Biju Patnaik University of Technology, Orissa

M.TECH FOR MECHATRONICS

First Semester

Sl.No.	Code No.	Subjects	L	T	P	Credit
		Theory Paper				
01	MCPC101	Mechatronics System Design	3	1	0	4
02	MCPC102	Instrumentation and control	3	1	0	4
03	MCPC103	Applied Electronics and Microprocessors	3	1	0	4
04		**Elective- I (Any One)**	3	0	0	3
	MCPE101 MCPE102 MCPE103	1. Sensors and Actuators. 2. Industrial Control System Engineering. 3. Applications of Mechatronics Systems				
05		**Elective- II (Any One)**	3	0	0	3
	MCPE104 MCPE105 MCPE106	1. Numerical Methods & Mathematical Modelling. 2. Digital Signal Processing and Applications 3. Software Engineering				
		Sessionals				
06	HTPR101	Engineering Software Laboratory	0	0	3	2
07	MCPR101	Microprocessors & Instrumentation Laboratory	0	0	3	2
08	MCPT101	Pre-thesis work and seminar				2
		Total Credits				24

Second Semester

Sl. No.	Code No.	Subjects	L	T	P	credits
		Theory Paper				
01	MCPC201	Mechatronics in Manufacturing System	3	1	0	4
02	MCPC202	Industrial Robotics	3	1	0	4
03		**Elective- III (Any One)**	3	0	0	3
	MCPE201 MCPE202 MCPE203	1. Hydraulic and Pneumatic Systems 2. Advances in CNC Systems 3. Simulation and Modeling of Systems				
04		**Elective- IV (Any One)**	3	0	0	3
	MCPE204 MCPE205 MCPE206	1. MEMS Technology 2. Computer Integrated Manufacturing System 3. Digital Electronic Systems				
05		**Elective- V (Any One)**	3	0	0	3
	MCPE207 MCPE208 MCPE209	1. Real Time Embedded Systems 2. Object Oriented System Analysis and Design 3. Automation and Intelligent System				
		Sessionals				
06	MCPR201	CAD, CAM & CNC Laboratory	0	0	3	2
07	MCPR202	Control system and Robotics Laboratory	0	0	3	2
08	MCPT201	Pre-thesis work and Seminar				2
09	MCCV201	Comprehensive viva-voce- I				2
		Total Credit				25

Third Semester

Sl. No.	Code No.	Subjects	L	T	P	credits
		Theory Paper				
01		**Open Elective (any One)**	3	0	0	3
		1. Research Methodology 2. Design of Experiments 3. Project Management and Costing				
		Sessionals				
02		Thesis Part- I				14
		Total Credit				17

Fourth Semester

Sl. No.	Code No.	Subjects	L	T	P	credits
		Sessionals				
01	MCPT401	Thesis Part- II (Presentation and Evaluation)				20
02	MCCV401	Seminar				2
03	MCCV402	Comprehensive Viva-Voce- II				2
		Total Credits				24

Grand Total Credits: 90

MECHATRONICS SYSTEM DESIGN

Module-I

Introduction- Mechatronics Design process- advanced approaches in Mechatronics, Modeling and simulation of physical system. Analogies and impedance diagrams. Electrical systems- mechanical translational system-mechanical rotational systems- Electro mechanical coupling- fluid systems.

Motion control- control devices-Electro hydraulic control devices-electro pneumatic proportional controls-control of electrical drives-power semiconductor devices- converters, choppers, invertors and cycloconvertors

Module-I I

Linear systems-pneumatic ram, diaphagram and bellows-hydraulic cylinder-motor and ball screw-motor and lead screw-direct linear electrical actuators-solenoids.

Mechanical systems and design- Mechatronics approach- control, program control, adaptive control and distributed system-design process-types of design-integrated product design-Mechanisms, load conditions, design and flexibility-structures, load conditions, flexibility and environmental isolation-Man machine interface, industrial design and ergonomics, information transfer from machine to man and man to machine, safety.

Module-III

Fault fining-fault detection techniques- Watchdog timer-partity and error coding checks-common hardware faults-microprocessor system-Emulation and simulation-PLC systems.

Communication system-centralized, hierarchical and distributed control-networks-protocols-open system interconnection communication model communication interfaces.

Real time interfacing introduction-elements of data acquisition and control-Overview of I/O process-Installation of I/O card and software-installation of application software-over framing.

TEXT BOOKS:

1. Boltan, “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 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.

REFERENCE BOOK:

1. Brian Morriss, “Automated Manufacturing Systems- Actuators, Controls Sensors and Robotics, McGraw Hill International Edition 1995.
2. Boltan, “Mechatronics- Electronic Vontrol Systems in Mechanical and Electrical Engineering” , 2nd edition, Addison Wesley Longman Ltd., 1999 (unit 1).

INSTRUMENTATION AND CONTROL

Module-I

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, multiplexers, data acquisition systems, virtual instrumentation and its advantages.

Module-II

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

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

Module-III

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

Practical Instrumentation systems and their applications: Agro-based: Biomedical and prosthetic strategic and defence related, Disaster mitigation, Opto-electronic, Concept of SCADA

Case studies and Future Trend

Books:

1. **Industrial control and Instrumentation by BOLTON.W**
2. **Instrumentation and control by PATRANABIS.D**

APPLIED ELECTRONICS & MICROPROCESSORS

Module-I

Analog Signal Conditioning

Introduction, Principles of Analog Signal Conditioning, Signal-Level Changes, Linearization, Conversions, Zero adjustment, Span adjustment, Level changing, AC/DC Power supply, Filtering and Impedance Matching, Passive Circuits, Divider Circuit, Bridge Circuits, RC Filters, Operational Amplifiers, Op Amp Characteristics, Op Amp Specifications, Op Amp Circuits in Instrumentation, Voltage Follower, inverting Amplifier, Non- inverting Amplifier, Differential Amplifier, Active Filters, Protection Voltage-to –Current Converter, Current-to-Voltage Converter, Integrator, Linearization.

Digital Signal Conditioning

Introduction, Review of Digital Fundamentals, Digital Information, Fractional Binary Numbers, Boolean Algebra, Digital Electronics, Programmable Logic Controllers, Busses and Tri-State Buffers, Converters, Comparators, Digital-to-Analog Converters (DCA), Analog-to-Digital Converters (ADCs), Sample and Hold, Multiplexer and De-multiplexer, decoder and encoder, Pulse modulations, Digital recorder.

Module-I I

8086 Microprocessor Architecture

8086 CPU Pins and Signals, Address and Data Lines, Control and Status Lines, Power and Timing Lines, Bus Cycle Definition, Address and Data Bus Concepts, System Data Bus Concepts, Executive Unit and Bus Interface Unit, Instruction Queue, Operating Modes, Minimum Mode, Maximum Mode, Clock Generation, Reset, READY Implementation and Timing, Interrupt Structure, Predefined Interrupts, User-Defined Software Interrupts, User-Defined Hardware Interrupts. The interrupt Acknowledge Sequence, System Interrupt Configurations, Interpreting the 8086 Bus Timing Diagrams, Minimum Mode Bus Timing, Address and ALE, Read Cycle Timing, Write Cycle Timing, Interrupt Acknowledge Timing, Ready Timing, Bus Control Transfer Timing, Maximum Mode Bus Timing, Address and ALE, Read Cycle Timing, Write Cycle Timing Interrupt Acknowledge Timing, Ready Timing, Other Considerations, Bus Control Transfer (HOLD/HIDA and RQ/GT), Minimum Mode, Maximum Mode.

8086 Assembly Language Instruction and Programming

Instruction Set, Registers and Flags, General Purpose Registers, Pointer Registers, Index Registers, Segment Registers, Flags Register, How Instructions Affect the Flags Register, Addressing Mode, Program Memory Addressing Modes, Data Memory Addressing Modes, Addressing Mode Byte, Segment Override, Memory Addressing Tables, Instruction Set Mnemonics, 8086 Instruction Groups and Programming.

Module-III

8051 Microcontroller

8051 Architecture Interfacing, 8051 Instruction Set, 8051 Application.

8085/8086/8051 Interfacing

Interfacing Peripherals (I/O'S) and Applications, Parallel Input/Output and Interfacing Applications, Keyboard and display Interface, Interrupts Interfacing Data Converters, Programmable Interface Devices, General Purpose Programmable Peripheral Devices, Serial I/O and Data Communication Microprocessor Applications.

Books:-

1. **Process Control** Instrumentation Technology: by **Curtis D**. **Johnson**,
2. A.K. Roy & K.M. Bhurchandi, Advanced Microprocessor and Peripherals (Architecture, Programming & Interfacing)– TMH Publication
3. Mazidi & Mazidi, The 8051 Microcontroller & Embedded Systems– Pearson / PHI publication

SENSOR AND ACTUATORS

Module-I

Principles of Sensors

Sensor classification, Characteristics and calibration of mechanical, electrical, optical, thermal, magnetic, chemical and biological sensors, Sensor reliability.

Displacement sensors

Principles of variable resistance, variable inductance, variable reluctance, synchros and resolver, variable capacitance, Hall effect device, Digital displacement sensors.

Force, Torque, tactile and Pressure Sensor

Different types of load cells, Digital force transducer, pressure transducer, Transmission type, Driving type and Absorption type Dynamometer, Tactile sensors using contact closure, magnetic, Piezoelectric, Photoelectric, capacitive and ultrasonic methods, Manometer, elastic elements, Electrical and Piezoelectric pressure transducers, McLeod gage, Pirani gage and Ionisation gage.

Flow sensors

Head type flow meter, Electromagnetic flow meter, Rotameter, Anemometer, Ultrasonic flow meter.

Temperature sensor

Mechanical and Resistance type temperature sensors, Thermocouples, Thermistor, Optical pyrometer.

Module-I I

Sensor Modeling

Modeling, Numerical modeling techniques, model equations, Different effects on modeling – Temperature, radiation, mechanical, chemical, magnetic, electrical like capacitive, resistive, piezo-resistive etc., Example of modeling/micro modeling of photodiodes, magnetic/mechanical sensor.

Smart Sensor

Methods of internal compensation, information coding, integrated sensor principles, present trends.

Sensors in Robotics

Potentiometers, Synchros and Resolvers, Optical encoders, Tactile and Proximity sensors, Non-contact ranging sensors, Gyroscopes.

Module-III

Actuators

Pneumatic Hydraulic system: Control valves, cylinder, rotary actuators, Mechanical actuating system: Types of Motion, Kinematics chains, Cams, Gear trains, Belts and chain drives, Electrical actuating systems: Solid-state switches, Solenoids, D.C. motors, AC motors, Stepper motors, Piezoelectric actuator, micro-actuators.

Books:-

H. Yamasaki, "Intelligent Sensors (Handbook of Sensors and Actuators)"
Publisher: Elsevier Science

Sensors And Actuators: Control System Instrumentation by Clarence W. De Silva Publisher: **Crc Press**

INDUSTRIAL CONTROL SYSTEM ENGINEERING

Module-I : (14 Hours)

***Digital Control* :** State Space Representations of Discrete Time Systems, Solution of Discrete Time State Equations, Discretization of Continuous Time State Equations. Controllability and observability of Linear Time Invariant Discrete Data Systems, Pole Placement, Deadbeat response, Digital Simulation.

Module -II : (15 Hours)

Optimal Control : Performance Indices, Quadratic Optimal Regulator / Control Problems, Formulation of Algebraic Riccati Equation (ARE) for continuous and discret time systems. Solution of Quadratic Optimal Control Problem using Lograng Multiplies for continuous and discrete-time systems. Evaluation of the minimum performance Index, Optimal Observer, The Linear Quadratic Gaussia (LQG) Problem, Introduction to H_∞ Control.

Module - III : (14 Hours)

***Non linear Systems* :** The Aizerman and Kalman Conjectures : Popov's stability criterion, the generalized circle criteria, simplified circle criteria. Simple variable structure systems, sliding mode control, feedback linearization, Model reference adaptive control, (MRAC), Self Tuning Regulator (STR).

***Fuzzy Logic Control* :** Fuzzy sets and crispsets, Fuzzy Relations and composition of Fuzzy Relations, Introduction to Fuzzy Logic Controllers.

Books :

1. Discrete Time Control Systems, by K.Ogata, 2nd edition (2001), Pearson Education publication.
2. Digital Control Systems, by B.C. Kuo, 2nd edition (1992), Oxford University Press.
3. Digital Control and State Variable Methods, by M.Gopal, 3rd edition (2009), Tata Mc. Graw Hill Education Pvt. Ltd.
4. Systems and Control by Stanislaw H.Zak, Oxford University Press (2003).
5. Design of Feedback Control Systems by Raymond T. Stefani, B.Shalia, Clement J. Savant, Jr. Gen H. Hostetter, 4th edition (2002), Oxford University Press.
6. Introduction to Control Engineering (Modeling, Analysis and Design) by Ajit K. Mandal, New Age International (P), Ltd., Publishers (2006).
7. Non Linear Systems, by Hassan K. Khallil, 3rd edition (2002), Prentice Hall, Inc. (Pearson Education), Publications.
8. Control Theory (Multivariable and non linear Methods) by Torkel Glad & Lennart

Ljung, Taylor & Francis (2009)

APPLICATION OF MECHATRONIC SYSTEM

Module-I

Introduction

Definition of robot, classification of robots according to coordinate system and control method, Main components of robots – manipulator, sensors, controller etc, Robot characteristics – payload, reach, repeatability, accuracy, resolution.

Kinematics of Robot

Homogenous coordinates homogeneous transformation matrices, Direct and Inverse Kinematics or robots.

Actuators and Controls

Characteristics of actuating systems, Actuating System – Hydraulic devices, pneumatic devices, electric motors, Microprocessor control of electric motors.

Robot End effecters

Types, Mechanical grippers, other types of grippers, Tools as end effecters.

Module-I I

Sensors and Artificial Intelligence

Characteristics of Sensors, Position Sensors, velocity sensors, acceleration sensors, force and pressure sensors, force and torque sensors, micro switches, touch and slip sensors, non-contact proximity sensors, Robot programming Languages – VAL, AML/2, ARM BASIC.

Robot Vision

Definition of image, digital image, Picture coding – gray scale images, binary images, non-length coding, differential – delta modulation, Object recognition and categorization and recognition, Commercial vision systems – binary vision system, gray – level vision system, structured light version system, character recognition systems, ad-hoc special purpose system.

Module-III

Application of Robots

Handling, Loading and unloading, Welding, Spray painting, Assembly, Machining, Inspection, Rescue robots, Underwater robots, Mobile robot, Parallel robot, medical robot.

Mechatronic Elements of Modern CNC Machines

Machine Structure, Guide ways, Feed drives, Spindle and spindle bearings, Measuring system, Controls, software and operator interface, Ganging, Tool Monitoring.

Mechatronic Systems Applications by: Annalisa Milella Donato Di Paola and Grazia Cicirelli

Publisher: InTech

NUMERICAL METHODS AND MATHEMATICAL MODELLING

Module-I

Regression Analysis, Curve fitting techniques, Solution of simultaneous algebraic equations, Solution of linear differential equations, Numerical integration techniques.

Module-I I

Mathematical Modelling of first and second order systems.

Simulation and response of mathematical systems to step, ramp, sinusoidal and random inputs.

Module-III

Interpolation methods, introduction to Finite Difference and Finite element methods.

Text Books:

1) Numerical Methods for Engineering-Mc. Cormick & salvadori
2) Numerical Methods by Hilderband
3) Mechanical Systems & Control by E.O. Doeblin.
4) Introduction to Finite Element Methods by Desai & Abel.

DIGITAL SIGNAL PROCESSING AND APPLICATIONS

Module-I

Introduction: elements of a digital signal processing systems, advantages of digital processing over analog processing, continuous time signals, discrete time signals, sampling of analog signals, sampling theorem, quantizaiton of signals, coding, digital signals Vs discrete time signals.

Discrete time signals and systems: Classificaiton, 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, rescursive and non-recursive systems, description by difference equations, structure for realizaiton, correlation of discrete-time signals.

Module-I I

Z transform: Direct and inverse Z transform, Properties, poles and zero, techniques of finding inverse Z-transform, analysis of LTI systems in Z-domain.

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

Module-III

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.

Case study illustrating DSP Applicaitons.

Text Book:

By Proikis & Meanagis

SOFTWARE ENGINEERING

Module-I

Project management concept-product- Project W5hh Principle- software Process and Project Metrics- Metrics in the process and Project Domains- Software Measurement Metrics Program-Software Project Planning- software Project Estimation- Empirical Estimation Models- automated Estimation Tools.

Risk analysis and management safety risks and hazards- RMMM plan- Project Scheduling and tracking- selection software engineering tasks- schelduling error tracking- software quality assurance- statistical configuration and management- change control- status reporting- SCM standard.

Module-II

Software testing techniques- basic path testing- box testing- software testing- strategies- integration testing validation testing testing system testing-technical metrics for software-software quality-metrics for the analysis model-metircs for the design model-metrics for testing.

Object oriented concept and principles-object oriented paradigm-identifying the elements of an object model-management of object oriented software project object oriented analysis-domain analysis-ceramic componenents of the OO analysis model-OOA process- object- relationship model- object behaviour model.

Module-III

Object oriented design-system design process-object design process-deisgn patterns-object oriented programming-object oriented testing-testing OOA and ODD model-test case desin for OO software- Inter class test case design- technical metrics for object-oriented systems-metrics for the OO design model- metrics for OO projects

TEST BOOKS:

1.Roger S.Pressman, “software Engineering- Practitioner’s Approach”, 5th edition, McGraw Hill publishers, 2001

Reference Books:

1.Richard Fairley, “Software Engineering Concepts”, Tata McGraw Hill, 1997

MCPC201 MECHATRONICS IN MANUFACTURING SYSTEM (3-1-0)

MODULE – I **(15 hours)**

INTRODUCTION: Introduction to Mechatronics - Systems - Mechatronics in Products - Measurement Systems - Control Systems - Traditional design and Mechatronics Design.

SENSORS AND TRANSDUCERS: Introduction - Performance Terminology - Displacement, Position and Proximity - Velocity and Motion - Fluid pressure - Temperature sensors - Light sensors - Selection of sensors - Signal processing - Servo systems.

MODULE – II **(15 hours)**

MICROPROCESSORS IN MECHATRONICS: Introduction - Architecture - Pin configuration - Instruction set - Programming of Microprocessors using 8085 instructions - Interfacing input and output devices - Interfacing D/A converters and A/D converters - Applications - Temperature control - Stepper motor control - Traffic light controller.

PROGRAMMABLE LOGIC CONTROLLERS: Introduction - Basic structure - Input / Output processing - Programming -Mnemonics Timers, Internal relays and counters - Data handling - Analog input / output - Selection of PLC

MODULE – III **(10 hours)**

DESIGN AND MECHATRONICS: Designing - Possible design solutions - Case studies of Mechatronics systems.

Text and Reference Books:

1. Michael B.Histand and David G. Alciatore, ***Introduction to Mechatronics and Measurement Systems***, McGraw-Hill International Editions, 1999.
2. Bradley, D.A., Dawson, D, Buru, N.C. and Loader, AJ., ***Mechatronics***, Chapman and Hall,1993.
3. Ramesh.S, Gaonkar, ***Microprocessor Architecture, Programming and Applications***, Wiley Eastern,1998.
4. Lawrence J.Kamm, ***Understanding Electro-Mechanical Engineering, An Introduction to Mechatronics***, Prentice-Hall, 2000.
5. Ghosh, P.K. and Sridhar, P.R., ***Introduction to Microprocessors for Engineers and Scientists - 0000 to 8085***, Second Edition, Prentice Hall, 1995.

Web Reference: *www.cs.indiana.edu*

MCPC202 INDUSTRIAL ROBOTICS (3-1- 0)

MODULE – I **(10 hours)**

Introduction and Robot Kinematics: Definition need and scope of Industrial robots – Robot anatomy – Work volume – Precision movement – End effectors – Sensors.

Robot Kinematics – Direct and inverse kinematics – Robot trajectories – Control of robot manipulators – Robot dynamics – Methods for orientation and location of objects.

MODULE – II **(15 hours)**

Robot Drives and Control: Controlling the Robot motion – Position and velocity sensing devices – Design of drive systems – Hydraulic and Pneumatic drives – Linear and rotary actuators and control valves – Electro hydraulic servo valves, electric drives – Motors – Designing of end effectors – Vacuum, magnetic and air operated grippers

Robot Sensors: Transducers and Sensors – Tactile sensor – Proximity and range sensors – Sensing joint forces – Robotic vision system – Image Representation - Image Grabbing –Image processing and analysis – Edge Enhancement – Contrast Stretching – Band Rationing - Image segmentation – Pattern recognition – Training of vision system

MODULE – III **(15 hours)**

Robot Cell Design and Application: Robot work cell design and control – Safety in Robotics – Robot cell layouts – Multiple Robots and machine interference – Robot cycle time analysis. Industrial application of robots.

Robot Programming, Artificial Intelligence and Expert Systems Methods of Robot Programming – Characteristics of task level languages lead through programming methods – Motion interpolation. Artificial intelligence – Basics – Goals of artificial intelligence – AI techniques – problem representation in AI – Problem reduction and solution techniques – Application of AI and KBES in Robots.

Text Book:

6. K.S.Fu, R.C. Gonzalez and C.S.G. Lee, ***Robotics Control, Sensing, Vision and Intelligence***, Mc Graw Hill, 1987

Reference Books:

1. Mikell P. Grover, Mitchell Weiss, ***Industrial Robotics, Technology, Programming and Application***, McGraw Hill International Edn., 1986.
2. Richard. D, Klafter, Thomas, A, Chmielewski, Michael Negin, ***Robotics Engineering – An Integrated Approach***, Prentice-Hall of India Pvt. Ltd., 1984.
3. Deb, S.R., ***Robotics Technology and Flexible Automation***, Tata Mc Graw-Hill, 1994.

MCPE201 HYDRAULIC AND PNEUMATIC SYSTEMS 3-0-0

MODULE – I (13 hours)

FLUID POWER SYSTEMS AND FUNDAMENTALS: Introduction: Introduction to fluid power, Advantages of fluid power, Application of fluid power system. Types of fluid power systems, Properties of hydraulic fluids – General types of fluids – Fluid power symbols.

Basics of hydraulics – Applications of Pascal's Law-Laminar and turbulent flow – Reynolds's number-Darcy's equation – Losses in pipe, valves and fittings.

HYDRAULIC SYSTEM AND COMPONENTS: Sources of Hydraulic Power: Pumping theory – Pump classification – Gear pump, Vane Pump, piston pump, construction and working of pumps – pump performance – Variable displacement pumps.

MODULE – II (13 hours)

FLUID POWER ACTUATORS: Linear hydraulic actuators – Types of hydraulic cylinders – Single acting, Double acting special cylinders like tandem, Rodless, Telescopic. Cushioning mechanism, Construction of double acting cylinder, Rotary actuators. Fluid motors, Gear, Vane and Piston motors.

DESIGN OF HYDRAULIC CIRCUITS: Construction of Control Components:Directional control valve – 3/2 way valve – 4/2, 4/3 way valve – Shuttle valve – check valve – pressure control valve – pressure reducing valve sequence valve, Flow control valve – Fixed and adjustable, electrical control solenoid valves, Relays, ladder diagram.

ACCUMULATORS AND INTENSIFIERS: Types of accumulators – Accumulators circuits, sizing of accumulators, intensifier – Applications of Intensifier – Intensifier circuit.

MODULE – III (14 hours)

PNEUMATIC SYSTEMS & COMPONENTS: Pneumatic Components: Properties of air – Compressors – Filter, Regulator, and Lubricator Unit – Air control valves, Quick exhaust valves, pneumatic actuators.

Fluid Power Circuit Design, Speed control circuits, synchronizing circuit, Pneumo hydraulic circuit, Sequential circuit design for simple applications using cascade method.

DESIGN OF PNEUMATIC CIRCUITS: Servo systems – Hydro Mechanical servo systems, Electro hydraulic servo systems and proportional valves.

FLUDICS: Introduction to fluidic devices, simple circuits, Introduction to Electro Hydraulic Pneumatic logic circuits, ladder diagrams, PLC applications in fluid power control. Fluid power circuits; failure and trouble shooting.

Text Books:

1. Antony Espossito, "***Fluid Power with Applications*** ", Pearson Education Inc.2003.
2. Majumdar S.R., **"*Pneumatic Systems – Principles and Maintenance*"**, Tata McGraw-Hill, 1995.

Reference Books*:*

1. Anthony Lal, **"*Oil Hydraulics in the Service of Industry*"**, Allied publishers,1982.
2. Harry L. Stevart D.B, **"*Practical Guide to Fluid Power*"**, Taraoeala sons and Port Ltd. Broadey, 1976.

MCPE202 ADVANCES IN CNC SYSTEMS (3-0-0) Credit :3

Module – I **(12 Hours)**

Introduction to CNC Machine Tools: Development of CNC technology, principles, features, advantages, economic benefits, applications, CNC, DNC concept, classification of CNC machine, types of control, CNC controllers, characteristics, interpolators.

Structure of CNC Machine Tool: CNC machine building, structural details, configuration and design, guide ways – friction, anti-friction and other types of guide ways, elements used to convert the rotary motion to a linear motion – screw and nut, recirculating ball screw, planetary roller screw, recirculating roller screw, rack and pinion, torque transmission elements – gears, timing belts, flexible couplings, bearings.

Module – II **(14 Hours)**

DRIVES AND CONTROLS: Spindle drives - DC shunt motor, 3 phase AC induction motor, feed drives - stepper motor, servo principle, DC & AC servomotors. Open loop and closed loop control, Axis measuring system - synchro, synchro-resolver,gratings, moire fringe gratings, encoders, inductosyn, laser interferometer.

CNC PROGRAMMING: Coordinate system, structure of a part program, G & M Codes, Manual part programming for Fanuc, Heidenhain, Sinumeric control system, CAPP, APT part programming using CAD/CAM, Parametric Programming.

Module – III **(14 Hours)**

TOOLING AND MAINTENANCE OF CNC: Cutting tool materials, carbide insets classification, qualified, semi qualified and preset tooling, tooling system for Machining centre and Turning centre, work holding devices, maintenance of CNC Machines.

Text Book:

1. HMT, ***Mechatronics***, Tata McGraw-Hill Publishing Company Limited, New Delhi, 1998. ISBN-13: 9780074636435.

Reference Books:

1. http://www.amazon.com/Theory-Modeling-Simulation-Bernard-Zeigler/dp/0127784551 - #James Madison, ***CNC Machining Hand Book***, Industrial Press Inc., 1996.
2. Steve Krar, Arthur Gill, ***CNC Technology and Programming***, McGraw-Hill International Editions, 1990.
3. Berry Leathan-Jones, ***Introduction to Computer Numerical Control***, Pitman, London, 1987.
4. Hans B. Kief, T. Fredericx Waters, ***Computer Numerical Control***, MacMillan / McGraw-Hill, 1992.
5. Bernard Hodgers, ***CNC Part Programming Work Book***, City and Guids / Macmillan, 1994.
6. David Gribbs, ***An Introduction to CNC Machining***, Cassell, 1987.
7. T.A. Sadasivan and D. Sarathy, ***Cutting Tools for Productive Machining***, Widia (India) Ltd., August 1999.
8. Radhakrishnan, P. ***Computer Numerical Control Machines***, New Central Book Agency, 1992.
9. Peter Smid, ***CNC Programming Hand Book***, Industrial Press Inc., 2000.

Web References

1. http:/liesu5.ieem.ust.hk/dfaculty/ajay/courses/ieem215/lecs/CNC.html
2. http://CNC-router-laser-machine.com/machinery.html

MCPE203 SIMULATION AND MODELING OF SYSTEMS (3-0-0) Credit :3

Module – I **(12 Hours)**

Basic Simulation Modeling: The Nature of Simulation, Systems, Models, and Simulation, Discrete-Event Simulation, Simulation of a Single-Server Queueing System, Simulation of an Inventory System, Parallel/Distributed Simulation and High Level Architecture, Steps in a Sound Simulation Study, Other Types of Simulation, Advantages, Disadvantages, and Pitfalls of Simulation. (Chapter 1 of Text Book)

Modeling Complex Systems: Introduction, List Processing in Simulation, A Simple Simulation Language – simlib, Single-Server Queueing Simulation with simlib, Time-Shared Computer Model, Multiteller Bank with Jockeying, Job-Shop Model, Efficient Event-List Manipulation. (Chapter 2 of Text Book)

Simulation Software: Introduction, Comparison of Simulation Packages with Programming Languages, Classification of Simulation Software, Desirable Software Features, General-Purpose Simulation Packages, Object-Oriented Simulation, Examples of Application-Oriented Simulation Packages. (Chapter 3 of Text Book)

Module – II **(14 Hours)**

Review of Basic Probability and Statistics: Introduction, Random Variables and Their Properties, Simulation Output Data and Stochastic Processes, Estimation of Means, Variances, and Correlations, Confidence Intervals and Hypothesis Tests for the Mean, The Strong Law of Large Numbers, The Danger of Replacing a Probability Distribution by its Mean. (Chapter 4 of Text Book)

Building Valid, Credible, and Appropriately Detailed Simulation Models: Introduction and Definitions, Guidelines for Determining the Level of Model Detail, Verification of Simulation Computer Programs, Techniques for Increasing Model Validity and Credibility. (Chapter 5 of Text Book)

Random-Number Generators: Introduction, Linear Congruential Generators, Other Kinds of Generators, Testing Random Number Generators. (Chapter 7 of Text Book)

Module – III **(14 Hours)**

Generating Random Variates: Introduction, General Approaches to Generating Random Variates, Generating Continuous Random Variates, Generating Discrete Random Variates. (Chapter 8 of Text Book)

Output Data Analysis for a Single System: Introduction, Transient and Steady-State Behavior of a Stochastic Process, Types of Simulations with Regard to Output Analysis, Statistical Analysis for Terminating Simulations, Statistical Analysis for Steady-State Parameters. (Chapter 9 of Text Book)

Simulation of Manufacturing Systems: Introduction, Objectives of Simulation in Manufacturing, Simulation Software for Manufacturing Applications, Modeling System Randomness, An Extended Example, A Simulation Case Study of a Metal-Parts Manufacturing Facility. (Chapter 13 of Text Book)

Textbooks:

1. Averill M. Law, ***Simulation Modeling and Analysis***, 4th Edn.,Tata McGraw Hill Education Private Limited, New Delhi, 2008, ISBN-10: 0070667330, ISBN-13: 978-0070667334.

Recommended Reading:

1. Bernard P. Zeiglerhttp://www.amazon.com/Theory-Modeling-Simulation-Bernard-Zeigler/dp/0127784551 - #, Herbert PraehoferamdTag Gon Kim, *Theory of Modeling and Simulation*, 2nd Edn., Academic Press, 2000, ISBN-10: 0127784551, ISBN-13: 978-0127784557.
2. Frank L. Severance, *System Modeling and Simulation: An Introduction*, Wiley, 2001, ISBN-10: 0471496944, ISBN-13: 978-0471496946.

3. Forbes T. Brown, *Engineering System Dynamics: A Unified Graph-Centered Approach*, 2nd Edn.,CRC Press, 2001, **ISBN 10:** 0849396484, **ISBN-13:** 978-0849396489.

MCPE204 MEMS Technology (3-0-0)

MODULE – I **(14 hours)**

Overview of MEMS and Microsystems.

Micromachining Techniques: Silicon as material for micromachining, Photolithography, thin film deposition, doping, wet and dry etching, surface and bulk micromachining, Wafer bonding, packaging.

MODULE – II **(10 hours)**

Microsystem Modeling and Design: Mechanics of deformable bodies, Energy method, Estimation of stiffness and damping for different micro-structures, Modeling of electromechanical systems, Pull-in voltage. (Section 4.1 to 4.3 and 6.2.2 of Text Book 1, Section 3.4 of Text Book 2)

MODULE – III **(15 hours)**

MEMS Applications: Mechanical sensors and actuators: Piezoresistive pressure sensors, MEMS capacitive accelerometer, Gyroscopes, Piezoelectric actuators.

Optical: Micro-lens, Micro-mirror, Optical switch.

Radio frequency MEMS: Inductor, Varactor, Filter, Resonator.

Microfluidics: Capillary action, Micropumping, Electrowetting, Lab-on-a-chip.

Textbooks:

1. G.K. Ananthsuresh, K.J. Vinoy, S. Gopalakrishnan, K.N. Bhat and V.K. Atre: Micro and Smart Systems, Wiley India, New Delhi, 2010.
2. N.P. Mahalik: MEMS, Tata McGraw-Hill, New Delhi, 2007.

Recommended Reading:

1. T. Hsu: MEMS and Microsystems: Design and Manufacture, Tata McGraw-Hill, New Delhi, 2002.

MCPE205 COMPUTER INTEGRATED MANUFACTURING SYSTEM (3-0-0)

MODULE – I (15 hours)

INTRODUCTION: The meaning and origin of CIM- The changing manufacturing & management scene- Evolution & Development of CIM, CIM-Wheel. Product Development through CIM- Product development cycle, Sequential Engineering, Concurrent Engineering techniques - Concepts of QFD, RP, VE, J-I-T, Taguchi method for Robust design, Failure mode & Effect analysis, Design for manufacturability & Assembly.

GROUP TECHNOLOGY AND COMPUTER AIDED PROCESS PLANNING : History of group technology, role of G.T. in CAD/CAM integration, part families, classification and coding - DCLASS and MICLASS and OPITZ coding systems. Facility design using G.T., benefits of G.T., Cellular manufacturing.

MODULE – II (12 hours)

PROCESS PLANNING: Role of process planning in CAD/CAM integration, approaches to computer aided process planning - variant approach and generative approaches , CAPP and CMPP process planning systems.

SHOP FLOOR CONTROL AND INTRODUCTION OF FMS: Shop floor control- phases -factory data collection system –automatic identification methods- Bar code technology-automated data collection system.

MODULE – III (13 hours)

FMS: FMS, components of FMS, types, FMS workstation -material handling and storage systems- FMS layout -computer control systems, application and benefits, computer aided quality control.

CIM DATA BASE & DATA BASE MANAGEMENT SYSTEMS: Development of databases - database terminology- architecture database systems, data modeling & data associations, RDBMS, Product Data Management (PDM).

***TEXT AND REFERENCE BOOKS*:**

1. Mikell.P.Groover “Automation, Production Systems and computer integrated manufacturing”, Pearson Education 2001.
2. Mikell.P.Groover and Emory Zimmers Jr., “CAD/CAM”, Prentice Hall of India Pvt. Ltd., New Delhi-1, 1998.
3. Radhakrishnan P, Subramanyan S.and Raju V., “CAD/CAM/CIM”, 2nd Edition New Age International (P) Ltd., New Delhi, 2000.
4. David D.Bedworth, Mark R.Hendersan, Phillip M.Wolfe “Computer Integrated Design and Manufacturing”, McGraw-Hill Inc.
5. Ranky, Paul G., “Computer Integrated Manufacturing”, Prentice Hall International, 1986.
6. Yorem koren, “Computer Integrated Manufacturing System”, McGraw-Hill, 1983.

MCPE206 DIGITAL ELECTRONIC SYSTEMS (3-0-0)

MODULE – I **(12 hours)**

INTRODUCTION: Review of Logic Design Fundamentals, Combinational logic, Boolean Algebra and Algebraic Simplification, Karnaugh Maps, Designing with NAND and NOR gates, Hazards in Combinational Networks, Flip-flops and Latches, Mealy Sequential Network Design, Design of Moore Sequential Network, Equivalent States and Reduction of State Tables, Sequential Network Timing, Setup and Hold Times, Synchronous Design, Trstate Logic and Busses. (Chapter 1 of Text Book)

INTRODUCTION TO VHDL: VHDL Description to Combinational Networks, Modelling Flip-flops using VHDL Processes, VHDL Models for Multiplexer, Compilation and Simulation of VHDL Code, Modelling a Sequential Machine, Variables, Signals, and Constants, Arrays, VHDL Operators, VHDL Functions, VHDL Procedures, Packages and Libraries, Example – VHDL Model for a 74163 Counter. (Chapter 2 of Text Book)

MODULE – II **(12 hours)**

DESIGNING WITH PROGRAMMABLE LOGIC DEVICES: Read-only Memories (ROMs), Programmable Logic Arrays (PLAs), Programmable Array Logics (PALs), Other Sequential Programmable Logic Devices (PLDs), Example – Design of a Keypad Scanner. (Chapter 3 of Text Book)

DESIGN OF NETWORKS FOR ARITHMATIC OPERATIONS: Design of a Serial adder with Accumulator, State Graph Control Networks, Design of a Binary Multiplier, Multiplication of Signed Binary Numbers, Design of Binary Divider. (Chapter 4 of Text Book)

MODULE – III **(12 hours)**

DESIGNING WITH PROGRAMMABLE GATE ARRAYS AND COMPLEX PLDS: Xilinx/Altera FPGAs, Designing with FPGAs. (Chapter 6 of Text Book)

FLOATING POINT ARITHMATIC: Representation of Floating-point Numbers, Floating-point Multiplication, Other Floating-point Operations. (Chapter 7 of Text Book)

VHDL MODELS FOR MEMORIES AND BUSES: Static RAM Memory, A Simplified 486 Bus Model, Interfacing Memory to a Microprocessor Bus. (Chapter 9 of Text Book)

Textbooks:

1. Charles H. Roth, Jr., ***Digital Systems Design using VHDL*****,** Thomson Books, 1998, ISBN: 981-240-053-4.

Recommended Reading:

1. K. Skahill, ***VHDL for Programmable Logic***, Addison Wesley, 1996.

MCPE207 REAL TIME EMBEDDED SYSTEMS (3-0-0)

MODULE – I **(10 hours)**

INTRODUCTION: Typical Real-Time applications – Digital control, High-level controls, Signal processing, Other real-time applications, Hard versus soft real-time systems – Jobs and processors, Release time, Deadlines, and Timing constraints, Hard real-time systems, Soft real-time systems, A reference model of real-time systems – Processors and Resources, Temporal parameters of real-time workload, Periodic task model, Precedence constraints and Data dependency, Other types of dependencies, Functional parameters, Resource parameters of job and Parameters of resources, Scheduling hierarchy.

MODULE – II **(12 hours)**

CLASSIC UNIPROCESSOR SCHEDULING RESULTS: Commonly used approaches to real-time scheduling with emphasis on optimality of EDF and LST algorithms, Clock-driven scheduling with emphasis on Cyclic executive, Priority-driven scheduling of periodic tasks – Maximum scheduling utilisation, Optimality of RM and DM algorithms, A schedulability test for fixed-priority tasks with short response times, Schedulability test for fixed-priority tasks with arbitrary response times, Sufficient schedulabilty conditions for the RM and DM algorithms, Some real systems – Overview, Time services and scheduling mechanisms, Capabilities of commercial real-time operating systems, Predictability of General-purpose operating systems.

MODULE – III **(12 hours)**

BEYOND UNIPROCESSOR INDEPENDENT TASK MODELS: Scheduling aperiodic and sporadic jobs in priority-driven systems – Assumptions and approaches, Deferrable servers, Sporadic servers, Constant utilisation, Total bandwidth and Weighted fair-queuing servers, Resources and resource access control – Assumptions on resources and their uses, Effect of resource contention and resource access control, Nonpreemptive critical sections, Basic priority-inheritance protocol, Basic priority-ceiling protocol, Stack-based, Priority-ceiling (Ceiling-priority) protocol, Multiprocessor scheduling, Resource access control and synchronisation – Model of multiprocessor and distributed system, Task assignment, Multiprocessor priority ceiling protocol, Elements of scheduling algorithms for end-to-end tasks.

Textbooks:

1. Jane W.S. Liu, ***Real-Time Systems*****,** Pearson Education, 2000, ISBN: 978-81-7758-575-9.

Recommended Reading:

1. C.M. Krishna and K.G. Shin, ***Real-Time Systems*****,** McGraw Hill, 1997, ISBN 0-07-057043-4.
2. Rajib Mall, ***Real-Time Systems – Theory and Practice*****,** Pearson Education, 2007, ISBN: 978-81-317-0069-3.
3. Philip. A. Laplante, ***Real-Time Systems Design and Analysis - an Engineer's Handbook, 3rd Edition*****,** John Wiley & Sons, Incorporated, ISBN: 0-471-22855-9.
4. Dr. K.V.K K Prasad, ***Embedded Real Time Systems: Concepts Design and Programming*****,** Dreamtech Press New Delhi, 2003.

MCPE208 OBJECT ORIENTED SYSTEM ANALYSIS AND DESIGN (3-0-0)

MODULE – I (12 hours)

Information Systems, Problems in Information Systems Development, Avoiding the Problems, What is Object-Orientation? Modelling Concepts, Requirements Capture, Requirement Analysis, Case Study – Agate Ltd., FoodCo Ltd., (Chapters 1 to 7 and Case Studies: A1, B1, A2 and A3).

MODULE – II (12 hours)

Refining the Requirement Model, Object Interaction, Specifying Operations, Specifying Control, Moving into Design, System Design, Object Design, Design Patterns, Case Study – Agate Ltd.. (Chapters 8 to 15 and Case Study: A4).

MODULE – III (12 hours)

Design Boundary Classes, Data Management Design, Implementation, Reusable Components, Managing Object Oriented Projects, System Development Methodologies, Case Study – Agate Ltd. (Chapters 17 to 22 and Case Study: A5).

Text Book:

1. Simon Bennett, Steve McRobb and Ray Farmer, ***Object-Oriented System Analysis and Design using UML***, Tata McGraw-Hill Education Pvt. Ltd., New Delhi.

Referrence Books:

1. Larman Craig, ***Applying UML and Patterns: An Introduction to Object-Oriented Analysis and Design***, Third Edition, Prentice-Hall.
2. Stephen R Schach, ***An Introduction to Object Oriented System Analysis and Design with UML and the Unified Process***, McGraw Hill.

MCPE209 AUTOMATION AND INTELLIGENT SYSTEM (3-0-0)

MODULE – I (12 hours)

Non-linear Control Primer : Norms of Signals, Vectors, and Matrices, Positive Definite Functions, Positive Definite Matrices, Continuous Time State–Space Model, Non-linear State–Space Model, Lyapunov Stability Theory, Discrete Time Systems, Modelling of Different Non-linear Systems, Non-linear Control Strategies.

Neural Networks: Feed-forward Networks, Multi-layered Neural Networks, Radial Basis Function Networks, Adaptive Learning Rate, Feedback Networks, Kohonen Self-organizing Map, System Identification Using Neural Networks, SOM Based Identification.

Fuzzy Logic: Classical Sets, Fuzzy Sets, Fuzzy Rule Base and Approximate Reasoning, Fuzzy Logic Control, System Identification Using T–S Fuzzy Models.

MODULE – II (14 hours)

Indirect Adaptive Control Using Neural Networks: Continuous Time Affine Systems, Discrete Time Affine Systems, Discrete Time Non-affine System.

Direct Adaptive Control Using Neural Networks: Direct Adaptive Control, Single Input Single Output Affine Systems, Multi-input Multi-output Systems, Single Input Single Output Discrete Time Affine Systems, Back-stepping Control.

Approximate Dynamic Programming: Linear Quadratic Regulator, The HJB Formulation, HJB for Affine Systems, HDP and DHP, Single Network Adaptive Critic, Continuous Time Adaptive Critic, Adaptive Critic Using the T–S Fuzzy Model.

Fuzzy Logic Control: Construction of an FLC, Fuzzy PD Controller, Fuzzy PI Controller, Fuzzy PI Controller for a Series DC Motor, FLC Using Lyapunov Synthesis, Horizontal Planar Two Link Robot Manipulator.

MODULE – III (14 hours)

Takagi–Sugeno Fuzzy Model Based Control: T–S Fuzzy Model, Linear Matrix Inequality Technique, Fixed Gain State Feedback Controller Design Technique, Variable Gain Controller Design Using Single Linear Nominal Plant, Variable Gain Controller Design Using Each Linear Subsystem as Nominal Plant, Controller Design Using Discrete T–S Fuzzy System.

Intelligent Control of a Pendulum on a Cart: T–S Fuzzy Model Representation, Control Using the T–S Fuzzy Model, Network Inversion Based Control, T–S Fuzzy Controller, Cart–Pole System: Simulation and Experiment.

Visual Motor Control of a Redundant Manipulator: System Model, Visual Motor Control Using Neural Networks, Visual Motor Control Using a Fuzzy Network.

***Textbooks*:**

1. Laxmidhar Behera and Indrani Kar, **"*Intelligent Systems and Control Principles and Applications*"**, Oxford University Press, New Delhi, 2010, ISBN13: 978-0-19-806315-5, ISBN10: 0-19-806315-6.

Reference Books:

1. J.S. Albus and A.M. Meystel, **"*Intelligent Systems: Architecture, Design, and Control*"**, Wiley, New York, 2002.
2. R.A. Aleev and R.R. Aleev, **"*Soft Computing and its Applications*"**, World Scientific, Singapore, 2001.
3. Mihir Sen, **"*Lecture Notes on Intelligent Systems*"**, Department of Aerospace and Mechanical Engineering, University of Notre Dame, Notre Dame, IN 46556, U.S.A.
4. Robust J. Schalkoff, **"*Intelligent Systems: Principles, Paradigms and Pragmatics*"**, Jones & Bartlett Publishers, Sudbury, MA, USA, 2009.
5. Ali Zilouchian and Mo Jamshidi, **"*Intelligent Control Systems using Soft Computing Methodologies*"**, CRC Press, New York, 2001.

6. Pedro Ponce Cruz and Fernando D. Ramirez-Figueroa, **"*Intelligent Control Systems with LabVIEW*™"**, Springer-Verlog London Limited, 2009.