TEACHING SCHEME

M.TECH PROGRAMME

MECHATRONICS AND ROBOTICS

PUNJAB TECHNICAL UNIVERSITY, JALANDHAR
for Batch 2012 onwards

**DETAILED SYLLABUS AND OTHER CONDITIONS FOR THE
PROPOSED COURSE
M.TECH. MECHATRONICS AND ROBOTICS**

<u>**Schedule of Teaching**</u>   <u>**Schedule of Examination**</u>

Lecture	*Tutorials*	*Total*		*Time*	*Theory*	*Viva*	*Total*
(per week)				(Hrs.)	Marks	Marks	
4	0	4	All theory subjects	3	100	50	150
			Project		50	50	100
			Seminar		100		100
			Dissertation			Satisfactory/not Satisfactory	

1st Semester		2nd Semester	
Subject Code	Subjects	Subject Code	Subjects
MER 500	Advanced Mathematics for Engineers	MER 504	Microprocessor, Microcontroller And Embedded Systems
MER 501	Design of Experiments	MER 505	Robotics
MER 502	Design of Mechatronics System	MER 506	Industrial Automation
MER 503	Digital Control Engineering	MER 507	Digital Signal Processing and Applications
	Elective- I (Bridge Course)		Elective- II
MER 520	LAB – I	MER 521	LAB – II
3rd Semester		4th Semester	
Subject Code	Subjects		THESIS
MER 508	MEMS and Nanotechnology		
MER 509	Neural Network & Fuzzy Logic		
	SEMINAR & PROJECT		

<u>LAB</u>

ROBOTICS LABORATORY
SENSORS LABORATORY
MECHATRONICS LABORATORY
INDUSTRIAL AUTOMATION AND PLC LABORATORY
DIGITAL SIGNAL PROCESSING LABORATORY
MICROPROCESSOR AND MICROCONTROLLER LABORATORY

<u>THEORY ELECTIVE</u>

<u>Elective 1</u>
Bridge Course
a. MER 518 PRINCIPLES OF DESIGN OF MACHINE ELEMENTS OR
b. MER 519 ELECTRONIC DEVICES AND CIRCUITS

<u>Elective 2</u>

MER 511 MODELING, SIMULATION AND ANALYSIS OF MANUFACTURING SYSTEMS
MER 512 DYNAMICS AND MECHANISM DESIGN
MER 513 DFM TECHNIQUES AND PRODUCT DESIGN
MER 514 COMPUTER CONTROL OF MANUFACTURING SYSTEMS
MER 515 DESIGN OF TRANSMISSION SYSTEMS
MER 516 ARTIFICIAL INTELLIGENCE
MER 517 ADVANCED CONTROL SYSTEMS

MER 500   ADVANCED MATHEMATICS FOR ENGINEERS

Fourier Transforms
Introduction, Fourier Integral Theorem, Fourier Sine and Cosine Integral, Complex form of Fourier Integrals, Fourier Transforms, Inverse Fourier Transform, Properties, Modulation Theorem, Convolution Theorem for Fourier Transforms, Parseval's Identity, Fourier Transforms of derivative of functions, Relation between Fourier and Laplace transform.

Z -Transforms
Introduction, Properties of Z- Transforms, Evaluation of inverse Z – Transforms.

Matrices And Linear System Of Equations
Solution of linear simultaneous equations by Gaussian elimination and its modification, Crout's triangularization method, Iterative methods-Jacobins method, Gauss-Seidal method, Determination of Eigen values by iteration.

Conformal Mapping
Conformal mapping, linear transformations, Bi-linear transformations, Schwarz's-Christoffel transformations.

Calculus Of Variations
Euler-Lagrange's differential equation, The Brachistochrone problems and other applications. Isoperi-metric problem, Hamilton's Principle and Lagrange's Equation. Rayleigh-Ritz method, Galerkin method.

Books Recommended:
1. Higher Engineering Mathematics - by Dr. B.S. Grewal; Khanna Publishers
2. Fourier Series and Boundary Values Problems - by Churchill; McGraw Hill.
3. Complex Variables & Applications - by Churchill; McGraw Hill.
4. Calculus of Variations - by Elsgole; Addison Wesley.
5. Calculus of Variations - by Galfand & Fomin; Prentice Hall.
6. The Use of Integral Transforms - by I.N. Sneddon., Tata McGraw Hill.

MER 501   DESIGN OF EXPERIMENTS

INTRODUCTION
Strategy of experimentation, Some typical applications of experimental design, Basic principles, Guidelines for designing experiments, A brief history of statistical design, Using statistical design in experimentation.

SIMPLE COMPARATIVE EXPERIMENTS
Introduction, Basic statistical concepts, Sampling and sampling Distribution, Inferences about the Differences in means, randomized designs, Inferences about the Differences in means, Paired comparison Designs, Inferences about the Variances of Normal Distributions.

RANDOMIZED BLOCK DESIGNS
Randomized complete block design, Latin square design, Balanced incomplete block design.

NTRODUCTION TO FACTORIAL DESIGN
Basic definition and principles, Advantages of factorials, The two factor factorial design, General factorial design, Fitting response curves and surfaces, Blocking in a factorial design.

FITTING REGRESSION MODELS
Introduction, Linear regression models, Estimate of parameters in linear regression models, Hypothesis testing in multiple regression, Confidence intervals in multiple regression, Prediction of new response observations, Regression model diagnostics, testing for lack of fit

TAGUCHI METHOD OF DESIGN OF EXPERIMENTS
Concept design, Parameter design, Tolerance design, Quality loss function, Signal-to-Noise ratio, Orthogonal array experiments, Analysis of Mean(ANOM), Quality characteristics, Selection and testing of noise factors, Selection of control factors, Parameter optimization experiment, Parameter design case study.

ANALYSIS OF VARIANCE (ANOVA)
Introduction, Example of ANOVA process, Degrees of freedom, Error variance and pooling, Error variance and application, Error variance and utilizing empty columns, the F-test.

BOOKS RECOMMENDED
1. Design and Analysis of Experiments, Douglas C Montgomery, John Wiley
2. Statistical Design and Analysis of Experiments, John P.W.M., Macmillan,
3. Introduction to Linear Regression Analysis, Montgomery D.C., Runger G. C.,
4. Response Surface Methodology: Process Ang Product Optimisation Using Designed Experiments, Myres R.H., Montgomery D. C., Wiley, New York
5. Introduction to Quality Engineering, Taguchi, G., Asian Productivity Organisation, UNIPUB, White Plains, New York
6. Statistical Analysis for Engineers And Scientists, J. Wesley Barnes, McGraw Hill Inc.

MER 502   DESIGN OF MECHATRONICS SYSTEM

INTRODUCTION
What is Mechatronics, Systems, Measurement Systems, Control Systems, Microprocessor- based controllers, The Mechatronics Approach.

SENSORS & TRANSDUCERS
Sensors and Transducers, Performance Terminology, (Displacement, Position & Proximity Sensors),(Velocity & Motion, Force, Fluid Pressure, Liquid Flow, Liquid Level, Temperature & Light Sensors), Selection of Sensors.

ELECTRONIC FUNDAMENTALS
Signal Conditioning Process, Operational Amplifier, Digital Logic, Logic Gates, Boolean Algebra, Data Acquisition Systems, Measurement Systems, Testing and Calibration.

ACTUATORS
Mechanical Actuation Systems, Hydraulic & Pneumatic Actuation Systems, Electrical Actuation Systems, A.C. Motor, D.C. Motor, Stepper Motor.

SYSTEM MODELLING & CONTROL
Mathematical Models, Engineering Systems, Electromechanical & Hydraulic- Mechanical Systems, Modeling Dynamic Systems, Transfer Functions, Introduction to METLAB & SIMULINK, Control Modes, PID Controller.

MICROPROCESSOR & COMPUTER
Computer and Interfacing, Microcomputer Structure, Microcontrollers, Application of Microcontrollers, PLC.

DESIGN & MECHATRONICS
Designing, Possible Design Solutions, Case Studies of Mechatronic Systems.

REFERENCE BOOKS

1. Bolton, -Mechatronics - Electronic Control systems in Mechanical and Electrical Engineering-, 2nd Edition, Addison Wesley Longman Ltd., 1999.
2. Devdas shetty, Richard A. Kolk, -Mechatronics System Design,- PWS Publishing company, 1997
3. Bradley, D.Dawson, N.C. Burd and A.J. Loader, Mechatronics: Electronics in Products and Processes, Chapman and Hall, London, 1991.

1. Brian Morriss, Automated Manufacturing Systems - Actuators, Controls, Sensors and Robotics¿, Mc Graw Hill International Edition, 1995.
2. Gopel Sensors A comprehensive Survey Vol I & Vol VIII, BCH Publisher, New York.

MER 503   DIGITAL CONTROL ENGINEERING

PRINCIPLES OF CONTROLLERS
Review of frequency and time response analysis and specifications of control systems, need for controllers, continues time compensations, continues time PI, PD, PID controllers, digital PID controllers.

SIGNAL PROCESSING IN DIGITAL CONTROL
Sampling, time and frequency domain description, aliasing, hold operation, mathematical model of sample and hold, zero and first order hold, factors limiting the choice of sampling rate, reconstruction.

MODELING AND ANALYSIS OF SAMPLED DATA CONTROL LANGUAGE
Difference equation description, Z-transform method of description, pulse transfer function, time and frequency response of discrete time control systems, stability of digital control systems, Jury's stability test, state variable concepts, first companion, second companion, Jordan canonical models, discrete state variable models, elementary principles.

DESIGN OF DIGITAL CONTROL ALGORITHMS
Review of principle of compensator design, Z-plane specifications, digital compensator design using frequency response plots, discrete integrator, discrete differentiator, development of digital PID controller, transfer function, design in the Z-plane.

PRACTICAL ASPECTS OF DIGITAL CONTROL ALGORITHMS
Algorithm development of PID control algorithms, software implementation, implementation using microprocessors and microcontrollers, finite word length effects, choice of data acquisition systems, microcontroller based temperature control systems, microcontroller based motor speed control systems.

REFERENCE BOOKS

1. M.Gopal, "Digital Control and Static Variable Methods", Tata McGraw Hill, New Delhi, 1997.
2. John J. D'Azzo, "Constantive Houpios, Linear Control System Analysis and Design", Mc Graw Hill, 1995.
3. Kenneth J. Ayala, "The 8051 Microcontroller- Architecture, Programming and Applications", Penram International, 2nd Edition, 1996.

MER 518   PRINCIPLES OF DESIGN OF MACHINE ELEMENTS

Simple stresses and strains: Concept of stress and strain (linear, lateral, shear and volumetric), Hook's law. Elastic constants and their relationship. Generalized Hook's law. Axial force diagram, stresses, strains and deformation in determinate and indeterminate homogeneous and composite bars under concentrated loads, self-weight and temperature changes.

Shear force and bending moment diagrams. Concept and definition of shear force and bending moment in beams due to concentrated load, UDL, uniformly varying loads and couples in determinate beams. Relation between SF, BM and intensity of loading, construction of SF, and BM diagrams for cantilevers, simple compound beams and bends.

Design concepts, material & process selection

Design concept, design process, types of design, factor of safety & design codes, materials and process selection.

Loads and stress in machine elements

Types of loads, static, shock, impact and fluctuating loads, types of stresses, tensile, compressive, direct and torsional shear, bending stresses, combined effect of direct, bending and torsional stresses,

Design of shaft based on torsional and lateral rigidity, combined loadings.

Spur Gears: Law of Gearing, Effect of Pressure angle and Centre Distance, Path of Contact, Arc of Contact, Contact Ratio, Interference and Undercutting, Minimum number of teeth to avoid interference, Design of Spur Gears, Selection of Type of Gears, Force Analysis, Gear tooth Failures, Selection of Materials, Beam Strength, Wear Strength, Effective Load Calculation, Dynamic Load, Gear Design for Maximum Power Transmitting Capacity. **Bevel Gears**:Force Analysis, **Worm Gears:** Force Analysis

Rolling Contact Bearings: Types, Static and Dynamic load Capacity, Stribeck's Equation, Concept of equivalent load, Load life Relationship, Selection of bearing from Manufacturer's Catalogue, Design for variable loads and Speeds, Bearings with Probability of Survival other than 90%, Lubrication and Mounting of bearing.

Introduction to Mechanical Vibrations, Importance of the Study of Vibrations, Elements of a Vibratory System, Examples of Vibratory Motion, Terms used in Vibratory Motion, Degrees of freedom and Examples of Degrees of freedom, Discrete and Continuous system, Types of Vibrations, Types of Free Vibrations.

Reference Books:
1. Ramamrutham S.: Strength of Materials, Dhanpat Rai & Sons, 1991.
2. Beer and Johnston: Strength of Materials- CSB Publisher.
3. Rao, J.S. & Dukkipati, R.V.: Mechanism & Machine Theory, New Age International Pvt.Ltd.
Publishers.
4. Ramamurthy, V.: Mechanics of Machines, Narosa Publishing House.
5. Manufacturing Technology, P.N. Rao, Tata McGraw-Hill Publishing Limited, II Edition, 2002.

6. S. S. Rattan, "Theory of Machines", Tata McGraw Hill Publishing Company Ltd., 2nd Edition, 2007

7. V. B. Bhandari, "Design of Machine Elements", Tata McGraw Hill Publishing Company Ltd., 2nd Edition, 2007

MER 519   ELECTRONIC DEVICES AND CIRCUITS

Basic Semiconductor and Diodes: Intrinsic and extrinsic semiconductors, diffusion and drift currents, p-n junction under open-circuit, reverse bias and forward-bias conditions, p-n junction in the breakdown region, Ideal diode, terminal characteristics of junction diode, Load-line analysis of diode circuits, half wave rectifier and full wave rectifiers, Clippers and Clampers, capacitive filters, RC and LC filter, voltage multipliers. Principles, construction and characteristics of Zener diodes, Light Emitting Diodes, Schottky Diode, Varactors

Bipolar and Unipolar Transistors: Bipolar junction transistor (BJT)- physical structure and modes of operation, Transistor characteristic and parameters, Common Base, Common Emitter and Common Collector Configurations, Transistor biasing, Transistor as a switch, Basics characteristics of an amplifier, Simple transistor model (re model), Common Emitter, Common Collector and Common base amplifiers, hybrid equivalent circuit, H-parameters, circuit analysis using h-parameters. Junction field effect transistor (JFET): Characteristics, parameters and biasing. Metal oxide field effect transistor (MOSFET): Characteristics, parameters and biasing. Class a power amplifier, Class B, Class AB Push-pull and Class C-power amplifiers.

Integrated Circuit and Operational-Amplifiers: Introduction to IC's, Op-Amps, Op-Amp Characteristics, Feedback, Different feedback configurations, Current– to–voltage converter and voltage-tocurrent converters, voltage and current amplifiers, mathematical operations using Op-Amp: summing, differentiation and integration, Comparators and Schmitt trigger

Oscillators and Active Filters: Oscillations, Feedback oscillator Principles,, RC phase shift oscillator, Wien bridge oscillator, Hartley oscillator, Colpitts oscillator, Crystal oscillators, frequency stability, Active Filters (1st order) with low pass, high pass, band pass, band stop and all pass. Pin configuration of 555 timer, 555 timer as Oscillator: monostable, bistable and astable multivibrator.

Regulated Power Supplies: Unregulated power supplies, line and load regulations, Zener diode voltage regulators, transistor series and shunt regulators, current limiting, Op-Amp voltage regulators, integrated circuit (LM-3XX) voltage regulators. Introduction to switching regulators. Working of Switched Mode Power Supply (SMPS).

Suggested Readings/ Books:
- Boylestad, Robert.L. Electronic Devices and Circuit Theory, Pearson Education
- Cathey Jimmie J., Theory and Problems of Electronic Devices and Circuits, McGraw-Hill
- Floyd Thomas L., Electronic Devices, Pearson Education

- Gayakwad, Ramakant A. OP-AMPS and Linear Integrated Circuits, Prentice Hall of India
- Malvino Albert Paul and Bates David, Electronic Principles, edition 7th, Tata McGraw Hill
- Millman Jacob, Integrated Electronic Devices and Circuits, Tata McGraw Hill.

MER 520 Lab-I

Max. Marks: 100
Time Allowed: 4hrs
One lab /field/industrial oriented project /problem will be allocated to each student related to the subjects related to the subjects taught in 1st semester.

MER 504   MICROPROCESSOR, MICROCONTROLLER AND EMBEDDED SYSTEMS

Microprocessor 8086 Architecture - BIU and EU, Registers, Pin Diagram, Memory addressing, Clock Generator 8284, Buffers and Latches, Maximum and Minimum Modes.

Addressing Modes, Instruction set of 8086, Assembly Language Programming, Assemblers, Procedures, Macros, Interrupts, 8086 Based Multiprocessor Systems - Coprocessors (8087 NDP), Closely and Loosely Coupled Multiprocessor Systems (8089 IOP).

Interfacing Chips- IC 8155 (Static Ram with I/O Ports and Timer), 8755 (EPROM with I/O Ports), 8251A (USART), 8255A (Programmable Peripheral Interface), 8253/8254 (Programmable Interval Timer/Counter), 8257 (DMA Controller), 8259A (Programmable Interrupt Controller).

Microcontrollers - Microcontroller 8051- Architecture, Pin Diagram, I/O Ports, Internal RAM and Registers, Interrupts, Addressing Modes, Memory Organization and External Addressing, Instruction Set, Assembly Language Programming, Real Time Applications of Microcontroller- Interfacing with LCD, ADC, DAC, Stepper Motor, Key Board and Sensors.

Embedded Systems-Introduction, Classification, Processors, Hardware Units, Software Embedded into System, Applications and Products of Embedded Systems, Structural Units in Processor, Memory Devices, I/O Devices, Buses, Interfacing of Processor Memory and I/O Devices, Case Study of an Embedded System for a Smart Card.

Text Books
1. B. B. Brey: The Intel Microprocessors, Architecture, Programming and Interfacing, Pearson Education.
2. Liu Gibson: Microcomputer Systems: The 8086/8088 Family- Architecture, Programming And Design , PHI.
3. D. V. Hall: Microprocessors and Interfacing, TMH.
4. Mazidi and Mazidi: The 8051 Microcontroller and Embedded Systems, Pearson Education.
5. V. Deshmukh: Microcontroller (Theory and Application), TMH.
6. Raj Kamal: Embedded Systems- Architecture, Programming and Design, TMH, New Delhi.

MER 505   INDUSTRIAL ROBOTICS

ROBOT FUNDAMENTALS
Robot components, robot classification and specification, Work envelopes, Other basic parameters of robots.

ROBOT MECHANICS
Robot kinematics - spatial descriptions and transformations, inverse transformation matrices, conventions of fixing frames to links, inverse robot kinematics – solvability, algebraic vs geometric solutions, examples of inverse manipulator kinematics.Differential motion and velocities - Differential motions of a robot and its hand frame, tool configuration jacobian, resolved motion rate control, manipulator jacobian, static forces and moments Robot dynamics - Lagrangian mechanics, effective moments of inertia, dynamic equations for multi-degree of freedom robots.

Trajectory planning - joint space trajectories: Cubic polynomials, Higher-order polynomials, Linear function with parabolic blends. Cartesian space trajectories: Positional transition, Rotational Transition. Trajectory Planning vs. path planning.

ROBOT ACTUATORS
Characteristics of actuating systems, Drives - electric, hydraulic, pneumatic and their relative merits. Speed reduction

ROBOT SENSORS
Robot sensors, sensor classification, micro-switches, proximity sensors, photo-electric sensors, rotary position sensors, sensor usage and selection, sensors and control integration.

ROBOT END-EFFECTORS
Types, grippers, gripper, force analysis, tool selection, process tooling.

IMAGE PROCESSING AND ANALYSIS
Image acquisition, histogram of images, thresholding, connectivity, noise reduction, edge detection, segmentation, Image analysis - object recognition, depth measurement with vision systems, stereo imaging.

ROBOT PROGRAMMING AND APPLICATIONS
Programming methods using Teach-pendent, on-line or off-line technique, Space position programming, motion interpolation.

REFERENCES:

- Fundamentals of Robotics: Analysis and Control, Robert Joseph Schilling, Prentice Hall publication.
- Introduction to Robotics by J.J. Craig, Pearson Education
- Robotics: Control, sensing, vision and intelligence by KS Fu, P Gonzalez, CSG Lee, McGraw Hill
- Industrial Robotics Technology, Programming and Applications, Mikell P. Groover, Mitchell Weiss, Roger N.Nagel, Nicholas G.Odrey McGraw- Hill International Editions, 1986.

MER 506   INDUSTRIAL AUTOMATION

Automation of assembly lines
Concept of automation, mechanization and automation

Automation using hydraulic systems.
Design aspects of various elements of hydraulic systems such as pumps, valves, filters, reservoirs, accumulators, actuators, intensifiers etc. Selection of hydraulic fluid, practical case studied on hydraulic circuit design and performance analysis. Servo valves, electro hydraulic valves, proportional valves and their applications.

Automation using pneumatic systems
Pneumatic fundamentals - control elements, position and pressure sensing -logic circuits - switching circuits - fringe conditions modules and these integration - sequential circuits - cascade methods - mapping methods – step counter method - compound circuit design - combination circuit design. Pneumatic equipments - selection of components - design calculations -application - fault finding – electro pneumatic circuits - use of microprocessors for sequencing.

Various Number Systems

Simple Logic Operations:
 Logic Circuits with AND, OR, XOR operations in electro-mechanical applications, Series and Parallel logic circuits.

Components of a PLC:
Chassis of a PLC, Power supply module, Input module, Output module, CPU.

Understanding Ladder Diagrams:
Programming contacts, Addressing contacts,Wiring diagrams, Ladder diagrams, Ladder diagram rules, Instructions to examine ON and examine OFF

Programming a Ladder Diagram:
Use of RSLogix software for ladder diagram programming, Setting up RSLogix for Allen-Bradley SLC 500 PLC, Hands-on wiring of input devices to input modules, Hands-on wiring of output devices to output module, Simple PLC programs to solve logical problems,

REFERENCES:
   Groover, M.P., CAD/CAM- Prentice Hall
   1. Yoram Koren, Robotics for Engineers- McGraw Hill 1992
   2. Paul, R.P., Robot Manipulators- MIT Press 1993
   3. Pressman R.S, Numerical Control and CAM-. John Wiley 1993 Williams
      Antony Espossito, " Fluid power with Applications ", Prentice Hall, 1980.
      Dudleyt, A.Pease and John J.Pippenger, " Basic Fluid Power ", Prentice Hall, 1987.
      Andrew Parr, " Hydraulic and Pneumatics ", (HB), Jaico Publishing House, 1999.
   4. Bolton. W. " Pneumatic and Hydraulic Systems ", Butterworth - Heineman, 1997.
   5. Programmable Logic controllers Principles and Application John w. Webb, Ronald A Reis

MER 507   DIGITAL SIGNAL PROCESSING AND APPLICATIONS

SIGNALS AND SYSTEMS
Basic elements of digital signal Processing –Concept of frequency in continuous time and discrete time signals –Sampling theorem –Discrete time signals. Discrete time systems –Analysis of Linear time invariant systems –Z transform –Convolution and correlation.

FAST FOURIER TRANSFORMS
Introduction to DFT – Efficient computation of DFT Properties of DFT – FFT algorithms – Radix-2 and Radix-4 FFT algorithms – Decimation in Time – Decimation in Frequency algorithms – Use of FFT algorithms in Linear Filtering and correlation.

IIR FILTER DESIGN
Structure of IIR – System Design of Discrete time IIR filter from continuous time filter – IIR filter design by Impulse Invariance. Bilinear transformation – Approximation derivatives – Design of IIR filter in the Frequency domain.

FIR FILTER DESIGN
Symmetric & Antisymteric FIR filters – Linear phase filter – Windowing technique – Rectangular, Kaiser windows – Frequency sampling techniques – Structure for FIR systems.

FINITE WORD LENGTH EFFECTS
Quantization noise – derivation for quantization noise power – Fixed point and binary floating point number representation – comparison – over flow error – truncation error – co-efficient quantization error - limit cycle oscillation – signal scaling – analytical model of sample and hold operations – Application of DSP – Model of Speech Wave Form – Vocoder.

TEXT BOOK
1.
   John G Proakis and Dimtris G Manolakis, "Digital Signal Processing Principles, Algorithms and Application", PHI/Pearson Education, 2000, 3rd Edition.

REFERENCES
2. Alan V Oppenheim, Ronald W Schafer and John R Buck, "Discrete Time Signal Processing", PHI/Pearson Education, 2000, 2nd Edition.
3. Johny R.Johnson, "Introduction to Digital Signal Processing", Prentice Hall of India/Pearson Education, 2002.
4. Sanjit K.Mitra, "Digital Signal Processing: A Computer – Based Approach", Tata McGraw-Hill, 2001, Second Edition.

MER 511   MODELING, SIMULATION AND ANALYSIS OF MANUFACTURING SYSTEMS

1. Principles of Modeling & Simulation: Basic Simulation Modeling, Limitation of Simulation, Monte - Carlo Simulation, Areas of Applications, Discrete and Continuous Systems.

2. Modeling Approaches: Modeling Complex Systems, Simulation Software, Basics Probability and Statistics, Building Valid and Credible Simulation Models.

3. Random Number and Variable Generation: Selecting Input Probability Distributions, Random Number Generators, Generating Random Variants, and Output Data Analysis for a Single System.

4. Statistical Techniques: Comparison of Alternative Systems, Variance Reduction Techniques.

5. Simulation Studies: Discrete Event Simulation, Simulation of Inventory Problems, Experimental Design and Optimization, Simulation of Manufacturing Systems, Case Studies.

6. Simulation Studies: Discrete Event Simulation, Simulation of Inventory Problems, Experimental Design and Optimization, Simulation of Manufacturing Systems, Case Studies.

REFERENCES:
1. Simulation, Modeling and Analysis –Averill Law & David M.Kelton, TMH 3rd Edition.
2. Discrete event and Simulation Systems – Banks & Carson, Prentice Hall Inc.

Reference Books:
1. "System Simulation"- Gordon, PHI.
2. "System Simulation with Digital computer" – Deo, PHI
3. "Computer Simulation And Modeling"– Francis Neelamkovil, John Wiley & Sons.

MER 512   DYNAMICS AND MECHANISM DESIGN

1. Geometry of Motion: Introduction, Analysis and Synthesis, Mechanism Terminology, Plane, Spherical and Spatial Mechanism, Mobility, Kinematic Inversion, Grashof's Law, Mechanical Advantage, Couplar Curves, Velocity and Acceleration Analysis using AuxilMARy Point Method, Goodman Analysis.

2. Generalised Principles of Dynamics: Fundamental Laws of Motion Generalised Co-Ordinates, Holonomic & Non-Holonomic Constraints, Euler's Equation of Motion.

3. System Dynamics: Motion of Gyroscopes, Mechanical Transients, Phase Plane Representation, Response of Linear Systems to Transient Forcing Functions Phase Plane Methods.

4. Lagrange's Equation: Lagrange's Equation 'From D' Alembert's Principles, Hamilton Principles, Lagrange's Equation from Hamilton Principle, Application of Lagrange Equation for Conservative and Non Conservative.

5. Autonomous Systems with Hologomic and Non Holonomic Constraints, Application to Systems with very small Displacements and to Impulsive Motion.

6. Synthesis of Linkages: Type, Number and Dimensional Synthesis Function Generation, Path Generation and Body Guidance, Precision Point, Chebychev Spacing, Position Synthesis of General Slider – Crank Mechanism with Optimum Transmission Angle.

7. Three Position Synthesis, Point Position Reduction, Four Precision Points, The Overlay Method, Couplar Curve Synthesis using Complex Algebra, Freudenstein's Equation, Synthesis of Dwell Mechanism Intermitten Rotary Motion Block Synthesis, Synthesis of Mechanical Error through Mathematical Programming.

Text Books:
1. Theory of Machines and Mechanisms - J.E. Shigley & J. J. Uicker, International student Edition McGraw Hill Co.
2. Kinematics and Dynamics of Plane mechanisms - J. Hirschior, McGraw Hill Co.

Reference Books:
1. Greenwood, Principles of Dynamics, Prentice Hall
2. A. R. Holowenko, Dynamics of Machinery, John Wiley and Sons.
3. 3. Hall, A. S., Kinematics and Linkages Design, Prentice Hall.
4. 4. Erdman and Sandoor, Advanced mechanism design, Analysis & Synthesis Vol 1 & Vol 2, PHI.
5. 5. Soni A. H, Mechanism Synthesis & Analysis, McGraw Hill.
6. 6. Levitskii N. I. Amerind, Analysis & Synthesis of Mechanisms.
7. 7. Rao V. Dukkipati, Solving Engineering Sysyem Dynamics Problems with MATLAB, 1st Edition, New Age International Publishers, 2007

MER 513   DFM TECHNIQUES AND PRODUCT DESIGN

INTRODUCTION: General principles for manufacturability, Basic Principles of designing for economic production, Process capability, Feature tolerance and surface finish.

DESIGNING FOR MACHINING: Parts cut to length, Screw machine products, machined round holes, molded parts, parts produced by planning, shaping and slotting, broached parts, ground parts, rolled burnished parts, gears.

REVIEW OF DESIGN CONSIDERATION: in formed metal components, non-metallic parts, design for heat treatment and economical deburring.

MECHANICAL ASSEMBLY: Application of selective assembly, deciding the number of groups – examples, design recommendations for different fastening arrangements, automatic assembly control of axial play in assemblies.

INTRODUCTION TO PRODUCT DESIGN: Definition of Product Design; design by evolution, design of innovation; essential factors of product design; production consumption cycles; the morphology of design (The seven Phases).

DESIGN OF PRODUCTION METAL PARTS: Produce ability requirements in the design of machine components; forging design; pressed component design; casting design; design for machining case; design powder metallurgical parts; expanded metals and wire forms.

OPTIMIZATION IN DESIGN AND HUMAN ENGINEERING CONSIDERATIONS IN PRODUCT DESIGN: Introduction; Siddal classification of product design approaches; optimization by differential calculus; Langrange multipliers; linear programming; geometric programming; Johonson's method of optimization; Human Engineering-Introduction; the design of controls; the design of displays; man/machine information exchange.

VALUE ENGINEERING AND PRODUCT DESIGN: Introduction; Historical perspective; Nature and measurement of value; Importance of value; the value analysis plan.

Text Books:
1. Hand book for product design for Manufacturing - James G. Bralla, McGraw Hill.
2. Product Design and Manufacturing - 2nd Edition - E.K.Chtale and R.C.Gupta.
3. Designing for Manufacturing - Harry Peck, Pitman Publications.
Reference Books:
1. Designing for Economic Production, Society of Manufacturing Engineering, 2nd Edition – Michigan.
2. Tolerance Control in Design and Manufacturing - Oliver R. Wade, Industrial Press, Inc New York.
3. Dimensioning and Tolarancing for Quality Production -Spotts M.F, Prentice Hall.
4. Design for Manufacturability Hand Book, 2nd Edition - James G. Bralla, TMH.
5. Product Design and Development - TMH Karl T. Ulrich, Steven D. Eppinger.

MER 514   COMPUTER CONTROL OF MANUFACTURING SYSTEMS

Introduction Basic concepts in Manufacturing Systems, Fundamentals of Numerical Control, Advantages of NC systems, Classification of NC Systems.

Interpolators for manufacturing systems DDA Integrator, DDA Hardware Interpolator, CNC software Interpolators , Reference word CNC interpolators, The concept of reference word interpolators. Tusten Method.

Control Loops of NC Systems: Introduction, Control of Point-to-point Systems, Control loops in Contouring Systems, Mathematical Analysis, operation of a two axis system.

Adaptive Control Systems: Introduction, Adaptive control with optimization, Adaptive control with Constraints. ACC for turning, Variable Gain AC systems Adaptive control for grinding, Cost analysis in machining.

Manufacturing system simulation : Introduction, Types of simulation, Need and elements of simulation, Simulation methodology.

Computerized Numerical Control: CNC Concepts, Advantages, The Digital Computer, , Reference Pulse Technique, Sampled-Data Technique, Design Principles, Optimization for Circular Motion , summary of design considerations, micro computers in CNC.

Computer integrated Manufacturing systems Introduction, Modern manufacturing, Sequence of functions in CIM, Elements of CIM system, CIM data base management system, CIM related standards, , Guide lines for CIM development Benefits of CIM.

Flexible manufacturing systems Introduction, Elements of FMS, Classification and Types of FMS, FMS work stations, Lay out configurations, Petrinets , modeling with Pertinets.

Text Books:
1. Computer control of manufacturing systems - Yorem Koren, Tata McGraw-Hill edition, 2005.
Reference Books:
1. Computer Aided Design and Manufacturing - Dr.Sadhusingh, Khanna Publishers, 2002
2. Simulation modeling and Analysis - Avverill M Law, TMH,2008.

DESIGN OF FLEXIBLE POWER TRANSMISSION SYSTEMS
V belts and pulleys - Flat belts and pulleys - Wire ropes and pulleys - Link chains and pulleys – Transmission chains and Sprockets-Silent chains - Ribbed V belts.

SPUR GEARS
Force analysis -Tooth stresses - Dynamic effects - Estimating gear size - Fatigue strength - Factor of safety – Gear materials - Gear blank design.

HELICAL BEVEL AND WORM GEARS
Parallel Helical Gears - Kinematics - Force analysis crossed helical gears - Worm Gearing - Force Analysis - Straight Bevel Gears - Kinematics Bevel Gear - Force Analysis. Gear Blank Design.

DESIGN OF GEAR BOXES
Geometric progression - Standard step ratio - Ray diagram, kinematic layout -Design of sliding mesh gear box - Constant mesh gear box.

CLUTCHES AND BRAKES
Internal Expanding Rim Clutches and Band Brakes - External - Contracting Rim Clutches and Band Brakes - Type Clutches and Brakes. Frictional contact Axial clutches, cone clutches and brakes - Energy Considerations. Temperature Rise - Friction Materials.

REFERENCES:
1. Joseph Edward Shigley and Charles, R. Mischke, " Mechanical Engineering Design ", McGraw Hill International Editions, 1989.
2. Gitin M.Maitra and L.V.Prasad, " Hand book of Mechanical Design ", II Edition, Tata Mc Graw Hill, 1985.
3. V.B. Bhandari, " Design of Machine Elements ", Tata McGraw Hill Publishing Company Ltd., 1994.
4. T.V.Sundarajamoorthy and N.Shanmugam, " Machine Design ", Khanna Publishers, Delhi-6, 1989.

MER 516   ARTIFICIAL INTELLIGENCE

INTRODUCTION TO FUZZY LOGIC
Basic concepts in Fuzzy Set theory – Operations of Fuzzy sets – Fuzzy relational equations – Propositional, Predicate Logic – Inference – Fuzzy Logic Principles – Fuzzy inference – Fuzzy Rule based systems – Fuzzification and defuzzification – Types.

FUZZY LOGIC APPLICATIONS
Fuzzy logic controllers – Principles – Various industrial Applications of Fuzzy logic control – Adaptive Fuzzy systems – Fuzzy Decision making – Fuzzy classification – Fuzzy pattern Recognition – Image Processing applications – Fuzzy optimization.

INTRODUCTION TO ARTIFICIAL NEURAL NETWORKS
Fundamentals of Neural networks – Neural network architectures – Learning methods – Taxonomy of Neural Network Architectures – Standard back propagation Algorithms – Selection of various parameters – Variations.

OTHER ANN ARCHITECTURES
Associative memory – Exponential Bidirectional Associative Memory – Adaptive Resonance Theory – Introduction – Adaptive Resonance Theory 1 – Adaptive Resonance Theory 2 – Applications – Kohen Self organizing maps – counter propagation networks – Industrial Applications.

RECENT ADVANCES
Fundamentals of Genetic Algorithms – Hybrid systems – Meta heuristic techniques like simulated Annealing, Tabu Search, Ant colony optimization, Perpetual self organizing, Artificial immune systems – Applications in Design and Manufacturing.

REFERENCES:
- Klir, G.J. Yuan Bo, 'Fuzzy sets and Fuzzy Logic: Theory and Applications', Prentice Hall of India Pvt. Ltd., 1997.
- Jacek M. Zurada, 'Introduction to Artificial Neural Systems' Jaico Publishing House, 1994
- Simon Haykin, 'Neural Networks – A comprehensive foundation', Prentice Hall, 2nd Edition, 1998.
- Laurene Fausett, 'Fundamentals of Neural Networks, Architectures, Algorithms and Applications, Prentice Hall, Englewood cliffs, 1994.
- S. Rajasekaran, GA Vijayalakshmi Pai, 'Neural Networks, Fuzzy Logic and Genetic Algorithms', Prentice Hall of India Private Limited, 2003.

MER 517   ADVANCED CONTROL SYSTEMS

STATE SPACE ANALYSIS
State Space Representation, Solution of State Equation, State Transition Matrix, Canonical Forms – Controllable Canonical Form, Observable Canonical Form, Jordan Canonical Form.

CONTROLLABILITY AND OBSERVABILITY
Tests for controllability and observability for continuous time systems – Time varying case, minimum energy control, time invariant case, Principle of Duality, Controllability and observability form Jordan canonical form and other canonical forms.

DESCRIBING FUNCTION ANALYSIS
Introduction to nonlinear systems, Types of nonlinearities, describing functions, describing function analysis of nonlinear control systems.

PHASE-PLANE ANALYSIS
Introduction to phase-plane analysis, Method of Isoclines for Constructing Trajectories, singular points, phase-plane analysis of nonlinear control systems.

STABILITY ANALYSIS
Stability in the sense of Lyapunov., Lyapunov's stability and Lypanov's instability theorems. Direct method of Lypanov for the Linear and Nonlinear continuous time autonomous systems.

MODAL CONTROL
Effect of state feedback on controllability and observability, Design of State Feedback Control through Pole placement. Full order observer and reduced order observer.

CALCULUS OF VARIATIONS
Minimization of functionals of single function, Constrained minimization. Minimum principle. Control variable inequality constraints. Control and state variable inequality constraints. Euler Lagrangine Equation.

OPTIMAL CONTROL
Formulation of optimal control problem. Minimum time, Minimum energy, minimum fuel problems. State regulator problem. Output regulator problem. Tracking problem, Continuous-Time Linear Regulators.

TEXT BOOKS:
1. Modern Control System Theory – by M. Gopal, New Age International Publishers, 2nd edition.

REFERENCE BOOKS:
2. Modern Control Engineering – by K. Ogata, Prentice Hall of India, 3rd edition, 1998
   Control Systems Engineering by I.J. Nagarath and M.Gopal, New Age International (P) Ltd.
3. Digital Control and State Variable Methods – by M. Gopal, Tata Mc Graw-Hill Companies, 1997.
4. Systems and Control by Stainslaw H. Zak , Oxford Press, 2003.

MER 521   Lab-II

Max. Marks: 100
Time Allowed: 4hrs
One lab /field/industrial oriented project /problem will be allocated to each student related to the subjects related to the subjects taught in 1st semester.