MAHATMA GANDHI INSTITUTE OF TECHNOLOGY (Autonomous)

M.Tech. in Mechatronics

Scheme of Instruction and Examination

(Choice Based Credit System)

For the batches to be admitted with effect from the academic year 2021-22

I Semester

S.No.	Course Code	Course Title	Instruction			Examination			Credits
			Hours Per Week			Max. Marks		Duration of SEE in Hours	
			L	T	P/D	CIE	SEE		
1	MT101PC	Applied Industrial Pneumatics	3	0	0	30	70	3	3
2	MT102PC	Applied Industrial Hydraulics	3	0	0	30	70	3	3
3	MT11XPE	Professional Elective- I	3	0	0	30	70	3	3
4	MT11XPE	Professional Elective-–II	3	0	0	30	70	3	3
5	MT101MC	Research Methodology & Intellectual Property Rights	2	0	0	30	70	3	2
6	AC10XHS	Audit Course - I	2	0	0	30	70	3	0
7	MT151PC	Pneumatics Lab	0	0	3	30	70	3	1.5
8	MT152PC	Hydraulics Lab	0	0	3	30	70	3	1.5
9	EN151HS	Finishing School – I	0	0	2	30	70	3	1
		Total Hours/Marks/Credits	**16**	**0**	**8**	**270**	**630**		**18**

II Semester

S.No.	Course Code	Course Title	Instruction			Examination			Credits
			Hours Per Week			Max. Marks		Duration of SEE in Hours	
			L	T	P/D	CIE	SEE		
1	MT201PC	Advanced CNC Technologies	3	0	0	30	70	3	3
2	MT202PC	Industrial Robotics	3	0	0	30	70	3	3
3	MT21XPE	Professional Elective- III	3	0	0	30	70	3	3
4	MT21XPE	Professional Elective- IV	3	0	0	30	70	3	3
5	AC20XHS	Audit Course - II	2	0	0	30	70	3	0
6	MT251PC	CNC Lab	0	0	3	30	70	3	1.5
7	MT252PC	Robotics Lab	0	0	3	30	70	3	1.5
8	MT253PC	Mini Project with Seminar	0	0	4	100	-	-	2
9	MA252BS	Finishing School – II	0	0	2	30	70	3	1
		Total Hours/Marks/Credits	**14**	**0**	**12**	**340**	**560**		**18**

L: Lecture **T**: Tutorial **D**: Drawing **P**: Practical **CIE** - Continuous Internal Evaluation **SEE** - Semester End Examination

List of Professional Electives

Professional Elective-I

MT111PE: Industrial Electrical & Electronics
MT112PE: Programmable Logic Controller & Applications
MT113PE: Control Systems

Professional Elective-II

MT114PE: Instrumentation & Sensor Technology
MT115PE: Fuzzy Logic & Neural Networks
MT116PE: Micro-Controller & Applications

Professional Elective-III

MT211PE: Manufacturing Systems: Simulation Modelling & Analysis
MT212PE: Additive Manufacturing Technologies
MT213PE: MEMS

Professional Elective-IV

MT214PE: Automation in Manufacturing
MT215PE: Nano Technology
MT216PE: Design for Manufacturing & Assembly

Audit Courses

Audit Course-I

AC101HS: English for Research Paper Writing
AC102HS: Sanskrit for Technical Knowledge
AC103HS: Stress Management by Yoga

Audit Course-II

AC201HS: Disaster Management
AC202HS: Value Education
AC203HS: Pedagogy Studies
AC204HS: Personality Development Through Life Enlightenment Skills

L	T	P	C
3	0	0	3

M.Tech. in Mechatronics
I Semester Syllabus
MT101PC: Applied Industrial Pneumatics

Course Objectives

- Impart fundamental theoretical concepts governing fluid power
- Understand different types of valves used in pneumatic systems and draw pneumatic circuits
- Enable them to obtain logics to draw multi cylinder circuits, and provide an overview of fluid logics and fluidics
- Familiarize with working principles of various motors that are used for pneumatic control
- Learn working of PLC and construction of ladder logic diagrams

Course Outcomes

- Recognize the need of fluid power and classify various pneumatic components along with their applications
- Select suitable valves for various applications and design simple pneumatic circuits for direction, flow, pressure control
- Design multi cylinder pneumatic circuits for industrial applications including PID control and fluid logics
- Analyze the working of various motors
- Integration of pneumatic circuits with PLC's and draw ladder logic diagrams for various electrical devices

Unit – I

Introduction to Pneumatic Systems: Merits of Fluid power & its utility for increasing productivity through Low Cost Automation, Transmission of Fluid Power through various types of Cylinders), Advantages and applications of pneumatic systems, Symbolic representation of Pneumatic elements (CETOP), Compressors and Air supply system including airline installations.

Unit – II

Pneumatic Circuits: Pneumatic control elements: Direction, Pressure and Flow control valves, Basic pneumatic circuits for controlling single & double acting cylinder, Advanced pneumatic circuits for controlling multi-cylinders (operable).

Unit – III

Advanced pneumatic circuits: Advanced pneumatic circuits for controlling multi-cylinders (inoperable circuits), Electro pneumatics with relay logic, Pneumatics system with PID controls, Application of fluidics and Fluid logic elements.

Unit – IV

Motors: Programmable sequential control using pneumatic modular elements, Brushless DC servo motors with Hall- effect sensor, Stepper Motors: Full step, Half Step and Micro-step.

Unit – V

Programmable Logic Controller: Programmable Logic Controller: Architecture of PLC, Input and Output module, Processor, Programming methods for PLC: Ladder Programming, Pneumonics and Advanced Programming. Latching and relays, Sequencing, Timers and counters.

Suggested Readings:

1. .Pneumatic systems - Principles and maintenance, SR Majumdar, TMH
2. Pneumatics Circuits and Low Cost Automation by Fawcett, Trade and technical press.

Reference Books:

1. Pneumatic Hand Book by Trade and technical press ltd.
2. Hydraulics & Pneumatics Power for Production by Stewart, Industrial press.
3. Fluid Power Logic Circuit Design by Peter Rohner, The Macmillan press 1979.
4. Pneumatics- Jagadeesha T, Universities press.

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M.Tech. in Mechatronics
I Semester Syllabus
MT102PC: Applied Industrial Hydraulics

Course Objectives

- Provide fundamentals of Hydraulic System, various symbols for hydraulic elements and systems
- Understand various pumps and valves
- Provide basis for designing Hydraulic circuits and proportional valves
- Provide basic principles of hydraulic motors, electro hydraulic systems working
- Learn trouble shooting and remedial measures in hydraulic system

Course Outcomes

- Acquire fundamentals of fluid power control and Hydraulic power system
- Design and analysis of hydraulic pumps and valves
- Design Hydraulic circuits and Utilization of servo valves and cartridge valves in various systems
- Analyze hydraulic motors for low cost automation
- Troubleshoot and provide suitable measures for problems in hydraulic systems

Unit – I

Introduction to Industrial Hydraulics Power System elements and standard symbolic representation (CETOP symbols)

Unit – II

Various control valves used in Hydraulics System, Hydraulics accessories, advantages of Hydro-Pneumatics and its applications, different types of Hydraulics pumps and their Applications, Hydraulics system and their classification

Unit – III

Hydraulics circuits, Hydraulic motors, Hydraulic fluids and effective contamination control

Unit – IV

Electro hydraulics system, Servo valves and proportional valves, Design of Cartridge Valves,

Unit – V

Trouble shooting and remedial measures in Hydraulic system

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Suggested Readings:

1. Industrial Hydraulics, John Pippenger, Tyler Hicks
2. Oil Hydraulic Systems BY Majumdar. S.R. Tata MC Graw-Hill
3. Introduction to Hydraulics and Pneumatics by S.ILANGO, V.SOUNDARARAJAN

Reference Books:

1. Hydraulics and Pneumatics controls by Dr.S.Ramachandran, Dr.P.Senthil Kumar
2. Fluid Mechanics and Machinery by D.Ramadurgaiah.
3. Hydraulic Circuits by Fawcelt, Trade and technical press.
4. Fluid Mechanics and Hydraulics by Jagdish Lal, Metropolitan Book Company

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M.Tech. in Mechatronics
I Semester Syllabus
Professional Elective-I
MT111PE: Industrial Electrical & Electronics

Course Objectives

- Impart basic knowledge of electrical quantities and study basic laws and principles associated with electrical systems
- Understand the principle of operation of DC and AC motors.
- Understand the principle of operation of special purpose electrical machines.
- Comprehend the concepts of different Electronic Devices and other display devices.
- Understand the concept of closed loop operation of electric drive.

Course Outcomes

- Apply basic electrical engineering laws and principles that led to the development of various electrical devices
- Identify different types of AC and DC machines & understand it's operation.
- Identify different types of special purpose electrical machines & understand it's operation.
- Understand the working principle and applications of various electronic components.
- Understand the concept of closed loop operation of electric drive.

Unit – I

Basic electrical Engineering, principle of operation of DC Motor, Types of DC Motors, DC Motor characteristics, Applications, Speed control of DC motor, Introduction to AC Motors, Torque equation of induction motor, Speed-Torque and torque-slip characteristics, Selection of proper motors for various applications, Special purpose machines: induction generator, Constructional aspects, classification of induction generator, steady state analysis, torque-speed characteristics, applications of induction generator, Induction generator connected to mini / micro hydel systems.

Unit – II

Doubly Fed Induction Machine: Introduction, Construction, Power flow, slip, principle of operation, Types of doubly fed induction machine: Standard doubly-fed induction machines, Cascaded doubly fed induction machine, control via static converter, Application to grid connected wind and mini/micro hydel systems.
Switched Reluctance Motor: Introduction, construction, operation, closed loop control of SRM, applications, advantages and disadvantages,
Brushless DC Motor: Construction, operating principle, applications, advantages and disadvantages.

Unit – III

Linear Induction Machine: Construction, working, types of linear induction machines, applications of linear induction motor, **Linear Synchronous Machine:** construction, working, applications, permanent magnets in electrical machines: Structure, magnetic materials used.
Types of Permanent Magnet Motors – Permanent magnet DC motors (PMDC): construction, working, speed control, advantages, disadvantages, applications, PM synchronous machine (PMSM): Construction and performance, advantages and applications.

Unit – IV

Introduction to Electrical drives, advantages of electrical drives, Components of electrical drives: electrical motors, power modulators, sources, control unit, choice of electrical drives, fundamental torque equations, speed torque conventions and multi-quadrant operation, Components of Load Torques, Nature and Classification of Load Torques, Closed-Loop Control of Drives: Current –limit control, Closed-loop torque control, closed-loop speed

control.

Unit – V

Introduction to basic electronics, Diodes, Characteristics of Diode, Applications of Diode, Types of Transistors, Transistor configurations, Introduction to SCR, SCR controls, characteristics of SCR, FET, UJT, A/D conversion, D/A conversion,

Optoelectronic Devices: Photo diode, LDR, LED, LCD, and PLASMA displays. Opto-coupler, opto-interrupter, high speed detectors-PIN and avalanche photo diodes. Power supplies: Ordinary DC power supplies, Regulated power supplies, Switched Mode Power Supplies, AC power supplies, operational amplifiers, applications of operational amplifiers.

Reference Books:

1. "A Text book of Electrical Technology" B. L. Theraja& A. K. Theraja, Volume-II, S-Chand Publications, Reprint, 2020.

2. "Principles of Electrical Engineering and Electronics, V.K.Mehta, Rohit Mehta, S-Chand Publications, Revised edition, 2020.

3. Fundamentals of Electrical Drives, Gopal K. Dubey, Narosa Publishing House

4. Electronic devices and circuit theory by Robert L.Boylestad and Louis Nashelsky, Eleventh Edition, Pearson Publications.

5. Micro Electronics by Sedra Smith, 5th edition, Oxford University Press

6. Power Electronics by P. S. Bimbra, KKhanna Publications

7. Low Power Electronics by Allen Helberg

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M.Tech. in Mechatronics
I Semester Syllabus
Professional Elective-I

MT112PE: Programmable Logic Controller & Applications

Course Objectives

- Understand basics of PLCs, their construction and their applications in automation systems
- Acquire the basics of Boolean Algebra and its relation in establishing logic gates
- Understand the characteristics of PLC registers and PLC functions
- Exercise basic functions used for data handling and learn to write PLC programs
- Learn PID module basics, control, tuning and functionalities

Course Outcomes

- Describe various types of PLCs and Identify the inputs and outputs of the PLC in various applications
- Construct ladder diagrams for various input/output modules including logic gates that are used in Industrial applications
- Use counters, Timers, algebraic and Boolean operations, Memory etc., of PLC to perform certain tasks
- Write and test PLC programs for small Industrial automation applications
- Learn to incorporate a PLC in simple SCADA to understand PID functionalities

Unit – I

PLC Basics PLC system, I/O modules and interfacing CPU processor programming equipment programming formats, construction of PLC ladder diagrams, devices connected to I/O modules.

Unit – II

PLC Programming input instructions, outputs, operational procedures, programming examples using contacts and coils. Drill-press operation. Digital logic gates programming in the Boolean algebra system, conversion examples Ladder diagrams for process control Ladder diagrams and sequence listings, ladder diagram construction and flowchart for spray process system.

Unit – III

PLC Registers: Characteristics of Registers module addressing holding registers input registers, output registers. PLC Functions Timer functions and industrial applications counters counter function industrial applications, Architecture functions, Number comparison functions, number conversion functions.

Unit – IV

Data handling functions: SKIP, Master control Relay Jump Move FIFO, FAL, ONS, CLR and Sweep functions and their applications. Bit Pattern and changing a bit shift register, sequence functions and applications, controlling of two axes and three axis Robots with PLC, Matrix functions.

Unit – V

Analog PLC Operation: Analog modules and systems Analog signal processing multi bit data processing , analog output application examples, PID principles position indicator with PID control, PID modules, PID tuning, PID functions

Reference Books:

1. Programmable Logic Controllers –Principle and Applications by John W Webb and Ronald A Reiss Fifth edition, PHI

2. Programmable Logic Controllers–Programming Method and Applications by J R Hack worth and F.D Hackworth – Jr-Pearson, 2004.
3. Tilak Thakur “Mechatronics” Oxford University Press2016.
4. Fundamentals of programmable logic controllers a practical approach by Vijay Singh, New age publication.

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M.Tech. in Mechatronics
I Semester Syllabus
Professional Elective-I
MT113PE: Control Systems

Course Objectives

- Provide a basic understanding of the concepts and techniques through mathematical modelling involved in designing control systems
- Learn transient response analysis and errors that encounter in control systems
- Learn how to represent transfer functions for system response
- Understand the concepts of root locus and bode a plot that influence stability of the systems
- Obtain the concepts of state variable Model and analysis schemes for dynamic systems

Course Outcomes

- Possess in-depth knowledge of concepts from classical control theory and formulate differential equations
- Identify and analyze the errors pertaining to transient response analysis
- Apply the concept of transfer function and use it for obtaining system response
- Analyze dynamic systems for their stability and performance
- Implement the concept of state variables and methods to achieve controllability and stability based performance requirements

Unit – I

Mathematical Model for Physical Systems – Open loop – closed loop control–Differential equations of physical systems – Transfer functions – Block diagram algebra – Signal flow graphs –Reduction using Mason's gain formula. Industrial Automatic Controls - Classification – Proportional derivative and integral control actions –Liquid level control systems with proportional and integral control – Pneumatic, hydraulic and electronic controllers

Unit – II

Transient Response Analysis - Standard signals – transient response of first and second order systems– Steady state errors and error constants.

Unit – III

Transfer Function Representation: Transfer function of DC servomotor – AC servomotor–Synchronous transmitter and receiver. Block diagram representation of systems – Representation by signal flow graph.

Unit – IV

Stability Analysis: Concepts of Stability – Necessary conditions for stability –Hurwitz stability criterion – Routh's stability criterion – Relative stability. Frequency Response Analysis- The root locus concept– Frequency response, polar plot, Bode plot– Nyquist stability criterion.

Unit – V

State Variable Model and Analysis - Concepts of state & state variables – Derivation of state models from Block diagrams - State space representation of systems – Transfer matrix - Solution of state equation –State transition matrix–Concepts of controllability and observability.

Suggested Readings:

1. Control systems, Principles and Design/M Gopal/TMH
2. Modern Control Engineering/K. Ogata/Prentice Hall
3. Control Systems/ Anand Kumar/Prentice Hall

Reference Books:

1. Control Systems Engineering/ Nagrath& M. Gopal/ Wiley Eastern
2. Automatic control systems/ B.C.Kuo /John Wiley &Sons\ Modern Control Systems/Richard C.Dorf and Robert H.Bishop.

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M.Tech. in Mechatronics
I Semester Syllabus
Professional Elective-II
MT114PE: Instrumentation & Sensor Technology

Course Objectives

- Introduce various sensors and transducers for measuring mechanical quantities.
- Understand working of various Mechanical and proximity sensors
- Learn basic conditioning of circuits for various sensors and electrical transducers.
- Obtain the knowledge of interfacing of various sensors and transducers to electronic circuits.
- Introduce advances in sensor technology.

Course Outcomes

- Apply concepts behind working of measurement systems and different types of sensors and transducers.
- Analyze working principles of sensors and transducers to measure certain physical parameters used in Industry
- Identify sources of errors; interpret working principles of resistive, inductive and capacitive transducers, understanding of thermocouples, piezoelectric and pyro-electric transducers and their applications.
- Interface various sensors and transducers to electronic circuits and Understanding digital sensors with applications.
- Apply various principles and design to improvise the effectiveness and accuracy in measurement to provide better scope for future

Unit – I

Measurement and Characteristics: Elements of a Measurement System; Classification of Instruments; Static Performance Parameters; Loading and Impedance Matching; Errors and Uncertainties in Measurement; Process and Standards of Calibration; Dynamic Characteristics-Transfer Function Representation of a Measurement System, Impulse and Step Responses of First and Second Order Systems, Frequency Response of First and Second Order Systems.

Unit – II

Mechanical Transducers: Temperature- Bimetallic Element and Fluid Expansion type Thermometers; Pressure- Manometers and Bourdon Gauges; Force- Balances, Helical Spiral Springs, Load Cells and Elastic Force Devices; Torque- Torsion Bars and Flat Spiral Springs; Liquid Level- Float Systems and Level to Pressure Converters; Flow- Pitot Static Tubes and Turbine type Flow Meters. Hot Wire Anemometer.
Proximity Sensors- Reed Sensors, Inductive proximity sensor, Capacitive proximity sensor, Optical sensor with through beam, Ultrasonic sensors.

Unit – III

Electrical Transducers: Resistance Thermometers; Interfacing Resistive Transducers to Electronic Circuits; Thermistors- Measurement of Temperature and Thermal Conductivity, Temperature Control; Resistance Strain Gauges- Gauge Factor, Bonded and Unbonded Strain Gauges; Self Generating and Non Self Generating Inductive Transducers; Linear Variable Differential Transformers; Capacitive Transducers - Potentiometric Transducers; Thermoelectric Transducers and Sources of Errors in Thermocouples; Piezoelectric Transducers.

Unit – IV

Basic Signal Conditioning Elements: Amplifiers- Non Electrical and Electrical types; Op-Amps Inverting, Non Inverting, Summing, Differential, and Charge Amplifiers; Differentiating and Integrating Elements; Filters; Data

Transmission Elements - Electrical, Pneumatic, Position and Radio Frequency Transmission types; Compensation Elements for First and Second Order Systems - Basic Indicating, Recording, and Display Elements.

Unit – V

Feedback in Instruments: Principles of Feedback and Advantages & Disadvantages of Feedback; Digital Voltmeters - Ramp and Dual Slope types; Servo type Potentiometric and Magnetic Tape Recorders; Digital Recorders of Memory type; Data Displays-Analog and Digital types.

Reference Books:

1. Electronic Measurements and Instrumentation, K. Lal Kishore, Pearson Education Publications
2. Electronic Instrumentation, H. S. Kalsi-TMH Publications
3. Albert D Helfrick and William D Cooper; Modern Electronic Instrumentation and Measurement Techniques; 2004, PHI
4. BC Nakra, and Chaudhry; Instrumentation, Measurement and Analysis; 2004, Tata McGrawHill.
5. DVS Murthy; Transducers and Instrumentation; 2003, PHI.
6. CS Rangan, GR Sarma, and VSV Mani; Instrumentation Devices and Systems; Tata McGraw-Hill
7. Doeblin and Ernest; Measurement Systems Application and Design; 2004, Tata McGraw-Hill.
8. Tilak Thakur “Mechatronics” Oxford University Press 2016

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M.Tech. in Mechatronics
II Semester Syllabus
Professional Elective-II

MT115PE: Fuzzy Logic & Neural Networks

Course Objectives

- Make students introduce concept of fuzziness and its role in various systems
- Comprehend the fuzzy logic control and adaptive fuzzy logic
- Get the exposure to Artificial Neural Networks and Fuzzy logic
- Learn Mapping and recurrent networks
- Learn the significance of fuzzy logic for real time applications

Course Outcomes

- Understand the concept of fuzziness involved in various systems and fuzzy set theory
- Design fuzzy logic using genetic algorithm
- Attain the concepts related to Artificial Neural Networks
- Understand the significance of self propagation, counter propagation and concepts related to Mapping and recurrent networks
- Analyze the application of fuzzy logic control to real time systems

Unit - I

Fuzzy Set Theory and Fuzzy Logic Control: Basic concepts of fuzzy sets-Operations on fuzzy sets- Fuzzy relation equations- Fuzzy logic control - Fuzzification –Defuzzification- Knowledge base-Decision making logic - Membership functions– Rule base.

Unit - II

Adaptive Fuzzy Systems: Performance index-Modification of rule base 0 - Modification of membership functions - Simultaneous modification of rule base and membership functions - Genetic Algorithms - Adaptive fuzzy system – Neuro fuzzy systems.

Unit - III

Artificial Neural Networks: Introduction- History of neural networks- multilayer perceptions – Back propagation algorithm and its Variants – Different types of learning, examples.

Unit - IV

Mapping and Recurrent Networks: Counter propagation –Self organization Map- Congnitron and Neo-cognitron - Hopfield Net - Kohonnen Nets - Grossberg Nets-Art-I, Art – II reinforcement learning

Unit-V

Case Studies: Application of fuzzy logic and neural networks to Measurement- Control- Adaptive Neural Controllers– Signal Processing and Image Processing

Suggested Readings:

1. Vallum B.R And Hayagriva V.RC++,Neural networks and Fuzzy logic, BPB Publications, New Delhi,1996

Reference Books:

1. Fuzzy logic & Neural Networks / ChennakesavaR.Alavala / New Age International, 2008
2. Neural Networks for control, MillonW.T,SuttonR.SandWerbos P.J, MIT Press1992

3. Fuzzy sets Fuzzy logic, Klir, G.J anfd Yuan B.B Prentice Hall of India Pvt. Ltd. New Delhi
4. Neural Networks and Fuzzy systems, Kosko. Prentice hallof India Pvt. Ltd. New Delhi 1994
5. Introduction to Fuzzy control, DirankovD.HellendoornH,ReinfrankM. Narosa Publications House, New Delhi 1996.
6. Introduction to Artificial Neural systems, Zurada J.M Jaico Publishing House, New Delhi 1994.

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M.Tech. in Mechatronics
I Semester Syllabus
Professional Elective-II

MT116PE: Micro-Controller & Applications

Course Objectives

- Provide an understanding about the concepts and basic architecture of 8051
- Impart knowledge about assembly language programs of 8051
- Help understand the importance of different peripheral devices and their interfacing to 8051
- Learn timer/counter programming and serial communication in 8051
- Impart knowledge of different types of external interfaces

Course Outcomes

- Attain comprehensive knowledge about architecture and addressing modes of 8051
- Write assembly language program in 8051 for various embedded system applications
- Create the memory interfacing techniques with 8051
- Explain the significance of interrupts and their programming in 8051
- Create the IO interfacing techniques with 8051

Unit – I

Overview of 8-bit Microcontrollers-Intel, Motorola, and overview of the 8051 family - 8051 Architecture.

Unit – II

8051 Assembly languages programming – addressing modes Instruction set - Jump, Loop+ CALL instructions & programs - Arithmetic instructions, Logic Instructions & Programs –Single bit instructions & Programming- I/o - Port programming.

Unit – III

Timer/Counter, programming of 8051 serial communication interrupts.

Unit –IV

Interfacing 8051 to external memory - semiconductor memory - Memory address decoding - Interfacing with external ROM-data memory space - Interfacing to 8255 Architecture of PIC microcontroller's features, interfacing of I/O devices with PIC Controllers.PIC 16c6x, 16c7x.18x, 24x PIC memory organization.

Unit – V

Applications – Interfacing of LCD to 8051 - Interfacing ADC, Sensors - Interfacing steeper motor - Interfacing keyboard - Interfacing DAC to 8051. ARM Controllers Introduction to ARM controllers. Comparison between RISC & CISC processor. Versions & variants of ARM processor. Register model of ARM processor. Modes of Operation. Applications of ARM processor.

Reference Books:

1. Muhammad Ali Mazzid, Jancie Gillispe Mazid "The Microcontroller & Embedded Systems", Pearson Education, 2000.
2. Julio Sanchez and Maria P.Canton, Microcontroller Programming – The Microchip PIC, CRC Press
3. MykePredko "Programming & Customizing the 8051",Tata McGrawHill,1999
4. Raj Kamal "Embedded systems, Architecture, Programming and Design, "Tata Mc Graw Hill,2003.
5. Kenneth J.Ayala, The 8051 Microcontroller, CENGAGE Publisher
6. Fernando E.Valdes - Perez and Ramon Pallas - Areny, Microcontrollers-Fundamentals and Applications with PIC, CRC Press
7. KVK Prasad, Embedded Real Time Systems, Dearm Tech Publishers.

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M.Tech. in Mechatronics
I Semester Syllabus
MT101MC: Research Methodology & Intellectual Property Rights

Course Objectives

- To understand the research problem
- To know the literature studies, plagiarism and ethics
- To get the knowledge about technical writing
- To analyze the nature of intellectual property rights and new developments
- To know the patent rights

Course Outcomes

- Understand research problem formulation.
- Analyze research related information
- Follow research ethics
- Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
- Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
- Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

Unit – I

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

Unit – II

Effective literature studies approaches, analysis, Plagiarism, Research ethics

Unit - III

Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

Unit – IV

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents.

Unit – V

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

Suggested Readings:

1. C. R. Kothari and Gaurav Garg, "Research Methodology – Methods and Techniques", New Age International
2. Ranjit Kumar, 2nd Edition , "Research Methodology: A Step by Step Guide for beginners"

3. T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008

Reference Books:

1. Stuart Melville and Wayne Goddard, “Research methodology: an introduction for science & engineering students’”
2. Wayne Goddard and Stuart Melville, “Research Methodology: An Introduction”
3. Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd, 2007.
4. Mayall, “Industrial Design”, McGraw Hill, 1992.
5. Niebel, “Product Design”, McGraw Hill, 1974.
6. Asimov, “Introduction to Design”, Prentice Hall, 1962.
7. Robert P. Merges, Peter S. Menell, Mark A. Lemley, “ Intellectual Property in New Technological Age”, 2016.

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M.Tech. in Mechatronics
I Semester Syllabus
Audit Course- I
AC101HS: English for Research Paper Writing

Course Objectives

Students will be able to:
- Improve their writing skills and level of readability
- Learn about structure and organization of sections and sub sections
- Develop requisite skills to write the title
- Enhance effective writing skills to publish research papers

Unit-I

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

Unit-II

Clarifying, Highlighting Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstract, Introduction

Unit-III

Review of the Literature, Methods, Results, Discussion, Conclusions, the Final Check

Unit-IV

Key Skills for: Writing a title, Writing an abstract, Writing an Introduction, Writing a review of the literature

Unit-V

Key skills for: Writing methods, Writing the results, Writing the discussion, Writing the conclusions.
Useful phrases and mechanics of effective writing to publish research papers.

Suggested Readings:

1. Adrian Wallwork, English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011.

Reference Books:

1. Goldbort R (2006) Writing for Science, Yale University Press(available on Google Books)
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book.

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M.Tech. in Mechatronics
I Semester Syllabus
Audit Course - I
AC102HS: Sanskrit for Technical Knowledge

Course Objectives

- To get a working knowledge in illustrious Sanskrit, the scientific language in the world
- Learning of Sanskrit to improve brain functioning
- Learning of Sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power
- The engineering scholars equipped with Sanskrit will be able to explore the huge knowledge from ancient literature

Course Outcomes

- Understanding basic Sanskrit language
- Ancient Sanskrit literature about science & technology can be understood
- Being a logical language will help to develop logic in students

Unit-I
Alphabets in Sanskrit

Unit-II
Past / Present / Future Tense, Simple Sentences

Unit-III
Order, Introduction of roots

Unit-IV
Technical information about Sanskrit Literature

Unit-V
Technical Concepts of Engineering - Electrical, Mechanical, Architecture, Mathematics

Suggested Readings:

1. Prathama Deeksha-Vempati Kutumbshastri "Teach Yourself Sanskrit", Rashtriya Sanskrit Sansthanam, New Delhi Publication

Reference Books:

1. Dr. Vishwas, Samskrita "Abhyaspustakam" -Bharti Publication, New Delhi
2. Suresh Soni "India's Glorious Scientific Tradition", Ocean books (P) Ltd., New Delhi

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M.Tech. in Mechatronics
I Semester Syllabus
Audit Course - I

AC103HS: Stress Management by Yoga

Course Objectives

- To achieve overall health of body and mind
- To overcome stress

Course Outcomes

- Develop healthy mind in a healthy body thus improving social health also
- Improve efficiency

Unit-I
Definitions of Eight parts of yog. (Ashtanga)

Unit-II
Yam and Niyam.

Unit-III
Do's and Don't's in life.
i) Ahinsa, satya, astheya, bramhacharya and aparigraha
ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan

Unit-IV
Asan and Pranayam

Unit-V
i) Various yoga poses and their benefits for mind & body
ii) Regularization of breathing techniques and its effects-Types of pranayam

Suggested Readings:
1. 'Yogic Asanas for Group Tarining-Part-I": Janardan Swami Yogabhyasi Mandal, Nagpur

Reference Books:
1. "Rajayoga or conquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata

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M.Tech. in Mechatronics
I Semester Syllabus
MT151PC: Pneumatics Lab

Course Objectives

- Impart knowledge on the concepts of Pneumatic Systems.
- Understand practically operation of basic pneumatic circuits
- Illustrate principles & operation of electro-pneumatic systems.
- Visualize operation of electro-pneumatic systems using PLC interface
- Study the performance of electro-pneumatic systems using simulation software.

Course Outcomes

- Demonstrate the concepts of Pneumatic Systems.
- Build and operate basic pneumatic circuits
- Analyze the working of pneumatic and electro-pneumatic systems.
- Operate electro-pneumatic systems through ladder logic diagrams
- Design various pneumatic circuits using Simulation software.

List of Experiments:

Do any TEN of the following Experiments:

1. Study of pneumatic components:
   i. Air compressor along with air receiver tank
   ii. FRL unit
   iii. Control valves
2. Draw the Circuit diagram to operate a Single Acting Pneumatic Cylinder using 3/2 Push Button Direction Control Valve (Manual).
3. Draw the Circuit diagram to operate a Double Acting Pneumatic Cylinder using two 3/2 Push Button Direction Control Valves (Manual).
4. Draw the circuit diagram to operate Double Acting Pneumatic Cylinder using 5/2 Direction Control Valve (solenoid) and Push button momentary switch.
5. Draw the circuit diagram to operate Double Acting Pneumatic Cylinder using 5/2 Direction Control Valve (solenoid) and Push button Latch Switch.
6. Draw the circuit diagram for sequential operation of Single acting Pneumatic cylinder & Double acting pneumatic cylinder using sequence valve.
7. Draw the Circuit diagram to operate a Single Acting Pneumatic Cylinder using 5/2 single Solenoid control valve and PLC.
8. Draw the Circuit diagram to operate a Double Acting Pneumatic Cylinder using 5/2 DCV (Double Solenoid) and PLC.
9. Draw the circuit diagram for sequential operation of Single acting Pneumatic cylinder &Double acting Pneumatic cylinder using PLC.
10. Draw the circuit diagram for speed control of single & Double Acting Pneumatic Cylinder.
11. Simulation of Single Acting Pneumatic Cylinder using 3/2 Push Button Direction Control valve using Simulation software.
12. Simulation of Double Acting Pneumatic Cylinder using 5/2 Push Button Direction Control Valve using Simulation software.

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M.Tech. in Mechatronics
I Semester Syllabus
MT152PC: Hydraulics Lab

Course Objectives

- Impart knowledge on the concepts of Hydraulic Systems.
- Demonstrate the working and operation of basic Hydraulic systems practically
- Understand and execute working of Electro-Hydraulic systems.
- Interpret the operation of Electro-Hydraulic systems using different types of control valves
- Analyze the performance of Electro-Hydraulic systems using simulation software.

Course Outcomes

- Demonstrate the concepts of Hydraulic Systems.
- Understand the necessity of Hydraulic systems in automated systems.
- Analyze the working of Hydraulic and Electro-Hydraulic systems.
- Design and operation of Hydraulic and Electro-Hydraulic systems.
- Design of Hydraulic circuits using Simulation software.

List of Experiments:

Do Any TEN of the Following Experiments:

1. Study of Pressure relief valve and Directional Control valves in Hydraulic System.
2. Draw the Circuit diagram to operate Double Acting Hydraulic Cylinder using 4/2 Direction Control Valve (Manual type).
3. Draw the Circuit diagram to operate Double Acting Hydraulic Cylinder using 4/3 Direction Control Valve (Manual type).
4. Draw the Circuit diagram to operate Double Acting Hydraulic Cylinder using 4/2 Direction Control Valve (Single Solenoid) using Push button momentary switch.
5. Draw the Circuit diagram to operate Double Acting Hydraulic Cylinder using 4/2 Direction Control Valve (Single Solenoid) using Latch Switch.
6. Circuit for measurement of oil pressure in a hydraulic system.
7. Draw the Circuit diagram to operate Double Acting Hydraulic Cylinder using 4/2 Direction Control Valve (Solenoid Control) using Push button switch for varying Flow rate using flow control valve.
8. Draw the Circuit diagram to operate Double Acting Hydraulic Cylinder using 4/2 Direction Control Valve (Solenoid Control) using Latch for varying flow rate using Flow control valve.
9. Simulation of Double Acting Hydraulic Cylinder using 4/2 Direction Control Valve (Manual control) using simulation software.
10. Simulation of Double Acting Hydraulic Cylinder using 4/3 Direction Control Valve (Manual control) using simulation software.
11. Simulation of Double Acting Hydraulic Cylinder using 4/2 Direction Control Valve using Push button with spring return valve.
12. Simulation of Double Acting Hydraulic Cylinder using 4/2 Direction Control Valve Using Electrical control with spring return valve.

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M.Tech. in Mechatronics
I Semester Syllabus
EN151HS: Finishing School-I
(Common to all Branches)

Course Overview

- In view of the growing importance of English as a tool for global Communication and the consequent emphasis on training students to acquire language skills, this syllabus has been designed to develop linguistic, communicative and critical thinking competencies of Engineering students.

Course Objectives

- The main objective of this finishing school curriculum is to provide content for developing the LSRW skills of language learning and to facilitate proficiency in both receptive and productive skills, among students.

Methodology:

- Every Session will have activities on all the four skills-Listening, Speaking, Reading and Writing.
- To personalize the learning a variety of case studies and structured problem solving activities will be given to small groups and the teachers will facilitate peer reviews.
- Continuous grading, peer review and positive reinforcement will be emphasized
- Vocabulary exercises will also be a part of every session
- All sessions are designed to be student-centric and interactive.

Unit-I: Fundamentals of Communication

Unit Overview:

This is an introductory module that covers the fundamentals of communication. This module is intended to enable the students to communicate using greetings and small sentences/queries.

Learning Outcomes:

The students should be able to:

- Respond to questions
- Engage in informal conversations.
- Speak appropriately in formal situations
- Write formal and informal emails/letters

Competencies:

- Greeting appropriately
- Introducing themselves, a friend
- Situational Dialogue writing
- Responding to simple statements and questions both verbally and in writing
- Writing an email with appropriate salutation, subject lines, introduction and purpose of mail.
- Using appropriate vocabulary for both formal and informal situations.
- JAM sessions.

Sessions:

1. Introduction to Formal and Informal Conversations (Listening Activity)
2. Informal Conversations
3. Informal Conversations - Writing
4. Formal Conversations
5. Formal Conversations – Writing

6. Grammar-Prepositions
7. Adjectives and Degrees of Comparison
8. Word formation: Prefixes and Suffixes

Unit–II: Rational Recap

Unit Overview:

The module enables the participants to organize their communication, structure their speaking and writing, explain their thoughts/ideas, and summarize the given information.

Learning Outcomes:

The students should be able to:

- Classify content and describe in a coherent form
- Recognize and list the key points in a topic/message/article.
- Compare and contrast using appropriate structure
- Explain cause and effect
- Use appropriate transitions in their presentations and written assignments

Competencies:

- Organizing the communication based on the context and audience
- Structuring the content based on the type of information.
- Explaining a technical/general topic in detail.
- Writing a detailed explanation/process
- Recapitulating

Sessions:

1. Introduction to Mind maps
2. Classification
3. Sequencing
4. Description and Enumeration

Unit-III: Narrations and Dialogues

Unit Overview:

The Module is intended to develop the desired level of language competence that enables them to narrate and participate in casual dialogues.

Learning Outcomes:

The students should be able to

- Narrate a message/story/incident, both verbally and in writing.
- Describe an event/a session/ a movie/ an object / image
- Understand Vocabulary in context

Competencies:

- Framing proper phrases and sentences to describe in context
- Reading Stories and articles and summarizing.
- Speaking fluently with clarity
- Listening for main ideas and reformulating information in his/her own words
- Drawing and write appropriate conclusions, post reading a passage.
- Speaking Reading and Writing descriptive sentences and paragraphs
- Using appropriate tenses, adjectives and adverbs in conversations and written tasks

Sessions:

Grammar: Verb, Tenses

1. Recalling and Paraphrasing
2. Describing Events
3. Describing Objects/ Places
4. Story Telling
5. Describing Hypothetical events

Unit-IV: Technical Expositions and Discussions

Unit Overview:

The module enables the students to build strategies for effective interaction and help them in developing decisive awareness and personality, maintaining emotional balance.

Learning Outcomes:

The students should be able to:

- Participate in Professional discussions by providing factual information, possible solutions, and examples.

Competencies:

- Comprehending key points of a topic and identifying main points including supporting details.
- Construct a logical chain of arguments and decisive points.
- Writing a review about a product by providing reasons, causes and effects

Sessions:

Based on Case Studies

1. Compare and Contrast
2. Cause and Effect
3. Problem and Solution

Unit-V: Drawing Conclusions

Unit Overview:

This module is intended to provide necessary inputs that enable the students to draw conclusions out of a discussion and provide reports.

Learning Outcomes:

Students should be able to:

- Provide logical conclusions to the topics under discussion.
- Prepare, present, and analyze reports.

Competencies:

- Reasoning skills - Coherent and logical thinking
- Reporting and Analyzing skills.
- Analyzing the points discussed.
- Connecting all points without gaps.
- Connectives
- Communicating the decisions

Sessions:

1. Report Writing
2. Reasoning
3. Analyzing
4. Generalization and Prediction
5. Précis writing

Minimum Requirement

Interactive Communication Skills Lab: A Spacious room with movable chairs and audio-visual aids with a Public-Address System, an LCD and a projector with Internet Connectivity, Handycam Camcorder with 4K recording facility with tripod.

Reference Books:

1. Learn Correct English – A Book of Grammar, Usage and Composition by Shiv K. Kumar and Hemalatha Nagarajan. Pearson 2007
2. Professional Communication by Aruna Koneru, McGraw Hill Education (India) Pvt. Ltd, 2016.
3. Technical Communication by Meenakshi Raman & Sangeeta Sharma, Oxford University Press 2009.
4. Technical Communication by Paul V. Anderson. 2007. Cengage Learning pvt. Ltd. New Delhi.
5. English Vocabulary in Use series, Cambridge University Press 2008.
6. Handbook for Technical Communication by David A. Mc Murrey & Joanne Buckley. 2012.Cengage

Learning.
7. Communication Skills by Leena Sen, PHI Learning Pvt Ltd., New Delhi, 2009.
8. Job Hunting by Colm Downes, Cambridge University Press 2008.
9. English for Technical Communication for Engineering Students, Aysha Vishwamohan, Tata Mc Graw-Hill 2009
10. Effective Technical Communication by M Asharaf Rizvi. McGraw Hill Education (India) Pvt. Ltd. 2nd Edition.

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M.Tech. in Mechatronics
II Semester Syllabus
MT201PC: Advanced CNC Technology

Course Objectives

- Understand various components and working of CNC Machine.
- Possess general understanding of computer aided part programming principles
- Understand different tooling systems for various operations performed in CNC.
- Obtain the knowledge of Computer Integrated manufacturing and its features
- Understand uses of various types of post processors.

Course Outcomes

- Familiarize the components of computer aided manufacturing, CNC machines and its constructional features.
- Execute Part Programming and apply its Techniques effectively
- Select appropriate Tooling systems and adapt methods to implement effective Automation in CNC.
- Increase the productivity and reduce manual processing by linking computers to all manufacturing machines by using DNC and Adaptive control System.
- Explain Post processor significance and its functions.

Unit - I

CNC Machine: Features of NC machines fundamentals of numerical control, advantage of NC systems, classification of NC systems, point to point, NC and CNC, incremental and absolute, open and closed loop systems, features on N/C machine tools, design consideration of NC machine tool, methods of improving machine accuracy.

Unit - II

Part Programming Methods: NC part programming manual programming basic concepts for MILLING, TURNING Operations, point to point contour programming, canned cycles, APT Part Programming, MACROS, Parametric programming Concepts.

Unit - III

CNC TOOLING: Tooling for CNC machines. Interchangeable tooling system, preset and qualified tools, coolant fed tooling system, modular fixturing, quick change tooling system, automatic head changers.

Unit - IV

DNC and Adaptive Control System: DNC systems and adaptive control: Introduction, type of DNC systems, advantages and disadvantages of DNC, adaptive control with optimization, adaptive control with constraints, adaptive control of machining processes like turning, grinding.

Unit - V

Post Processors for CNC: Introduction to post processors: The necessity of a processor, the general structure of a post processor, the functions of a post processor, DAPP based post processor, communication channels and major variables in the DAPP based post processor, the creative of a DAPP processor.

Suggested Readings:

1. CAD/CAM Principles and Applications / P. N. Rao / Mc Graw Hill.
2. Computer control of manufacturing systems /YoramKorem /Mc Graw Hill Int. 1983.

Reference Books:

1. CAD/CAM/ Groover M.P/ Pearson
2. CAD/CAM/CIM/ Radhakrishnan and Subramanian / New Age
3. Machine tools hand book Volume 3, (Automation & Control)/Manfred weck/John Wiley and sons, 1984.

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M.Tech. in Mechatronics
II Semester Syllabus
MT202PC: Industrial Robotics

Course Objectives

- Familiarize with the theoretical aspects of Robotics and applications
- Learn to apply forward and inverse kinematics for various robotic manipulators
- Enable to learn robot dynamic control and machine vision
- Posses general understanding of various Robotic programming languages
- Acquire practical experience in the field of Robotics through design projects and case studies.

Course Outcomes

- Identify various basic components such as links, joints, actuators, end-effectors of any robot and classify types of robots, grippers.
- Develop DH table and solve for forward kinematics, impart Jacobian formulation technique for inverse kinematics
- Implement trajectory planning and machine vision applications
- Design of intelligent robots using sensors.
- Programme a robot to perform tasks in industrial applications.

Unit - I

Introduction: Automation and Robotics, Robot anatomy, robot configuration, motions joint notation work volume, robot drive system, control system and dynamic performance, precision of movement, Power Transmission Systems.
End Effectors: Grippers-types, operation, mechanism, force analysis, tools as end effectors consideration in gripper selection and design.

Unit - II

Motion Analysis and Control: Manipulator kinematics, position representation Homogeneous transformation, D-H Notation, D-H Transformation Matrix, Forward & Inverse transformations, problems on planar & spatial manipulators, Differential Kinematics, Jacobian Formulation, problems,

Unit - III

Manipulator path control: Slew, Joint Interpolated & Straight line motions, trajectory planning: Joint space scheme, Cartesian space scheme, Cubic Polynomial fit without and with via point, blending
Machine Vision: Functions, Sensing and Digitizing-imaging, Devices, Lighting techniques, Analog to digital single conversion, Image storage, Image processing and Analysis-image data reduction, Segmentation feature extraction. Object recognition, training the vision system, Robotics application.

Unit - IV

Robot Programming & Languages: Lead through programming, Robot programming as a path in space, Motion interpolation, WAIT, SINGNAL AND DELAY commands, Branching capabilities and Limitations, Textual robot languages – VAL & AML.
Robot actuators and feedback components (sensors): Internal & External Sensors, Positions sensors, velocity sensors - Desirable features, tactile, proximity and range sensors, uses sensors in robotics

Unit - V

Robot Cell Design and Control: Robot cell layouts-Robot centered cell, In-line robot cell, Considerations in work cell design, Work cell control, Inter locks, Error detection, and Work cell controller.
Robot Applications: Material transfer, Machine loading/unloading. Processing operations, Assembly and

Inspection, Future Applications.

Reference Books:

1. Robotics & control/R K Mittal & I J Nagrath/ Tata McGraw Hill
2. Industrial robotics / Mikell P. Groover / McGraw Hill.
3. Introduction to Robotics Mechanics & Control/ John J.Craig/Pearson
4. Modeling & Ctrl of Robot Manipulators/L. Sciavicco & B. Siciliano/Springer
5. Robot Technology Fundamentals, James G. Keramas, CENGAGE
6. Robotics / K.S. Fu / McGraw Hill.
7. Robot Analysis/Lung Wen Tsai/John Wiley & Sons
8. Fundamentals of Robotics/Robert J. schilling/PHI
9. Robotics by saha /TMG
10. Robotic Engineering/ Richard D. Klafter, Thomas A. Chmielewski /PHI

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M.Tech. in Mechatronics
II Semester Syllabus
Professional Elective-III

MT211PE: Manufacturing Systems: Simulation Modelling & Analysis

Prerequisites: Operations Research, Optimization Techniques and Applications and Probability Statistics

Course Objectives

- Learn the way of analyzing the Systems
- Build and verify the suitability of simulation model
- Classification of systems based nature of Dynamics and Knowledge of elements
- To develop simulation model for dynamic discrete–events to chastic system
- To analyze the output data of simulation for specified performance measures based on type of simulation and method of output data analysis.

Course Outcomes

- Define the state of system w.r.t. specified performance measures.
- Identify Design and analyze systems for specified speeds and feeds.
- Develop the simulation model for the said systems.
- Analyze the model and present the results for specified confidence level
- Analyze and interpret various queuing models

Unit-I

System – ways to analyze the system – Model - types of models – Simulation – Definition – Types of simulation models – steps involved in simulation – Advantages & Disadvantages. Parameter estimation – estimator – properties – estimate – point estimate – confidence interval estimates –independent – dependent – hypothesis – types of hypothesis- steps – types 1 & 2 errors – Framing –strong law of large numbers.

Unit-II

Building of Simulation model – validation – verification – credibility – their timing – principles of valid simulation Modeling – Techniques for verification – statistical procedures for developing credible model. Modeling of stochastic input elements –importance – various procedures – theoretical distribution – continuous – discrete –their suitability in modeling.

Unit-III

Generation of random variates – factors for selection – methods – inverse transform – composition – convolution – acceptance – rejection – generation of random variables – exponential – uniform –weibull – normal Bernoulli – Binomial – uniform – poison. Simulation languages – comparison of simulation languages with general purpose languages –Simulation languages vs Simulators –software features – statistical capabilities – G.P.S.S – SIMAN- SIMSCRIPT –Simulation of M/M/1queue –comparison of simulation languages.

Unit-IV

Output data analysis – Types of Simulation with respect to output data analysis – warm up period-Welch algorithm – Approaches for Steady – State Analysis – replication – Batch means methods – comparisons.

Unit-V

Applications of Simulation – flow shop system – job shop system – M/M/1queues with infinite and finite capacities – Simple fixed period inventory system – New boy paper problem.

Suggested Readings:

1. Simulation Modelling and Analysis by Law, A.M. & Kelton, McGraw Hill, 2nd Edition, New York, 1991.
2. Discrete Event System Simulation by Banks J. & Carson J.S., PH, Englewood Cliffs, NJ, 1984.

Reference Books:

1. Simulation of Manufacturing Systems by CarrieA., Wiley, NY, 1990.
2. A Course in Simulation by Ross,S.M.,Mc Millan,NY,1990.
3. Simulation Modelling and SIMNET by Taha H.A., PH, Englewood Cliffs, NJ,1987.

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M.Tech. in Mechatronics
II Semester Syllabus
Professional Elective-III
MT212PE: Additive Manufacturing Technologies

Course Objectives

- Understand the fundamental concepts of Additive Manufacturing (i.e. Rapid Prototyping) and 3-D printing, its advantages and limitations.
- Classify various types of Additive Manufacturing Processes and know their working principle, advantages, limitations etc.
- Study methods of additive manufacturing with introduction to common machines used for the technology.
- Learn the file formats and software's used for additive manufacturing.
- To have a holistic view of various applications of these technologies in relevant fields such as mechanical, bio-medical, aerospace etc.

Course Outcomes

- Describe various CAD issues for 3D printing/additive manufacturing and related operations.
- Formulate and solve typical problems on reverse engineering for surface reconstruction from physical proto type models through digitizing and spline-based surface fitting.
- Formulate and solve typical problems on reverse engineering for surface reconstruction from digitized mesh models through topological modelling and subdivision surface fitting.
- Explain and summarize the principles and key characteristics of additive manufacturing technologies and commonly used 3D printing and additive manufacturing systems.
- Explain and summarize typical rapid tooling processes for quick batch production of plastic and metal parts.

Unit-I

Introduction: Historical development, Need for Additive Manufacturing, Fundamentals of Additive Manufacturing/Rapid Prototyping, Advantages and Limitations; Commonly used Terms; Classification of Additive Manufacturing process, Additive Manufacturing Process Chain: Fundamental Automated Processes. Distinction between AM and CNC, other related technologies.

Unit-II

Liquid-based AM Systems: Process, Working principle, Applications, Advantages and Disadvantages ,Models and specifications, Case studies of (a) Stereo lithography Apparatus (SLA), (b) Solid Ground Curing (SGC) and (c) Poly jet Process;

Layering technology, laser and laser scanning, Photo polymerization.

Solid-based AM Systems: Process, working principle, Applications, Advantages and Disadvantages, Models and specifications, Case studies of (a) Laminated Object Manufacturing(LOM); (b) Fused Deposition Modeling(FDM) and (c) Multi Jet Modelling (MJM).

Unit-III

Powder Based AM Systems: Process, Working principle, Applications, Advantages and Disadvantages, Models and specifications, Case studies of (a)Selective Laser Sintering (SLS), (b) Three-Dimensional Printing (3DP) and (c) Laser Engineered Net Shaping (LENS) and Electron Beam Melting (EBM).

Rapid Tooling: Introduction to Rapid Tooling (RT), Conventional Tooling Vs RT, Need for RT. Rapid Tooling Classification: Indirect Rapid Tooling Methods: Arc Spray Metal Deposition, Investment Casting; Direct Rapid Tooling: Direct AIM, Direct Metal Tooling using 3DP.

Unit-IV

AM Data Formats: STL Format, STL File Problems, Consequence of Building Valid and Invalid Tessellated Models, STL file Repairs: Generic Solution, Other Translators, Newly Proposed Formats. Mesh Refining by Sub division Techniques.

AM Software's: Need for AM software, Features of various AM software's like Magics, Mimics, Solid View, View Expert, 3 D View, Velocity 2, Rhino, STL View, 3 Data Expert and 3 D doctor.

Unit-V

AM Applications: Application – Material Relationship, Application in Design, Application in Engineering, Analysis and Planning, Aerospace Industry, Automotive Industry, Jewelry Industry, Coin Industry, GIS application, Arts and Architecture. RP Medical and Bioengineering Applications: Planning and simulation of complex surgery, Customized Implants & Prosthesis, Design and Production of Medical Devices. Web Based Rapid Prototyping Systems

Suggested Readings:

1. 3D Printing and Additive Manufacturing: Principles and Applications (Fifth Edition of Rapid Prototyping) - Chee Kai Chua and Kah Fai Leong - World Scientific Publications
2. Additive Manufacturing Technologies - Gibson, I., Rosen, D., Stucker, B., & Khorasani, M. - Springer.

Reference Books:

1. Rapid Manufacturing - D.T. Pham and S.S. Dimov - Springer
2. Terry Wohlers, Wholers Report 2000, Wohlers Associates
3. Rapid Prototyping and Manufacturing - PaulF.Jacobs - ASME

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M.Tech. in Mechatronics
II Semester Syllabus
Professional Elective-III
MT213PE: MEMS

Course Objectives

- Provide overview of MEMS (Micro electro Mechanical System) and various fabrication techniques.
- Design, analysis, fabrication and testing of MEMS based components.
- Introduce various opportunities in the emerging field of MEMS.
- Understand the heat conduction in solids and multi-layered thin films.
- Learn the concepts of lithography methods such as UV photo-lithography, X-ray photo-lithography, electron beam lithography, soft-lithography and their comparisons.

Course Outcomes

- Synthesize and characterize nano-materials for engineering applications
- Design and analyze methods and tools for micro and nano manufacturing.
- Improve the quality of MEMS by analyzing the variables of the underlying micro and nano-manufacturing method
- Select appropriate industrially-viable process, equipment and tools for a specific product.
- Determine the most appropriate dry etchant and dry etching process to selectively micro machine features into one or more materials, given the simultaneous presence of other materials that are not to be etched.

Unit-I

Overview and working principles of MEMS and Microsystems

MEMS & Microsystems, Evolution of Micro fabrication, Microsystems & Microelectronics, Microsystems & miniaturization, Applications of MEMs in Industries, Micro sensors, Micro actuation, MEMS with Micro actuators Micro accelerometers, Micro fluidics

Unit-II

Engineering Science for Microsystems Design and Fabrication

Atomic structure of Matter, Ions and Ionization, Molecular Theory of Matter and Intermolecular Forces, Doping of Semiconductors, The Diffusion Process, Plasma Physics, Electrochemistry, Quantum Physics.

Unit-III

Engineering Mechanics for Microsystems Design

Static Bending of Thin plates, Mechanical Vibration, Thermo mechanics, Fracture Mechanics, Thin- Film Mechanics, Overview of Finite Element Stress Analysis.

Unit-IV

Thermo Fluid Engineering & Microsystems Design

Overview of Basics of Fluid Mechanics in Macro and Micro scales, Basic equations in Continuum Fluid Dynamics, Laminar Fluid Flow in Circular Conduits, Computational Fluid Dynamics, Incompressible Fluid Flow in Micro conduits, Fluid flow in Sub micrometer and Nano scale, Overview of Heat conduction in Solids, Heat Conduction in Multilayered Thin films and in solids in sub micrometer scale, Design Considerations, Process Design Mechanical Design, Mechanical design using FEM, Design of a Silicon Die for a Micro pressure sensor.

Unit-V

Materials for MEMS & Microsystems and their fabrication

Substrates and Wafers, Active substrate materials, Silicon as a substrate material, Silicon compounds, Silicon Piezo resistors, Gallium Arsenide, Quartz, Piezoelectric Crystals and Polymers, Photolithography, Ion implantation, Diffusion and oxidation, Chemical and Physical vapor deposition, etching, Bulk micro manufacturing, Surface Micromachining, The LIGA Process.

Suggested Readings:

1. Tia-Ran - Hsu, MEMS & Microsystems. Design & Manufacturing, TMH 2002.
2. Foundation of MEMS/ Chang Liu/Pearson, 2012.

Reference Books:

1. MEMS, NitaigourPremchandMahalik, TMH.
2. Mechatronics Systems Fundamentals-Rolf Isermann-Springer International Edition.
3. Introductory MEMS: Fabrication and application by Adams, Thomas M. Layton Richard A., 1st Edition 2010 IBNL 978-0-387-09510-3, Springer.
4. Microsystems Design, Stephen D.Senturia, Springer International Edition.
5. An Introduction to Microelectromechanical Systems Engineering by Maluf M., Artech House, Boston 2000
6. Micro robots and Micromechanical Systems by Trimmer, W.S.N., Sensors & Actuators, Vol 19, 1989.
7. Applied Partial Differential Equations by Trim, D.W., PWS-Kent Publishing, Boston, 1990.

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M.Tech. in Mechatronics
II Semester Syllabus
Professional Elective-IV

MT214PE: Automation in Manufacturing

Course Objectives

- Understand the concepts of Automation in manufacturing systems, Advanced Automation Functions, Levels of automation.
- Understand fundamental concepts of Material handling, Conventional and Automated storage system and Automatic data capture
- Acquire the concepts of Manual Assembly Lines and Assembly line design.
- Know the fundamentals of Automated Production Lines and the analysis of transfer lines.
- Understand Design and Analysis of Automated Assembly Systems.

Course Outcomes

- Adopt the principles of automation and implement the strategies in designing an Automated Manufacturing Systems.
- Analyze the issues related to Material Handling Systems, Storage and retrieval systems.
- Analyze and design simple Assembly Lines trough Line balancing methods.
- Carry out the analysis of transfer lines with and without buffer storages.
- Perform quantitative analysis of Automated Assembly Systems.

Unit-I

Introduction to Automation: Automation in Production Systems, Automated Manufacturing Systems, Computerized Manufacturing Support Systems, Reasons for Automation, Automation Principles and Strategies; Manufacturing operations, Production facilities, Manufacturing Costs, Basic Elements of an Automated Systems, Advanced Automation Functions, Levels of Automation.

Unit-II

Introduction to Material Handling: Overview of Material Handling, Considerations in Material Handling System Design, the 10 Principles of Material Handling. Material Transport Systems, Automated Guided Vehicle Systems, Monorails and other Rail Guided Vehicles, Conveyor Systems, Analysis of Material Transport Systems. Storage Systems, - Conventional Storage Methods and Equipment, Automated Storage Systems, Analysis of Storage Systems. Automatic identification and data capture - overview of Automatic identification methods, bar code technology, and other AIDC technologies.

Unit-III

Manual Assembly Lines - Fundamentals of Manual Assembly Lines, Analysis of Single Model Assembly Lines, Line balancing problem: Largest Candidate Rule, Kilbridge& Wester method, and Ranked Positional Weights Method; Alternative Assembly Systems, Considerations in Assembly Line Design.

Unit-IV

Automated Production Lines, Fundamentals of Automated Production Lines, Applications of Automated Production Lines. Analysis of Transfer Lines with no Internal Storage, Analysis of Transfer lines with Storage Buffers.

Unit-V

Automated Assembly Systems, Fundamentals of Automated Assembly Systems, Quantitative Analysis of Assembly Systems - Parts Delivery System at Work Stations, Multi- Station Assembly Machines, Single Station Assembly Machines.

Suggested Readings:

1. Automation, Production Systems and Computer-Integrated Manufacturing - Mikell P. Groover, Fourth Edition, Pearson.

Reference Books:

1. CAD CAM: Principles, Practice, and Manufacturing Management - Chris Mc Mohan, Jimmie Browne, Pearson edu. (LPE)
2. Automation - Buckinghsm W, Haper& Row Publishers, New York, 1961
3. Automation for Productivity - Luke H.D, John Wiley & Sons, New York, 1972

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M.Tech. in Mechatronics
II Semester Syllabus
Professional Elective-IV
MT215PE: Nano Technology

Course Objectives

- Make the students understand the importance of Nanostructured materials
- Study various Nano defects, composition, properties and applications
- Understand the principles, process steps and system components of the various Lithographic techniques
- Make them understand the fabrication of Nano structures , Nano material synthesis and related techniques
- Enable them to understand various Nanostructure characterization techniques

Course Outcomes

- Understand the evolution of Nano systems, and various fabrication Techniques
- Learn about Nano-materials and various Nano-measurements techniques.
- Acquire fabrication techniques of Nano structures and properties of thin films
- Obtain the knowledge on synthesis of Nano materials and synthesise Nano materials using different methods
- Acquire the techniques related to characterization and application of various carbon based Nano materials

Unit – I

Over View of Nano technology: Definition – historical development – properties, design and fabrication Nano systems, working principle, applications and advantages of nano-system. Nano-materials – ordered oxides – Nano arrays– potential health effects

Unit – II

Nano defects, Nano Particles and Nano layers: Nano defects in crystals – applications – Nuclear Track nano-defects. Fabrication of nano-particles – LASER ablation – sol gels – precipitation of quantum dots. Nano layers – PVD, CVD, Epitaxy and ion implantation – formation of Silicon oxide-chemical composition – doping properties– optical properties

Unit – III

Nano structuring: Nano photo lithography – introduction – techniques – optical – electron beam – ion beam – X-ray and Synchrotron – nano lithography for microelectronic industry – nano polishing of Diamond – Etching of Nano structures – Nano imprinting technology – Focused ion beams – LASER interference Lithography nano arrays – Near - Field Optics - case studies and Trends

Unit – IV

Science and Synthesis of Nano Materials: Classification of nano-structures – Effects of nano-scale dimensions on various properties – structural, thermal, chemical, magnetic, optical and electronic properties fluid dynamics – Effect of nano-scale dimensions on mechanical properties - vibration, bending, fracture Nanoparticles, Sol-Gel Synthesis, Inert Gas Condensation, High energy Ball Milling, Plasma Synthesis, Electro deposition and other techniques. Synthesis of Carbon nanotubes – Solid carbon source based production techniques – Gaseous carbon source based production techniques – Diamond like carbon coating. Top down and bottom up processes

Unit – V

Characterization of Nano Materials: Nano – processing systems – Nano measuring systems – characterization – analytical imaging techniques – microscopy techniques, electron microscopy scanning electron microscopy, confocal LASER scanning microscopy – transmission electron microscopy, transmission electron microscopy, scanning tunneling microscopy, atomic force microscopy, diffraction techniques – spectroscopy techniques – Raman spectroscopy, 3D surface analysis– Mechanical, Magnetic and thermal properties– Nano positioning systems.

Suggested Readings:

1. Tai–RanHsu ,MEMS and Microsystems Design and Manufacture, Tata-McGrawHill,NewDelhi,2002.
2. Fahrner W.R., Nano technology and Nano electronics, Springer (India) Private Ltd., 2011.
3. Mark Madou, Fundamentals of Micro-fabrication, CRC Press, New York, 1997.
4. Norio Taniguchi, Nano Technology, Oxford University Press, New York, 2003.

Reference Books:

1. Mohamed Gad-el-Hak, MEMS Handbook, CRC press, 2006, ISBN: 8493-9138-5.
2. Aqar Ahmed and Mark J.Jackson, Emerging Nanotechnologies for Manufacturing, ElsevierInc.,2013, ISBN:978-93-82291-39-8 29.
3. Sami Franssila, Introduction to Micro-fabrication, John Wiley & sons Ltd, 2004. ISBN:470-85106-6.
4. Charles PPoole, Frank JOwens, Introduction to Nanotechnology, John Wiley and Sons, 2003.
5. Julian W.Hardner Micro Sensors, Principles and Applications, CRCPress1993.

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M.Tech. in Mechatronics
II Semester Syllabus
Professional Elective-IV
MT216PE: Design for Manufacturing and Assembly

Course Objectives

- Understand various general design rules for manufacturability and criteria for material selection.
- Differentiate various machining process and tolerance aspects in machining.
- Estimate the design considerations for casting and welding process.
- Understand the conceptual design factors to be considered in forging, extrusion and sheet metal work.
- Identify various assembly transfer systems, general design guidelines for manual assembly and development of DFA Methodology.

Course Outcomes

- Design philosophy and various principles of design for manufacturability and economical Production, Role of materials in design and selection criteria.
- Consider design Factors for casting, machining and economic production.
- Design of welding joints, Principles of forging and design guide lines for sheet metal Forming.
- Impart methodology of DFA and automatic assembly transfer systems.
- Decide the geometric code for any part for assembly process using data charts, Estimating the handling time, insertion time and principles of chamfer design

Unit-I

Introduction: Design philosophy steps in Design process - General Design rules for manufacturability - basic principles of designing for economical production. Materials: Selection of Materials for design Developments in Material technology - criteria for material selection – Material and process selection charts.

Unit-II

Machining Process: Overview of various machining processes - general design rules for machining - Dimensional tolerance, Design for machining - Ease - Redesigning of components for machining ease with suitable examples.
Metal Casting: Appraisal of various casting processes, selection of casting process,- general design considerations for casting - casting tolerances - use of solidification simulation in casting design.

Unit-III

Metal Joining: Appraisal of various welding processes, Factors in design of weldments - general design guidelines for welding, effects of thermal stresses in weld joints, design of brazed joints. Forging - Design factors for Forging - Closed dies forging design Extrusion & Sheet Metal Work: Design guidelines for extruded sections - design principles for Punching, Blanking, Deep Drawing - Keeler Goodman Forming Line Diagram.

Unit-IV

Assemble Advantages: Development of the assemble process, choice of assemble method assemble advantages social effects of automation.
Automatic Assembly Transfer Systems: Continuous transfer, intermittent transfer, indexing mechanisms, and operator - paced free – transfer machine.

Unit-V

Design of Manual Assembly: Design for assembly fits in the design process, general design guidelines for manual assembly, development of the systematic DFA methodology, assembly efficiency, classification system for manual handling, classification system for manual insertion and fastening, effect of part symmetry on handling time, effect of part thickness and size on handling time, effect of weight on handling time, estimation of insertion time.

Suggested Readings:

1. Assembly Automation and Product Design/ Geoffrey Boothroyd/ Marcel Dekker Inc., NY, 1992.
2. Engineering Design - Material & Processing Approach/ George E. Deiter/McGraw Hill Intl. 2nd Ed. 2000.
3. Hand Book of Product Design/ Geoffrey Boothroyd/ Marcel and Dekken, N.Y. 1990.

Reference Books:

1. Computer Aided Assembly London/ A Delbainbre/.
2. Product Design for Manufacturing and Assembly/ Geoffrey Boothroyd, Peter Dewhurst &Winston Ansthony Knight/CRC Press/2010
3. Manufacturing Technology, P.N.Rao.

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M.Tech. in Mechatronics

II Semester Syllabus

Audit Course – II

AC201HS: Disaster Management

Course Objectives

- Learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.
- Critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
- Develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
- Critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in
- Provide knowledge about different disasters tools to handle disasters, methods for disaster management

Course Outcomes

- Understanding disasters, manmade hazards & vulnerabilities
- Understanding disaster management mechanism
- Understanding capacity building
- Understanding concepts
- Understanding planning of disaster management

Unit-I: Introduction & Disaster Prone Areas in India

Disaster: Definition, Factors and Significance; Difference between Hazard and Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude. Study of Seismic Zones; Areas prone to Floods and Droughts, Landslides and Avalanches; Areas prone to Cyclonic and Coastal Hazards with special reference to Tsunami; Post-Disaster Diseases and Epidemics

Unit-II: Repercussions of Disasters and Hazards

Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts and Famines, Landslides and Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks and Spills, Outbreaks of Disease and Epidemics, War and Conflicts.

Unit-III: Disaster Preparedness and Management

Preparedness: Monitoring of Phenomena triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological and other Agencies, Media Reports: Governmental and Community preparedness.

Unit-IV: Risk Assessment

Disaster Risk- Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment: Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival.

Unit-V: Disaster Mitigation

Meaning, Concept and Strategies of Disaster Mitigation, Emerging Trends in Mitigation. Structural Mitigation and Non-Structural Mitigation, Programs of Disaster Mitigation in India.

Suggested Readings:

1. Nishith R., Singh A K, "Disaster Management in India: Perspectives, issues and strategies "'New Royal book Company.
2. Sahni, Pardeep et. al.," Disaster Mitigation Experiences and Reflections", Prentice Hall of India, New Delhi.
3. Manual on Disaster Management, National Disaster Management, Agency Govt of India.

Reference Books:

1. Goel S.L., Disaster Administration and Management Text and Case Studies", Deep Publication Pvt. Ltd., New Delhi.
2. Pandharinath N., Rajan CK, Earth and Atmospheric Disasters Management BS Publications 2009.
3. National Disaster Management Plan, Ministry of Home affairs, Government of India (http://www.ndma.gov.in/images/policyplan/dmplan/draftndmp.pdf).

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M.Tech. in Mechatronics
II Semester Syllabus
Audit Course – II
AC202HS: Value Education

Course Objectives

- Understand value of education and self-development
- Imbibe good values in students
- Let the should know about the importance of character

Course Outcomes

- Knowledge of self-development
- Learn the importance of Human values
- Developing the overall personality

Unit-I
Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism. Moral and non-moral valuation. Standards and principles. Value judgements

Unit-II
Importance of cultivation of values. Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness. Honesty, Humanity. Power of faith, National Unity. Patriotism. Love for nature, Discipline.

Unit-III
Personality and Behavior Development -Soul and Scientific attitude. Positive Thinking. Integrity and discipline, Punctuality, Love and Kindness.

Unit-IV
Avoid fault Thinking. Free from anger, Dignity of labour. Universal brotherhood and religious tolerance. True friendship. Happiness Vs suffering, love for truth. Aware of self-destructive habits. Association and Cooperation. Doing best for saving nature.

Unit-V
Character and Competence –Holy books vs Blind faith. Self-management and Good health. Science of reincarnation, Equality, Nonviolence, Humility, Role of Women. All religions and same message. Mind your Mind, Self-control. Honesty, Studying effectively.

Suggested Readings:
1. Chakroborty, S.K. “Values and Ethics for organizations Theory and practice”, Oxford University Press, New Delhi.

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M.Tech. in Mechatronics

II Semester Syllabus

Audit Course – II

AC203HS: Pedagogy Studies

Course Objectives

- Review existing evidence on the review topic to inform programme design and policy making undertaken by the DfID, other agencies and researchers.
- Identify critical evidence gaps to guide the development.

Course Outcomes

- What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?
- What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
- How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

Unit-I

Introduction and Methodology: Aims and rationale, Policy background, Conceptual framework and terminology, Theories of learning, Curriculum, Teacher education. Conceptual framework, Research questions. Overview of methodology and Searching.

Unit-II

Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries. Curriculum, Teacher education.

Unit-III

Evidence on the effectiveness of pedagogical practices, Methodology for the indepth stage: quality assessment of included studies. How can teacher education (curriculum and practicum) and the scho curriculum and guidance materials best support effective pedagogy? Theory of change. Strength and nature of the body of evidence for effective pedagogical practices. Pedagogic theory and pedagogical approaches. Teachers' attitudes and beliefs and Pedagogic strategies.

Unit-IV

Professional development: alignment with classroom practices and follow-up support, Peer support, Support from the head teacher and the community. Curriculum and assessment, Barriers to learning: limited resources and large class sizes.

Unit-V

Research gaps and future directions: Research design, Contexts, Pedagogy, Teacher education, Curriculum and assessment, Dissemination and research impact.

Suggested Readings:

1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2): 245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361-379.
3. Alexander RJ (2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.
4. Chavan M (2003) Read India: A mass scale, rapid, 'learning to read' campaign.

Reference Books:

1. Akyeampong K (2003) Teacher training in Ghana -does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.
2. Akyeampong K, Lussier K, Pryor J, WestbrookJ (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272–282.
3. www.pratham.org/images/resource%20working%20paper%202.pdf.

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M.Tech. in Mechatronics
II Semester Syllabus
Audit Course-II
AC204HS: Personality Development Through Life Enlightenment Skills

Course Objectives

- To learn to achieve the highest goal happily
- To become a person with stable mind, pleasing personality and determination
- To awaken wisdom in students

Course Outcomes

- Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life
- The person who has studied Geeta will lead the nation and mankind to peace and prosperity
- Study of Neetishatakam will help in developing versatile personality of students

Unit-I

Neetisatakam-Holistic development of personality

- Verses-19, 20, 21, 22 (wisdom)
- Verses-29, 31, 32 (pride & heroism)
- Verses-26, 28, 63, 65 (virtue)

Unit-II

Neetisatakam-Holistic development of personality

- Verses-52, 53, 59 (dont's)
- Verses-71, 73,75,78 (do's)

Unit-III

Approach to day to day work and duties.

- Shrimad Bhagwad Geeta: Chapter 2-Verses 41, 47, 48,
- Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5, 13, 17, 23, 35,
- Chapter 18-Verses 45, 46, 48.

Unit-IV

Statements of basic knowledge.

- Shrimad Bhagwad Geeta: Chapter2-Verses 56, 62, 68
- Chapter 12 -Verses 13, 14, 15, 16, 17, 18
- Personality of Role model. Shrimad Bhagwad Geeta:

Unit-V

- Chapter2-Verses 17, Chapter 3-Verses 36, 37, 42,
- Chapter 4-Verses 18, 38, 39
- Chapter18 –Verses 37, 38, 63

Suggested Readings:

1. "Srimad Bhagavad Gita" by Swami Swarupananda Advaita Ashram (Publication Department), Kolkata.
2. Bhartrihari's Three Satakam (Niti-sringar-vairagya) by P.Gopinath, Rashtriya Sanskrit Sansthanam, New Delhi.

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M.Tech. in Mechatronics
II Semester Syllabus
MT251PC: CNC Lab

Course Objectives

- Familiarize various components of CNC Machine and its working.
- Write programming and understand techniques for NC part programming.
- Understand different tooling systems for CNC based on application
- Learn the usage of CAM Software and interface with CNC Machines.
- Understand various types of post processors.

Course Outcomes

- Familiarize the components CNC machines and its constructional features.
- Execute Part Programming and understand its Techniques.
- Select proper Tooling systems to automate processes in CNC
- Using CAM Software and interfacing with CNC machines for various operations.
- Attain Postprocessor significance and its functions.

List of Experiments

Do Any TEN of the following Experiments

1. Study and operation of CNC lathe machine.
2. Study and operation of CNC milling machine.
3. Preparation of testing of typical part programs on CNC Lathe machine.
4. Preparation of testing of typical part programs on CNC milling machine.
5. Exercises using CAM software.
6. Training on Desktop Tutors.
7. Part program generation through G and M codes for Turning, Boring, Drilling, Reaming and Milling.
8. Development of tool path simulation by setting tool offsets for multi-operations.
9. Study of various cutting tools used in CNC Machines such as twist drill, End Mill Cutter, Ball nose cutter and other Standard tooling.
10. Machining of various Components by generation of CNC code by using CAM Software.
11. Interfacing the CNC Codes to the CNC Lathe and CNC Mill.
12. Study and Operation of NC simulator for CNC Machining Operations

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M.Tech. in Mechatronics
II Semester Syllabus
MT252PC: Robotics lab

Course Objectives

- Identifying various Robotic components and programming
- Understand Robot specification.
- Interfacing PLC to get desired output
- Programming of PLC system taking into consideration of motor, fan by using different logic conditions like switch relay ,latch, unlatch, on delay timer ,off delay timer, AND gate, OR gate, NAND gate, NOR gate and EXOR gate

Course Outcomes

- Distinguishing various movements of robotic manipulator through links, joints and end-effectors
- Provide Robot specifications based on degrees of freedom and actuation
- Attain desired results by setting up PLC, interfacing parameters
- Programming of PLC system by consideration of motor ,fan, LED by using different logic conditions like switch relay, unlatch ,on delay timer, off delay timer ,AND gate, NAND gate, NOR gate and EXOR gate.

List of Experiments:

Note: Conduct 10 experiments of the following

1. Study of Robot and its components
2. Robot Programming .
3. Determination of Robot specifications.
4. Study of Programmable Logic Controller setup with software.
5. PLC Programming for operation of motor with fan using different logic condition switch relay timers.
6. PLC Programming for operation of buzzer using different logic conditions using latch and unlatch.
7. PLC Programming for operation of indicator lamp and LED lights using different logic conditions with ON Delay Timer and OFF Delay Timer.
8. PLC Programming using AND gate using different input and output devices.
9. PLC Programming using OR gate using different input and output devices.
10. PLC Programming using NAND gate using different input and output devices.
11. PLC Programming using NOR gate using different input and output devices.
12. PLC Programming using EXOR gate using different input and output devices.

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M.Tech. in Mechatronics
II Semester Syllabus
MA252BS: Finishing School-II
(Common to all Branches)

Course Objectives

This is a foundation course and aims to enhance employability skills in students.

- Students will be introduced to higher order thinking skills and problem-solving on the following areas - Arithmetic ability, Numerical ability and General reasoning.
- Students will be trained to work systematically with speed and accuracy while solving problems.

Course Outcomes

- Solve questions on the above-mentioned areas using shortcut and smart methods
- Understand the fundamental concepts of Aptitude skills
- Perform calculations with speed and accuracy.

Unit-I: Quantitative Aptitude - Numerical Ability

- Number systems
- LCM & HCF
- Speed Math
- Divisibility Rules
- Square root
- Cube root
- Problems on numbers with shortcuts

Unit -II: Quantitative Aptitude- Arithmetic Ability-I

- Percentage
- Profit loss and discounts
- Simple and Compound interest
- Ratio proportions
- Averages

Unit-III: Quantitative Aptitude- Arithmetic Ability-II

- Pipes and Cisterns
- Ages
- Time-Speed-Distance
- Clocks & Calendars
- Venn diagrams
- Tables and graphs

Unit-IV: Reasoning Ability – General Reasoning-I

- Coding decoding
- Directions
- Series completions - Letter, Number & Element Series
- Seating arrangements
- Odd one out
- Spatial ability questions

Unit-V: Reasoning Ability- General Reasoning -II

- Analogies
- Alphabet Analogy
- Numerical Analogy
- Classification
- Alphabet Classification
- Word Classification
- Miscellaneous Classification
- Alphabet test
- Arranging words in Alphabetical Order
- Problems based on Letter-Word
- Problems based on Alphabetical Quibble
- Blood Relations
- Statements and conclusions
- Direction Sense test

Reference Books:

1. R.S. Aggarwal - Quantitative Aptitude for Competitive Examinations.
2. Arun Sharma - Quantitative Aptitude for CAT.
3. Arihant Publications - Fast Track Objective Arithmetic.
4. Sarvesh K.-Quantitative aptitude
5. A New Approach to Reasoning Verbal & Non-Verbal, Book by B.S. Sijwalii and Indu Sijwali
6. A Modern Approach to Logical Reasoning, Book by Agarwala Vikas and R.S. Aggarwal.

III Semester

S. No.	Course Code	Course Title	Instruction Hours Per Week			Examination Max. Marks		Duration of SEE in Hours	Credits
			L	T	P/D	CIE	SEE		
1	MT31XPE	Professional Elective-V	3	0	0	30	70	3	3
2		Open Elective	3	0	0	30	70	3	3
3	MT351PC	Dissertation I	0	0	20	50+ 50	-	-	10
Total Hours/Marks/Credits			**6**	**0**	**20**	**160**	**140**		**16**

IV Semester

S.No.	Course Code	Course Title	Instruction Hours Per Week			Examination Max. Marks		Duration of SEE in Hours	Credits
			L	T	P	CIE	SEE		
1	MT451PC	Dissertation -II	0	0	32	50+ 50	--	-	16
		VIVA VOCE				--	100	-	
Total Hours/Marks/Credits			**0**	**0**	**32**	**100**	**100**		**16**

L: Lecture **T**: Tutorial **D**: Drawing **P**: Practical **CIE** - Continuous Internal Evaluation **SEE** - Semester End Examination

Professional Elective-V

MT311PE: Intelligent Manufacturing System
MT312PE: Autotronics and Vehicle Intelligence
CS313PE: Artificial Intelligence

List of Open Electives Offered by Mechatronics Department to Other Branches

MT321OE: Entrepreneurship
MT322OE: Optimization Techniques & Applications
MT323OE: Advanced Finite Element and Boundary Element Methods

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3	0	0	3

M.Tech. in Mechatronics
III Semester Syllabus
Professional Elective-V
MT311PE: Intelligent Manufacturing Systems

Course Objectives

- Understand the advanced manufacturing systems and their integration through computers and communication between the various systems.
- Learn about the knowledge base systems and their utilization.
- Understand the importance of artificial intelligence and machine learning in integrating the manufacturing systems.
- Explain process planning using the knowledge base systems.
- Learn to design a manufacturing cell in automated manufacturing system.

Course Outcomes

- Describe various components of Computer Integrated Manufacturing Systems
- Design the basic communication systems adopting various approaches.
- Formulate and solve typical problems involving the artificial intelligent aspects of the manufacturing systems.
- Formulate the process planning steps using knowledge base systems.
- Able to use various group technology approaches for designing a machine cell.

Unit – I

Computer Integrated Manufacturing Systems – Structure and functional areas of CIM system - CAD, CAPP, CAM, CAQC, ASRS. Advantages of CIM. Manufacturing Communication Systems – MAP/TOP, OSI Model, Data Redundancy, Top-down and Bottom - up Approach, Volume of Information. Intelligent Manufacturing – System Components, System Architecture and Data Flow, System Operation.

Unit – II

Components of Knowledge Based Systems – Basic Components of Knowledge Based Systems, Knowledge Representation, Comparison of Knowledge Representation Schemes, Interference Engine, Knowledge Acquisition.

Unit – III

Machine Learning – Concept of Artificial Intelligence, Conceptual Learning, Artificial Neural Networks - Biological Neuron, Artificial Neuron, Types of Neural Networks, Applications in Manufacturing

Unit – IV

Automated Process Planning – Variant Approach, Generative Approach, Expert Systems for Process Planning, Feature Recognition, Phases of Process planning. Knowledge Based System for Equipment Selection (KBSES) – Manufacturing system design, Equipment Selection Problem, Modeling the Manufacturing Equipment Selection Problem, Problem Solving approach in KBSES, Structure of the KBSES.

Unit – V

Group Technology: Models and Algorithms – Visual Method, Coding Method, Cluster Analysis Method, Matrix Formation – Similarity Coefficient Method, Sorting-based Algorithms, Bond Energy Algorithm, Cost Based method, Cluster Identification Method, Extended CI Method. Knowledge Based Group Technology - Group

Technology in Automated Manufacturing System, Structure of Knowledge based system for group technology (KBSGT) – Data Base, Knowledge Base, Clustering Algorithm.

Suggested Readings:

1. Intelligent Manufacturing Systems/ Andrew Kusiak/Prentice Hall.
2. Artificial Neural Networks/ Yagna Narayana/PHI/2006
3. Automation, Production Systems and Computer-Integrated Manufacturing /Mikell P. Groover/Fourth Edition, Pearson.

Reference Books:

1. Neural networks: A comprehensive foundation/ Simon Haykin/ PHI.
2. Artificial neural networks/ B. Vegnanarayana/PHI
3. Neural networks in Computer intelligence/ Li Min Fu/ TMH/2003
4. Neural networks/ James A Freeman David M S kapura/ Pearson education/2004
5. Introduction to Artificial Neural Systems/Jacek M. Zurada/JAICO Publishing House Ed. 2006.

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M.Tech. in Mechatronics
III Semester Syllabus
Professional Elective-V
MT312PE: Autotronics & Vehicle Intelligence

Prerequisites: Basic knowledge in sensor technology, IC engines and image processing.

Course Objectives

- Understand the basic automobile components.
- Learn about the different sensors used in automobiles.
- Introduce different fuel injection systems used in vehicles.
- Understand about the technologies used in electric and hybrid vehicles.
- Broaden the importance of vehicle intelligence system.

Course Outcomes

- Learn the synchronization among various components of automobiles.
- Analyze various electronics systems viz. sensors.
- Helps in understanding various mechanisms of fuel injection systems.
- Improvement in the efficient use of various automobile technologies.
- Design intelligence vehicle systems.

Unit – I
Automotive fundamentals: The engine components drive train starting & charging systems operation ignition system, suspension systems, brakes, ABS steering systems.

Unit – II
Automotive Sensors: Temperature sensor, gas sensor, knock sensor, pressure sensor, flow sensor, torque sensor, crash sensor, speed sensor and acceleration sensor, micro sensor, smart sensor, operation, types, characteristics, advantage and their applications.

Unit – III
Fuel injection and Ignition system: Introduction, fuel system components, electronic fuel system, fuel injection, types, throttle body versus port injection, electronic control fuel injection, operation, different types, fuel injectors, idle speed control, continuous injection system, high pressure diesel fuel injection, MPFI system, electronic ignition system, operation, types, electronic spark timing control.

Unit – IV
Electrical Vehicles and Hybrid Vehicles: Introduction, electric vehicle development, system layout, basic system components, electric battery solar cells, rapid charging system, motor drive system, fuel cell electric vehicle, hybrid vehicle, series hybrid vehicle, parallel hybrid vehicle, CNG electric hybrid vehicle.

Unit – V
Vehicle Intelligence: Introduction, based structure, vision based autonomous road vehicles, architecture for dynamics vision system, features, applications, a visual control system using image processing and fuzzy theory, an

application of mobile robot vision to a vehicle information system, objective detection, collision warning and avoidance system, low type pressure warming systems.

Suggested Readings:

1. Understanding automotive electronics, William B Ribben, 8th Edition Elsevier science,.

Reference Books:

1. Sensor and Transducers, Ronald k jurgen, SAE-2003.
2. Automotive technology by jack Erjavec, Robert Scharff Delmar Publications, Inc 1992.

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M.Tech. in Mechatronics
III Semester Syllabus
Professional Elective-V
MT313PE: Artificial Intelligence

Pre-Requisites: UG level course in Mathematics, Data Structures

Course Objectives

- To train the students to understand different types of AI agents, various AI search Algorithms.
- To give understanding of fundamentals of knowledge representation.
- To train the students to understand different Machine Learning Algorithms.
- Learn the concepts of supervised and unsupervised learning
- Provide introduction to Expert systems and phases involved in building Expert systems

Course Outcomes

After completion of course, students would be able to:

- Solve basic AI based problems
- Apply AI techniques to real-world problems to develop Knowledge representation models
- Apply Machine learning Algorithms to real world problems and develop models.
- Build models and apply suitable methods to assist supervised and unsupervised learning

Unit – I

Introduction: Overview of AI problems: Definition, Foundations, And Applications.
AI Agents: agents, Agent Environments, Structure of Agents, and Types of Agents Problem Solving Agents: Problem spaces, states, goals and operators.
Uninformed Searches: Breadth-First, BFS Algorithm, Traversing, and Complexity Study Uniform cost Search: Algorithm, Traversing, and Complexity Study. Depth-First Search: Algorithm, Traversing, Complexity Study. Depth-first with Iterative Deepening: Algorithm, Traversing, Complexity Study.
Heuristic Search, Hill Climbing: Algorithm, Traversing, Complexity Study, Generic Best-First: Algorithm, Traversing, Complexity Study. **A***: Algorithm, Traversing, Complexity Study.

Unit – II

Constraint Satisfaction Problems: Definition, Crypt-Arithmetic Problems, Map Coloring, Backtracking. **Game Playing:** Adversarial Searches. Two player games. Min-max Search: Algorithm, Problems. Draw Back of Min-Max Algorithm. Alpha-beta pruning: Algorithm, Problems.
Knowledge representation and reasoning: Propositional Logic: Basics of logic, truth tables and sentence conversions. First order logic: Difference between Proposition & First order logic. Conjunctive Normal form. Disjunctive Normal Form. Conversion of English sentences into First order logic. Resolution and theorem proving. Problems of Resolution. Forward Chaining: Definition, Example problems. Backward Chaining: Definition, Example problems

Unit – III

Probabilistic reasoning: Basics of probability: Probability, Joint & Conditional Probability. Bayes theorem. Representing Knowledge in an Uncertain Domain: Bayesian Networks.
Advanced Knowledge Representation: Semantic Nets: Definition, Examples. Extended Semantic Nets: Inference rules in ESNet. Semantic Frames: .Description, inheritance. Monotonic & Non-Monotonic reasoning.

Unit – IV

Introduction Machine learning, Types of machine learning: Supervised, Unsupervised, Semi-supervised learning.

Supervised learning: Linear Regression, Building Regression Model, Ordinary least square method. Decision Trees: Algorithm, Building Decision Tress, Information Gain.

Unsupervised learning: Types of Data: Binary, Interval Scaled, Categorical, and Ordinal. Partitioning Methods: K-Means Clustering. Hierarchical Clustering: Agglomerative Nesting, Divisive Analysis.

Unit – V

Introduction to Expert Systems: Def Expert Systems, Knowledge Engineering. Phases in Building Expert Systems. Expert System Architecture, Expert System Shell, Applications of Expert Systems.

Suggested Readings:

1. Artificial Intelligence: A Modern Approach by S. Russell and P. Norvig, Prentice Hall
2. Introduction to Artificial Intelligence and Expert Systems by Dan W. Patterson, Pearson Education
3. Tom Michel, Machine Learning, McGrawHill,1997

Reference Books:

1. Artificial Intelligence by Elaine Rich, Kevin Knight and Shiva Shankar B Nair, Tata Mc Graw Hill.
2. Machine Learning: An Algorithmic Perspective, Stephen Marshland, Taylor & Francis.

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M.Tech. in Mechatronics
III Semester Syllabus
Open Elective
MT321OE: Entrepreneurship

Course Objectives

- To understand concept of entrepreneurship & types of business enterprises.
- To understand SWOT analysis and feasibility study.
- Insights into Sources of finances and government grants and subsidies for entrepreneurs.
- To know the various Entrepreneurial strategies.
- To create awareness on women entrepreneurship and EDP's.

Course Outcomes

- To assess the commercial viability of a new technology- based idea. The candidate can use various methods and tools for this purpose.
- To transform research-based ideas into feasibility and business plans. The candidate can use (tacit and explicit) method sand tools for this purpose.
- To present new ideas to the market.
- To assess the need for innovation, initiate the process and run innovations in organizations.
- To seize opportunities, organize and finance viable initiatives through to fruition.

Unit-I

Nature of Entrepreneurship: Essential features, attitude and leadership of entrepreneur characteristics, qualities and skills, functions of entrepreneur, entrepreneur scenario in Indian economy, types of ownership, sole trading, partnership, joint stock company, important features of various types of businesses, corporate entrepreneurship, entrepreneurship, role of government in the promotion of entrepreneur, state enterprises in India.

Unit-II

Aspects of Promotion: Opportunity analysis, SWOT analysis, internal and external environment analysis, technological competitiveness, entrepreneurs and legal regulatory systems, patents and trademarks, intellectual property rights, project planning. Feasibility studies: The concept of project, project life cycle, project planning, feasibility, SWOT analysis, product and process development, major steps in product development.

Unit-III

Financial Aspect of the Entrepreneurship: Source of capital, debit equity financing commercial banks, bank loans, assessment of benefits and costs, informal agencies in financing entrepreneurs, government grants and subsidies, types of investors and private offerings.

Unit-IV

Entrepreneurial Strategy: Generation of new entry opportunity, decisions under uncertainty, entry strategy, new entry exploitation, environmental instability and first mover disadvantages, risk reduction strategies, market scope strategy, imitation strategies and managing newness.

Unit-V

Women Entrepreneurship: Introduction, the dynamic need, entrepreneurship in a developing economy, the scope of entrepreneurship among women, promotional efforts supporting women entrepreneurs in India, issues of

employment generation, rural entrepreneurship and EDPs: Need, rural industrialization, NGOs and rural entrepreneurship, need for EDPs, objectives of EDPs course contents and curriculum of EDPs, Phases of EDPs & evaluation of EDPs.

Reference Books:

1. Madhurimalali, Shikhasahai, entrepreneurship, Excel books, first edition, New Delhi, 2006.
2. Nandan H, fundamentals of entrepreneurship, PHI New Delhi, 2009.

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M.Tech. in Mechatronics
III Semester Syllabus
Open Elective
MT322OE: Optimization Techniques & Applications

Course Objectives

- Numerical optimization techniques for single variable and multi variable non- linear optimization problems. And sensitivity analysis on LPP queuing
- Simulation of annexing problem & inventory problem. And geometry cutting plane method & branch bound method for linear IPP.
- Meaning of stochastic programming problem simple problems for finding mean variance of random variables chance constrained algorithm.
- Formulation of GP model and solving it using arithmetic geometric inequality theorem.
- State of art non-traditional optimization technique, namely genetic algorithm simulated annealing & particle swarm optimization.

Course Outcomes

- Apply appropriate optimization techniques and solve optimization problem like single variable or multivariable. And make sensitivity analysis to study effect of changes in parameters of LPP on the optimal solution without reworking.
- Simulate the system to estimate specified performance measures. And solve integer programming problem by either geometry cutting plane algorithm or branch band method.
- Apply chance constrained algorithm and solve stochastic linear programme.
- Formulate GP model and solve it.
- Solve given optimization problem by genetic algorithm or simulated annealing or PSO.

Unit – I
Single Variable Non-Linear Unconstrained Optimization
Elimination methods: Uni-Model function- its importance, Fibonacci method & Golden section method. Interpolation methods: Quadratic & Cubic interpolation methods.

Unit – II
Multi variable non-linear unconstrained optimization
Direct search methods — Univariant method, Pattern search methods — Powell's, Hook -Jeeves, Rosenbrock search methods. Gradient methods: Gradient of function& its importance, Steepest descent method, Conjugate direction methods: Fletcher- Reeves method & variable metric method.

Unit – III
Linear Programming
Formulation, Simplex method & artificial variable optimization techniques: Big M & Two-phase methods. Sensitivity analysis: Changes in the objective coefficients, constants& coefficients of the constraints. Addition of variables, constraints. Simulation — Introduction — Types- steps — applications: inventory & queuing — Advantages and disadvantages.

Unit – IV
Integer and Stochastic Programming
Introduction to Integer Programming — formulation — Geometry cutting plane algorithm — Zero or one algorithm, branch and bound method
Basic concepts of probability theory, random variables- distributions-mean, variance, correlation, co variance, joint probability distribution. Stochastic linear programming: Chance constrained algorithm.

Unit – V

Geometric Programming and Non-Traditional Optimization Algorithms

Posynomials — Arithmetic - Geometric inequality — unconstrained G.P- constrained G.P (type only) Genetics Algorithm - Working Principles, Similarities and Differences between Genetic Algorithm & Traditional Methods. Simulated Annealing-Working Principle- Simple Problems. Introduction to Particle Swarm Optimization (PSO) (very brief)

Suggested Readings:

1. Optimization theory & Applications by S. S. Rao, New Age International.
2. Optimization for Engineering Design by Kalyanmoy Deb, PHI

Reference Books:

1. Operations Research by S. D. Sharma
2. Operation Research by H. A. Taha, TMH
3. Optimization in operations research by R. L. Rardin
4. Optimization Techniques by Benugundu&Chandraputla, Pearson Asia.
5. Optimization Techniques theory and practice by M. C. Joshi, K. M. Moudgalya, Narosa Publications.

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M.Tech. in Mechatronics
III Semester Syllabus
Open Elective
MT323OE: Advanced Finite Element and Boundary Element Methods

Course Objectives

- Introduce the basic concepts of the finite element and the boundary element methods
- Learn the theory and characteristics of finite elements that represent various engineering structures
- Learn to apply FEM to various steady state processes and lumped heat analysis
- discuss the advantages and limitations of each method and material Nonlinearities
- Develop the knowledge and skills needed to effectively evaluate FEM analysis

Course Outcomes:

- Understand the background of mathematical equations used for development of modeling software modules to develop the various structural related applications
- Identify mathematical model for solution of common engineering problems.
- Demonstrate the capabilities of each method to solve variety of problems including 1D, 2D and lumped models
- Solve structural, thermal, fluid flow problems.
- Use professional-level finite element software to solve engineering problems in Solid mechanics, fluid mechanics and heat transfer.

Unit – I

One Dimensional Problems: Formulation of Stiffness Matrix for a Bar Element by the Principle of Minimum Potential Energy, Properties of Stiffness Matrix, Characteristics of Shape Functions, Quadratic shape functions.
Analysis of Trusses: Derivation of Stiffness Matrix for Trusses-Plane Truss and Space Truss, Stress and strain Calculations, Calculation of reaction forces and displacements.
Analysis of Beams: Derivation of Stiffness matrix for two noded, two degrees of freedom per node beam element, Load Vector, Deflection, Stresses, Shear force and Bending moment, Problems on uniform and stepped beams for different types of loads applied on beams.

Unit – II

Finite element – formulation of 2D Problems: Derivation of Element stiffness matrix for two-dimensional CST Element, Derivation of shape functions for CST Element, Elasticity Equations, constitutive matrix formulation, Formulation of Gradient matrix. Two dimensional Iso-parametric Elements and Numerical integration. Finite element – formulation of 3D problems: Derivation of Element stiffness matrix for Tetrahedron Element, Properties of Shape functions for 3D Tetrahedral Element, Stress-Strain Analysis for 3D Element, Strain Displacement for Relationship Formulation.

Unit – III

Steady state heat transfer analysis: One Dimensional Finite Element analysis of fin and composite slabs. Two-dimensional steady state heat transfer problems: Derivation of Thermal Stiffness matrix for 2D heat transfer problems-CST, Derivation of thermal force vector for 2D heat transfer problems. Dynamic Analysis: Formulation of mass matrices for uniform bar and beam Elements using lumped and consistent mass methods, Evaluation of Eigen values and Eigen vectors for a stepped bar and beam Problems.

Unit – IV

Plate Bending: Introduction – Plate behavior – C1 (Kirchoff's) Plate elements – C0 (Mindlin) Plate elements – Mindlin beam – More devices for C0 Plate elements – Boundary conditions - Analytical problems. Nonlinear finite

element of solids: Material Nonlinearities, objective rates, nonlinear elasticity, Plasticity, visco-plasticity, viscoelasticity

Unit – V

Boundary Element Method: Potential Problems: Introduction, boundary Element Approach Fundamental solution. Numerical Implementation - Determination of Ci, Final Relation, Three dimensional analysis, tackling kernel singularity. Boundary Element Formulation for Electrostatic Problems: Introduction, Basic Relation- Boundary condition, other relations. Discretization and Matrix Formulation – Determination of term C(p)m.

Suggested Readings:

1. Finite and Boundary Element Methods in Engineering by O.P. Gupta, Oxford & IBH Publishing Co. Pvt. Ltd
2. The finite element methods in Engineering by S.S. Rao, Elsevier, 4th edition

Reference Books:

1. Finite Element Methods by Alavala, PHI.
2. Introduction to Finite Elements in Engineering by Tirupathi K. Chandrupatla and Ashok D. Belagundu.
3. An Introduction to Finite Element Methods by J. N. Reddy, Mc Graw hill
4. The Finite element method in engineering science by O.C. Zienkowitz, Mc Graw hill.
5. Concepts and Applications of Finite Element Analysis by Robert Cook, Wiley