MEMS, Using MATLAB SIMULINK for modeling and simulation Mechatronic systems.

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

REFERENCES:

Bolton, W, *Mechatronics*. 3rd edn, Addison-Wesley.

Fuller, J, *Robotics: Introduction, Programming and Projects*, 2nd edn, Prentice-Hall.

Schuler, C, & McNammee, W, *Industrial Electronics & Robotics*, McGraw-Hill.

Karnopp DC, Margolis DL & Rosenberg RC, *System Dynamics: Modeling and Simulation of Mechatronics Systems*. 3rd edn. Wiley Interscience.

Bishop, RH (ed.) *The Mechatronics Handbook*, CRC Press.

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 activites of Smart Materials, Mechanically Smart Materials, Megnetically Smart Materials, Optically Smart Materials, Potential applications of Smart Materials, shape Memory application, Noise and Vibtration 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 ckts, 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_α 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
2. K. Ogata*, Discrete Time Control System*, Pearson Education.
3. Grewal & Andrews, *Kalman Filtering, Prentice Hall Information & System Sciences Series*
4. Anderson & Moore, *Optimal Control: Linear Quadratic Methods*, PHI
5. Glad & Ljung*, Control Theory: Multivariable & Nonlinear Methods,* Taylor & Francis.

MEC- 105/1 : ELECTIVE- I

(Bridge Course for students having ME,Prod,Met,Min,Automobile,C.E.background)

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

Electric Circuits and Components: Introduction, Basic Electrical Elements – Resistor, Capacitor, Inductor, Kirchhoff's Laws – Series Resistance Circuit, Parallel Resistance Circuit, Voltage and Current Sources and Meters, Thevenin and Norton Equivalent Circuits, Alternating Current Circuit Analysis, Power in Electrical Circuits, Transformer, Impedance Matching, Grounding and Electrical Interference, Electrical Safety.

Semiconductor Electronics: Review Semiconductors devices: Junction Diode – Zener Diode, Coltage Regulators, Optoelectronics Diodes, Analysis of Diode Circuit, Three terminal devices – BJT, JFET, MOSFET, Four terminal devices, SCR, DIAC, Triac – Photo devices:- Photo diode, Photo transistor, Photo SCR, LED, LCD, Opto-isolator and Photo Coupled Pairs.

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:

1. *Electronic devices & Circuit theorem* , 8th Ed., Robert L Boylested, Pearson Education
2. *Digital Fundamentals* , 3rd Edition, Floyd, Pearson Education
3. *Electronic Devices,* Floyd, Pearson Education
4. *Electronics Principle,* Albert Paul Malvino, Tata McGraw Hill, Sixth Edition 1999

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:

1. S. H. Crandall, N. C. Dahl and T. J. Lardner, *An Introduction to the Mechanics of Solids,* Tata McGraw Hill
2. J. E. Shigley, *Theory of Machines and Mechanisms,* McGraw Hill Inc., 1995
3. J. E. Shigley, *Mechanical Engineering Design*, McGraw Hill International, 2001
4. W. Ernst, *Oil Hydraulic, Power And Its Industrial Application,* McGraw Hill Inc.,
5. A. Esposito, *Fluid Power with Applications,* Pearson Education, 2003

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.

MEC-201 : MICROPROCESSORS, MICROCONTROLLERS AND EMBEDDED SYSTEM DESIGN

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

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

1. F. Vahid and T. D. Givargis, *Embedded System design: A Unified Hardware / Software Introduction,* Wiley 2002 (Cheap Edition)
2. W. Wolf, *Computers as Components; Principles of Embedded Computer Systems Design,* Elsevier/ MK, 2000 (Cheap Edition)
3. J.W.S. Liu, *Real Time Systems,* Prentice Hall, 2000 (Cheap Edition)

REFERENCE BOOKS

1. D.D. Gajski, F. Vahid, S. Narayan and J. Gong, *Specification and Design of Embedded Systems,* PH / Pearson, 1994
2. S. Heath, *Embedded Systems Design,* Second Edition, Elsevier/ Newnes, 2002
3. P. Marwedel, *Embedded System Design,* Springer, 2004 / 2006
4. A. S. Berger, *Embedded Systems Design: An Introduction to Processes, Tools and Techniques,* CMP Books, 2001
5. J. Catsoulis, *Designing Embedded Hardware,* ORA,2002
6. L. Edwards *Embedded Systems Design on a Shoestring,* Elsevier / Newnes, 2003
7. J, Gannsle, *The Art of Designing Embedded Systems,* Elsevier / Newnes, 1999
8. J. J. Labrosse, *Embedded Systems Building Blocks,* CMP Books, 1999
9. D. Patterson and J. Hennessy, *Computer Organization Design: The Hardware / Software Interface,* Third Edition, Elsevier/ MK, 2004 (Cheap Edition)
10. G. De Micheli, R. Ernst and W. Wolf, *Readings in Hardware / Software Co-design,* Morgan Kufmann, 2001
11. J. Staunstrup and W. Wolf, Hardware / Software : Principles and Practice, Kluwer, 1997.

MEC-202 : MEMS TECHNOLOGY

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

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

1. M.J.Madou, *Fundamentals of Microfabrication*, Second Edition, CRC, 2002.
2. M.Bao, *Analysis and Design Principles of MEMS Devices,* Elsevier, 2005.

REFERENCE BOOKS

1. C.Liu, *Fundamentals of MEMS,* Pearson/PH, 2006.
2. J.A.Pelesko and D.H.Bernstein, *Modeling MEMS and NEMS*, CRC, 2002.
3. G.M.Rebeiz, *RFMEMS: Theory Design and Technology*, Wiley, 2003.
4. V.Varadan, K.J.Vinoy and S. Gopalakrishnan, *Smari Material Systems and MEMS: Design and Development Methodologies,* Wiley, 2006.
5. J.J.Allen, *Micro Electro Mechanical System Design*, CRC, 2005.
6. N.Maluf and K.Williams, *Introduction to Microelectromechanical Ssystem Engineering*, Artech, 2004.
7. K.Gilleo, *MEMS/MOEM Packagin, McGrar-Hill, 2006.*
8. M.Gad-el-Hak, *The MEMS Handbook* (3 Volumes Set), Second Edition, CRC, 2005.
9. S.Franssila, *Introduction to Microfabrication*, Wiley, 2004.
10. G.S. May and S.M.Size, *fundamentals of Semiconductor Fabrication,* Wiley, 2004.
11. J.D.Plummer, *M.D.Deal and and P.B.Grifin, Silicon VLSI Technology: Fundamentals,* Practice and Modeling Pearsom /PH, 2001.
12. G.S.May and C.J.Spanos, *Fundamentals of Semiconductor Manufacturing and Process Control*, Wiley, 2006.
13. P.Van Zant, *Microchip Fabrication: A Practical Guide to Semiconductor*

Processing, Fifth Edition, MH, 2004. (Cheap Edition).

14. S.K.Gandhi, *VLSI Fabrication Principles*, Second Edition, Wiley, 1994.
15. S.M.Sze,*VLSI Technology*, Second Edition, MH, 1988. (Cheap Edition).
16. R.Yanda, M.Heynes and A.Miller, *Demystifying Chipmaking*, Elsevier/Newnes, 2005.

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
2. *Introduction to Robotics: Mechanics and Control* (3rd Edition) by John J. Craig
3. *Robot Dynamics and Control:* by Spong and Vidyasagar
4. *A Robot Engineering Testbook:* Mohsen Sahinpur
5. *Control of Robot Manipulations:* F.I.Lewis, C.T.Abdallah, D.M.Dawson
6. *Kinematic Analysis of Robot Manipulators:* Carl D. Crane and Joseph Duffy
7. *Robot Grippers:* D.T.Pham and W.B.Heginbotham
8. *Robotics for Engineers*: Koren Y.
9. *Robot Modelling: Control and Application with software:* by P.G.Ranky and C.Y.Ho

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 Industrila 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 Miodellation.

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]

1. Jordan & Smith, *Nonlinear ordinary differential equations,* Cambridge University Press, 1990
2. A.H. Nayfeh, *D.T. Mook, Nonlinear Oscillations,* New York, Wiley, 1979.
3. A.H. Nayfeh, *Introduction to Perturbation Techniques,* New York, Wiley, 1981.

MEC 301/02 : ELECTIVE - II: POWER ELECTRONICS AND MACHINE CONTROL
Full Marks : 100 **4L+1T+0S**

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.

Half wave and full wave uncontrolled and controlled rectifier circuits : With resistive load and R-L load. Output average and RMS voltages. Effect of freewheeling diode.

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 exited 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

1. M.Rashid, *Power Electronics,* PHI Pub.
2. Ned Mohan, *Undeland, Robbins, Power Electronics,* John Wiley Publication
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 **4L+1T+0S**

The evolution of Computers, Introduction of different Computer generations.

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.

Introduction to Computer Communication and Network : Communication Protocol, Circuit Switch, Message Switch and Packed Switch. Local Communication, Long distance communication, Interconnection Structure, Ethernet ARPANET etc., various communication devices.

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.

Dynamic set operations, Hashing. Disjoint set union algorithm, fast UNION-FIND algorithm, Analysis and Applications.

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 : Interoceptive 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:

1. *Computational Principles of Mobile Robotics* by Gregory Dudek an Michael Jenkin.
2. *Introduction to Autonomous Mobile Robots* by Roland Siegwart and IIIah R. Nourbakhsh.
3. *Navigating Mobile Robots: Systems and Techniques* by J. Borenstein, B. Everett and L. Feng.
4. *Intelligent Mobile Robot Navigation:* Cuesta Federico
5. *Modern Navigation, Guidance and Control Processing* by Ching-Fang Lin
6. *Autonomous* Robots by George A. Bekey.

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 Fitering by Theory and Practice,* M. S. Grewal, A. P. Andrews
3. *Applied Optimal Estimation* by A. Gelb.
4. *Stochastic Models, Estimation and Control* by P. S. Maybeck.
5. *Navigating Mobile Robots: Systems and Techniques* by J. Borenstein, B. Everett and L. Feng
6. *Intelligent Mobile Robot Navigation:* by Cuesta Federico
7. *Modern Navigation, Guidance and Control Processing* by Ching-Fang Lin.

MEC 301/07 : ELECTIVE - II I : 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.

Concept of stability, Stability in the sense of Lyapunov and absolute stability. Second (or direct) method of Lyapunov stability. Construction of Lyapunov function-Methods of Aizerman, Zubov; variable gradient method. Lure 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.

Neuro-Fuzzy-Expert systems for uncertain reasoning. Concept learning, associative memory. Model based optimization using evolutionary algorithms. Multi-sensor integration for environment interaction and error recovery.

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
4. *Fuzzy logic Techniques for Autonomous Vehicle Navigation* by Dimiter Driankou, Alessandro Saffiotli.

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 sys\nthesis for FPGA implementation

TEXT BOOK

1. *J.Bhasker, A VHDL Primer,* third Edition, PH/Pearson, 1999.
2. *J.Bhasker, A VHDL Synthesis Primer,* Second Edition, Star Galaxy, 1998.
3. M.J.S.Smith, *Application specific Integrated Circuits,* AW/Pearson, 1997.
4. W.Wolf, *FPGA-based System Design,* PH.Pearson, 2004. (Cheap Edition).

REFERENCE BOOKS

1. P.J.Ashenden, *The Designer's Guide to VHDL,* Second Edition, Morgan Kaufmann, 2001 (Cheap Edition).
2. Z.Navabi, *Digital Design and Implementation with Field Programmable Devices,* Springer, 2005.
3. J.Armstrong and F.G.Gray, *VHDL Desigh Respresentation and Synthesis,* Second Edition, PH/Pearson, 2000.
4. S.Sjoholm and L.Lindh, *VHDL for Designers,* Prentice-Hall, 1997.
5. Z.Navabi, *VHDL: Analysis and Modeling of Digital Systems,* Third Edition, MH,1998. (Cheap Edition)
6. D.Naylor and S.Jones, *VHDL: A Logic Synthesis Approach,* Chapman & Hall, 1997.

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

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

Introduction : Digital Image Representation, Fundamental Steps in Image Processing, Elements of Digital Image Processing Systems.

Digital Image Fundamentals :A Simple Image Model, Sampling and Quantization, Neighbors of a Pixel, Connectivity, Labeling of Connected Components, relations, Equivalence and Transitive Closure, Distance Measures, Arithmetic/Logic Operations.

Image Transforms : Spatial and Frequency Domain, Discrete Fourier Transform, Fast Fourier Transform, Discrete cosine Transform.

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

1. Gonzalez & Woods, *Digital Image Processing,* Addison-Wesley.
2. Anil K. Jain, *Fundamentals of Digital Image Processing,* PHI
3. Chanda & Majumder, *Digital Image Processing and Analysis,* PHI

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.

Aspherics : Fabrication of Aspherical optical surfaces & components using Single Point Diamond Turning (SPDT) machine. Testing & measurements of aspherical optical surfaces/elements/components and systems using null optics and optical profilers.

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**

Artificial Neural Network : Biological Neural Networks, Models of Artificial Neuron, Perceptron, Learning laws, Activation Dynamics Models, Learning Methods, Supervised and Unsupervised Learning, Stability and Convergence, ANN's for Pattern Recognition tasks, Feedforward and Feedback ANN, Analysis of Pattern association Network, Pattern classification, Perceptron Convergence Theorem, Perceptron representation problem, Pattern mapping Problem, Back Propagation Algorithm, Hopfield Model, Pattern Storage problem, Stochastic Networks, Boltzman's Machine.

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

1) *Artificial Neural Networks* - B. Yegnanarayana, Prentice Hall of India Pvt. Ltd., 2004.
2) *Fuzzy sets and fuzzy Logic* - George Klir and Bo Yuan. Prentice Hall of India Pvt. Ltd., 1997.

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 *I* 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
- *Dimentional Metrology* by Miller

MEC – 351 : PROJECT & THESIS

Full Marks : 300 **0L+0T+30S**

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 **0L+0T+35S**

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 **0L+0T+35S**

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