Course Structure & Syllabus for
M. Tech. (Mechanical CAD/CAM)
(CBCS 2023 Course)
As per NEP2020 Guidelines

Semester I					**Total Duration: 24 hrs./week** **Total Marks: 500** **Total Credits: 20**				
Courses	**Teaching Scheme (Hrs.) Hrs./Week**		**Examination Scheme (Marks)**						**Credits**
	L	**P**	**Theory**	**Internal Assessment**	**TW**	**PR**	**Oral**	**Total**	
Advanced Finite Element Method	04	--	50	50	-	--	--	100	04
Computer Integrated Micromachining	04	--	50	50	-	--	--	100	04
Modeling & Simulation	04	--	50	50	--	--	--	100	04
Open Elective - I	04	--	50	50	--	--	--	100	04
Computer Aided Design Laboratory	--	04	--	--	25	--	25	50	02
Finite Element Analysis Laboratory	--	04	--	--	25	--	25	50	02
	16	**8**	**200**	**200**	**50**	**--**	**50**	**500**	**20**

Semester II					**Total Duration: 24hrs/week** **Total Marks : 500** **Total Credits: 20**				
Courses	**Teaching Scheme (Hrs.) Hrs./Week**		**Examination Scheme (Marks)**						**Credits**
	L	**P**	**Theory**	**Internal Assessment**	**TW**	**PR**	**Oral**	**Total**	
Computational Fluid Dynamics	04	--	50	50	--	--	--	100	04
Additive Manufacturing	04	--	50	50	--	--	--	100	04
Virtual Factory	04	--	50	50	--	--	--	100	04
Open Elective - II	04	--	50	50	--	--	--	100	04
Computer Aided Manufacturing Laboratory	--	04	--	--	25	--	25	50	02
Computational Fluid Dynamics Laboratory	--	04	--	--	25	--	25	50	02
Total	**16**	**8**	**200**	**200**	**50**	**--**	**50**	**500**	**20**

Semester III					**Total Duration: 08 hrs/week** **Total Marks : 250** **Total Credits: 20**				
Courses	**Teaching Scheme (Hrs) Hrs./Week**		**Examination Scheme (Marks)**						**Credits**
	L	**P**	**Theory**	**Internal Assessment**	**TW**	**PR**	**Oral**	**Total**	
Seminar	--	02	--	--	50	--	50	100	05
Dissertation Stage - I	--	06	--	--	100	--	50	150	15
Total	**--**	**08**	**--**	**--**	**150**	**--**	**100**	**250**	**20**

Semester IV					**Total Duration: 08 hrs/week** **Total Marks : 250** **Total Credits: 20**				
Courses	**Teaching Scheme (Hrs) Hrs./Week**		**Examination Scheme (Marks)**						**Credits**
	L	**P**	**Theory**	**Internal Assessment**	**TW**	**PR**	**Oral**	**Total**	
Dissertation Stage - II	--	08	--	--	150	--	100	250	20
Total	**--**	**08**	**--**	**--**	**150**	--	**100**	**250**	**20**

List of Self Learning Courses, Department Electives and Open Elective

Department Elective - I	**Department Elective - II**
1. Automatic Control system	1. Industrial Robotics & Automation
2. Research Methodology	2. Design of Experiment
3. Introduction to Internet of Things	3. Introduction to Artificial Intelligence & Machine Learning

ADVANCED FINITE ELEMENT METHOD

Teaching Scheme:	Examination Scheme:		Credits Allotted
Theory: - 04 Hours/ Week	End Semester Examination	50 Marks	04
	Total	**100 Marks**	**04**

Course Prerequisites: -

The students should have knowledge of

1. Engineering Mathematics
2. Engineering Mechanics
3. Strength of Materials
4. Numerical methods

Course Objectives: -

To provide Knowledge about

1. Develop finite element procedures for accurately investigating the problem, and effectively perform and document findings.
2. Solve 1 D, 2 D and dynamic problems using Finite Element Analysis approach

Course Outcomes: -

The students should be able to–

1. Remember the basic concepts of Solid mechanics and understand the concepts of Nodes and elements.
2. Understand the Formulation of Element Stiffness Matrix and Load Vector and apply it for 2D elements.
3. Understand the concept of Isoperimetric elements, element quality Criteria and concept free vibration to evaluate the Eigenvalues and Eigen vectors for stepped bar and beam.

Course Contents

Unit I Introduction to FEA (08 Hrs.)

Introduction to FEM, Stress strain relations, Vibrational methods of approximation-Rayleigh Ritz Method, Methods of Weighted Residuals-Least Square Method, Subdomain Method, Collocation Method, Garlekin's method Finite element modeling, Convergence of results, Potential energy approach, Global stiffness matrix, properties of stiffness matrix, load vector, Penalty approach, Elimination approach. Shape functions- linear and quadratic, Triangular, Quadrilateral, Higher order elements.

Unit II Two Dimensional Problems (10 Hrs.)

Finite Element Analysis of 2-D truss structure and Constant strain triangle. Plain Stress, Plain Strain, Types of 2D elements, Formulation of elemental stiffness matrix, and load vector for truss element, Formulation of elemental stiffness matrix and load vector for CST element. Shape function for CST.

Unit III Isoperimetric Elements (10 Hrs.)

Isoperimetric formulation – Natural Co-ordinate system, Lagrangian interpolation polynomials, Shape function using Lagrangian interpolation, Isoperimetric element, Numerical Integration Newton Cotes formula, Gauss Quadrature formula in two and three dimensions, triangular elements, rectangular elements. Sub modeling and Substructuring. Dynamic Analysis, Formulation of Dynamic problems, Consistent and Lumped Mass Matrices. Solution of Eigen Value Problems. Transformation Method, Jacobi Method, Vector Iteration Method, Subspace Iteration Method**.**

Unit IV Dynamic Analysis (10 Hrs.)

Need of dynamic analysis, Undamped free vibration, Lumped mass and Consistent Mass Matrices; Free Vibration Problems, Formulation of Eigen Value and Eigen Vector Problem by Power Method, Step wise solution of Problems on Vibration in Bar Element; FEM Formulation. Time dependent Problems. Longitudinal vibration of thin uniform beam-frequency and mode shape.

Unit V 1D Steady State Heat Transfer Problem (10 Hrs.)

Governing Differential Equation, Steady state heat transfer formulation of 1D element for conduction and convection, Boundary conditions and solving for temperature distribution, Processing steps in 1D heat transfer.

Text Books/ Reference Books

1. K. J. Bathe, "Finite Element Procedures", PHI
2. R. D. Cook, D. S. Malus, M. E. Plesha, "Concepts and Applications of Finite Element Method Analysis", John Wiley
3. J. N. Reddy, "An introduction to Finite Element Method Analysis", MGH

4. Desai & Abel, “Introduction to Finite Element Methods”
5. D. L. Logan, “A course in the Finite Element Method”, Third Edition, Thomson Learning
6. T. R. Chandrupatia, A. D. Belegundu, “Introduction to Finite Elements in Engineering”, Third Edition, PHI
7. John D. Anderson, “Computational Fluid Dynamics: The Basics with Applications”, McGraw Hill, 1995
8. Patrick Knupp and Stanly Steinberg, “Fundamentals of Grid Generation”, CRC Press, 1994
9. D. C. Wilcox, “Turbulence Modelling for CFD”, 1993
10. Pieter Wesseling, “An Introduction to Multigrid Methods”, John Wiley & Sons, 1992
11. J. F. Thompson, Z. U., A. Warsi and C. W. Mastin, “Numerical Grid Generation: Foundations and Applications”, North Holland, 1985
12. S. V. Patankar, “Numerical Heat Transfer and Fluid Flow”, McGraw-Hill,1981
13. Thomas B. Gatski, M. Yousuff Hussaini, John L. Lumley,, “Simulation and Modelling of Turbulent Flows”, Eds., Oxford University Press, 1996
14. Laney, C. B., “Computational Gas Dynamics”, Cambridge Uni. Press, 1998

COMPUTER INTEGRATED MICROMACHINING

Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: - 04 Hours/ Week	End Semester Examination	50 Marks	04
	Total	**100 Marks**	**04**

Course Prerequisites: -
The student should have knowledge of
1. Manufacturing process-I
2. Manufacturing process-II
3. Advance Manufacturing processes

Course Objectives:-
To provide Knowledge about
1. Role of computer in micromachining
2. Mathematical modelling of micromachining

Course Outcomes: -
The students should be able to–
1.Understand working principle of micromachining processes
2.Develop the mathematical equation for micromachining processes
3.Design and develop the micromachining setup

Course Contents

Unit I Introduction to Micromachining Processes **(08 Hrs.)**

Introduction, Methods of micro fabrication, Classification of micromachining and nanofinishing processes, Principal of mechanical micromachining, Ultrasonic Micromachining, Electrodischarge micromachining, Laser beam micromachining, Electrochemical Micromachining, Advance nano finishing processes, Advance abrasive finishing process with no external control of forces, Abrasive based nano-finishing processes with external control of forces

Unit II Micro Milling and Ultrasonic Machining **(10 Hrs.)**

Introduction, Micro milling mechanism and method, Micro milling machine, Micro milling cutters, Application of micro milling

Difference between USM and USMM, Basic principal, Machine tool, Basic element of USMM, Mechanism of Material Removal in USMM

Unit III Micro-electrochemical and Discharge Machining **(10 Hrs.)**

Electrochemical machining overview, Importance of EMM, Fundamentals of EMM ,Major factors of EMM, Application of EMM

Role of EDM in micromachining, Principal of Micro EDM, Micro-EDM system development, Empirical modeling of micro EDM, Analytical modeling of Micro EDM

Unit IV Abrasive Jet Micro Machining **(10 Hrs.)**

Abrasive jet micromachining system, Masking Technology, Erosion Mechanisms, Metal Mask, Elastomer Mask, Photo-resist Mask, Comparison between mask material, Surface properties, Constant power feeding, Nozzle configuration for uniform micro blasting, Microstructure fabrication by AJMM process

Unit V Micro Turning and Micro Grinding **(08 Hrs.)**

Introduction, Macro-Meso-and micro turning, Applications of Micro turning, Machines for micro turning, Mechanism of material removal in micro turning, Forces in micro turning, Surface finish in micro turning, Material for micro turning

Introduction, Type of grinding wheels, Machining and grinding comparison, Grindability, Grinding Mechanism, Micro grinding its definition and application

Reference Books

1. V.K. Jain "Introduction to Micromachining", Narosa Publishing House, 2014.
2. J.A. McGeough" Micromachining of Engineering Materials", CRC Press, November 29, 2001.

MODELING AND SIMULATION

Teaching Scheme:	Examination Scheme:		Credits Allotted
Theory: - 04 Hours/ Week	End Semester Examination	50 Marks	04
	Total	**100 Marks**	**04**

Course Prerequisites: -

The students should have knowledge of

1. Statistics

Course Objectives: -

1. Understand the broad applicability of discrete-event process simulation to industrial engineering problem.
2. Learn analytical techniques for interpreting input data and output results pertinent to simulation models**.**

Course Outcomes: -

At the end of the course, students will demonstrate the ability to:

1. Understand the steps of modeling and experimenting simulation.
2. Apply statistical knowledge and modeling techniques to construct simulation models
3. Interpret, analyze and simulation results using Simulation Programming Languages

Course Contents

Unit I Introduction (8 Hrs.)

Simulation Modeling, Why Simulate? .Types of Simulation, The Simulation Clock, Randomness in Simulation. Discrete Simulation Languages .Design Environment for Event-Driven Simulation. The Two Sides of Simulation

Unit II Probability and Statistics in Simulation (10 Hrs.)

Probability and Statistics in Simulation. Role of Probability and Statistics in Simulation. Characterization of Common Distributions in Simulation. Properties of Common Distributions. Uniform Distribution. Negative Exponential Distribution. Gamma Distribution. Normal Distribution .Lognormal Distribution. Weibull Distribution. Beta Distribution, Triangular Distribution. Poisson Distribution.

Identifying Distribution on the Basis of Historical Data Building Histograms. Goodness-of-Fit Tests. Maximum Likelihood Estimates of Distribution Parameters.

Unit III Elements of Discrete Simulation (10 Hrs.)

Elements of Discrete Simulation, Concept of Events in Simulation. Common Simulation Approaches. Event-Scheduling Approach, Activity-Scanning Approach, Process-Simulation Approach.

Computations of Random Deviates, Inverse Method, Convolution Method. Acceptance–Rejection Method, Other Sampling Methods ,Generation of (0, 1) Random Numbers, Collecting Data in Simulation, Types of Statistical Variables ,Histograms ,Queue and Facility Statistics in Simulation, Queue Statistics ,Facility Statistics .

Unit IV Gathering Statistical Observations in Simulation (10 Hrs.)

Introduction, Peculiarities of the Simulation Experiment, Issue of Independence, Issue of Stationary (Transient and Steady-State Conditions), Issue of Normality. Peculiarities of the Simulation Experiment Normality and Independence, Transient Conditions ,Gathering Simulation Observations

Subinterval Method, Replication Method, Regenerative Method and Variance Reduction.

Unit V Simulation Applications (10 Hrs.)

Materials-Handling Models :Introduction, Transporter Car, Overhead Crane, Conveyor, Belt Conveyor

Inventory Control Models: Introduction, Discount Store Model, Periodic Review Model, Continuous Review Model

Reference Books

3. Jerry Banks, John S. Carson II, Barry L. Nelson, David M. Nicol: Discrete-Event System Simulation, 5th Edition, Pearson Education, 2010.
4. Lawrence M. Leemis, Stephen K. Park: Discrete – Event Simulation: A First Course, Pearson Education, 2006.
5. Averill M. Law: Simulation Modeling and Analysis, 4 th Edition, Tata McGraw-Hill, 2007

COMPUTATIONAL FLUID DYNAMICS

Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: - 04 Hours/ Week	End Semester Examination	50 Marks	04
	Total	**100 Marks**	**04**

Course Prerequisites: - The students should have knowledge of
1. Engineering Mathematics
2. Engineering Mechanics
3. Strength of Materials
4. Numerical methods

Course Objectives: - To provide Knowledge about
1. To study the basic governing equations and understand the basic concepts of CFD.
2. To understand discretization techniques and solving methods for improving accuracy.
3. To inculcate the knowledge required to solve real time physical problems using simulation software.

Course Outcomes: - The students should be able to–
1. Understand physical significance of each term in governing equations in CFD.
2. Apply the numerical methods in CFD on practical engineering problems.
3. Apply the concepts of grid generation and meshing on practical engineering problems.
4. Understand the concepts of turbulence modelling and apply them on practical engineering problems.
5. Understand the concepts of convection and diffusion modelling and apply them on practical engineering problems.

Course Contents

Unit I Governing Equations in CFD (08 Hrs.)

Continuity equation in Cartesian Coordinates, Navier-Stokes Equation, Non-conservation and conservation forms of Momentum equation, Energy Equation. Mathematical behavior of governing equations. General scaler transport equation. Reynold's Transport Theorem.

Unit II Numerical methods in CFD (10 Hrs.)

Finite Difference, Finite Volume Methods. Classification of Partial Differential Equations – Solution of Linear Algebraic Equations – Direct and Iterative Approaches. Finite difference

methods: Taylor's series – FDE formulation for 1D and 2D steady state heat transfer problems – Cartesian, cylindrical and spherical co-ordinate systems – boundary conditions – Un steady state heat conduction – Errors associated with FDE – Explicit Method – Stability criteria – Implicit Method

Unit III Grid Generation & Meshing in CFD (10 Hrs.)

Surface mesh generation, Surface mesh repair, volume grid generation, Volume mesh improvement, mesh smoothing algorithms, grid clustering and quality checks for volume mesh. Adaptive, Moving and Hybrid Grids, Need for adaptive and, moving grids, Tet, pyramid, prism, and hex grids, using various elements in combination.

Unit IV Turbulence Modelling (10 Hrs.)

Introduction and background of Turbulence Modeling, Algebraic models, One equation models, Two equation models, Near wall treatment, Reynolds stress models. Computation of turbulent fluid flow and heat transfer, eddy-viscosity based turbulence modelling: k-ε and k-ω modelling.

Unit V Convection & Diffusion Modelling (10 Hrs.)

Steady one-dimensional convection and diffusion: The central differencing scheme. Properties of discretisation schemes: Conservativeness, Boundedness, Transportiveness. Assessment of the central differencing scheme for convection–diffusion problems. The upwind differencing scheme. Assessment of the upwind differencing scheme, The hybrid differencing scheme, Assessment of the hybrid differencing scheme. Higher-order differencing schemes for convection–diffusion problems. Quadratic upwind differencing scheme: the QUICK scheme. Assessment of the QUICK scheme.

Textbooks/ Reference Books

1. Patrick Knupp and Stanly Steinberg, "Fundamentals of Grid Generation", CRC Press, 1994
2. D. C. Wilcox, "Turbulence Modelling for CFD", 1993
3. Pieter Wesseling, "An Introduction to Multigrid Methods", John Wiley & Sons, 1992
4. J. F. Thompson, Z. U., A. Warsi and C. W. Mastin, "Numerical Grid Generation: Foundations and Applications", North Holland, 1985
5. S. V. Patankar, "Numerical Heat Transfer and Fluid Flow", McGraw-Hill,1981

6. Thomas B. Gatski, M. YousuffHussaini, John L. Lumley,, “Simulation and Modelling of Turbulent Flows”, Eds., Oxford University Press, 1996
7. Laney, C. B., “Computational Gas Dynamics”, Cambridge Uni. Press, 1998

ADDITIVE MANUFACTURING

Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: - 04 Hours/ Week	End Semester Examination	50 Marks	04
	Total	**100 Marks**	**04**

Course Prerequisites: -

The students should have knowledge of

1. Solid Modeling, Auto CAD
2. Manufacturing Technology
3. Design & Analysis of Machine Components

Course Objectives: -

1. To understand the fundamental concepts of Additive manufacturing and 3-D printing.
2. To classify various types of Additive Manufacturing Processes and know their working principle, advantages, limitations etc.
3. To have a holistic view of various applications of these technologies in relevant fields such as mechanical, Bio-medical, aerospace, electronics etc.

Course Outcomes: -

The students should be able to–

1. Understand the importance of additive manufacturing process and AM process chain
2. Understand and apply Liquid-based and Solid Based additive manufacturing processes.
3. Understand and apply powder based additive manufacturing processes.
4. Understand and apply various Metal Additive Manufacturing process for different products
5. Apply various AM data formatting and data processing techniques for different products
6. Select suitable material for AM process and explore different applications of AM parts from various fields like Automobile, Aerospace, Bio-medical etc.

Course Contents

Unit I	Introduction to Additive Manufacturing (AM)	(10 Hrs.)

Introduction: AM fundamentals, Historical development, Advantages and Limitations of AM, commonly used Terms, Classification of AM process.

Liquid-based Rapid Prototyping Systems: Stereo lithography Apparatus (SLA), Solid ground curing (SGC). Models and specifications, Process, working principle, Applications, Advantages and Disadvantages, Case studies.

Solid-based Rapid Prototyping Systems: Laminated Object Manufacturing (LOM), Fused Deposition Modeling (FDM), Models and specifications, Process, working principle, Applications, Advantages and Disadvantages, Case studies.

Unit II	Powder Based Rapid Prototyping	(10 Hrs.)

Powder Bed Fusion AM Processes: Selective laser Sintering (SLS), Materials, Indirect and direct SLS, Powder fusion mechanism and powder handling, Process Modeling, SLS Metal and ceramic part creation, post processing, post curing, surface deviation and accuracy, Electron Beam melting (EBM), Process Benefits and Drawbacks, Applications of Powder Bed Fusion Processes, Post processing of AM parts

Laser Engineered Net Shaping (LENS): Processes, materials, products, advantages, limitations, and applications– Case Studies.

Unit III	Design for Additive Manufacturing	(10 Hrs.)

Design tools for AM, Part Orientation, Removal of Supports, Hollowing out parts, Inclusion of Undercuts and Other Manufacturing Constraining Features, Interlocking Features, Reduction of Part Count in an Assembly, Identification of markings/ numbers etc.

Guidelines for process selection: Introduction, selection methods for a part, challenges of selection, example system for preliminary selection, production planning and control

Unit IV	AM Data Formatting and Data Processing	(10 Hrs.)

Rapid Prototyping 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. Rapid Prototyping Software's: Features of various RP software's like Magics, Mimics, Solid View, View Expert, 3 D View, Velocity 2, Rhino, STL View 3

Data Expert and 3 D doctor.

AM Data Processing: Part Orientation and Support Structure Generation, Model Slicing and Contour Data Organization, Direct and Adaptive Slicing, Hatching Strategies and Tool Path Generation.

Unit V	**AM Materials and Applications**	**(10 Hrs.)**

3D Printing Materials: properties, characteristics, and application of all types (ABS, PLA, PVA, HDPE, PET, PETG etc.) Types of Composites Materials, properties, characteristics, and application of all types. (N6, N12, ABS Corban Fiber, etc.)

RP Applications: 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.

Reference Books

1. Chua Chee Kai, Leong Kah Fai, "Rapid Prototyping: Principles and Applications", World scientific, 2003.
2. Ian Gibson, David W Rosen, Brent Stucker., "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 2010
3. D.T. Pham, S.S. Dimov, Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, Springer 2001.
4. David F. Rogers, J. A. Adams, "Mathematical Elements for Computer Graphics", TMH, 2008.
5. Kevin N. Otto, Kristin L. Wood, "Product Design", Pearson Education, 2004.

Textbooks

1. Ali K. Kamrani, Emand Abouel Nasr, "Rapid Prototyping: Theory and Practice", Springer, 2006.
2. Anupam Saxena, Birendra Sahay, "Computer Aided Engineering Design", Springer, 2005.
3. Patri K. Venuvinod and Weiyin Ma, "Rapid Prototyping: Laser-based and Other

Technologies", Springer, 2004.

4. Chua Chee Kai, Leong Kah Fai, "3D Printing and Additive Manufacturing: Principles & Applications", 4th Edition, World Scientific, 2015.
5. Rafiq Noorani, Rapid Prototyping: Principles and Applications in Manufacturing, John Wiley & Sons, 2006.

VIRTUAL FACTORY

Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: - 04 Hours/ Week	End Semester Examination	50 Marks	04
	Total	**100 Marks**	**04**

Course Prerequisites: -

The students should have knowledge of

1. Manufacturing Technology-I, II
2. Automatic Control System
3. Electro-Hydraulic and Pneumatics
4. Power Electronics & Drives
5. Object Oriented Programming (Using Python)
6. Programmable Logic Controller

Course Objectives: -

To provide Knowledge about

1. Modern manufacturing systems
2. To understand the concepts and applications of flexible manufacturing systems
3. To introduce the concept of smart factories, especially the various technologies involved within the smart manufacturing.
4. To introduce the applications and scope for technology involved in Industry 4.0.

Course Outcomes: -

The students should be able to–

1. Recognize the recent manufacturing trends related to Industry 4.0, FMS, and its implementation in manufacturing
2. Perform Planning, Scheduling, and control of Flexible Manufacturing systems
3. Identify the role of cloud manufacturing for smart factories, challenges, and scope
4. Understand and apply the concept of agile manufacturing and cyber security in future factory
5. Identify applications of AR and VR in smart manufacturing.
6. Understand and apply the concept of digital twins in future factory

Course Contents

Unit I Introduction to smart manufacturing technologies (08 Hrs.)

Introduction to Industry 4.0, Smart manufacturing, Related technologies, Traditional Factory and Smart Factory, The Smart Factory Opportunity, CIM wheel, CIMS Structure and Functions, Future Trends of smart Factory and applications. Introduction & composition of FMS, hierarchy of computer control, computer control of work center and assembly lines, FMS supervisory computer control, types of software specification and selection, Big Data and Analytics, Big Data decision-making.

Unit II Applications of FMS and factory of the future (10 Hrs.)

FMS application in machining, sheet metal fabrication, prismatic component production, aerospace application, FMS development towards factories of the future. Flexibility rules, Sustainability, Man in the factory, building blocks for the factory of the future, Building architecture and factory planning, IT Infrastructure and cyber security, Data Management, Machines and manufacturing systems Introduction to Cloud computing, Industrial Internet of Things, supply chain management.

Unit III Agile Manufacturing and Safety with Future Factory (10 Hrs.)

Agile Manufacturing: Introduction to Agile Manufacturing, Agile Manufacturing Principles, Implement Agile Manufacturing, Applications of Agile Manufacturing, Real-Time Data to Guide Iteration, Computer Vision to Augment Operators, Manufacturing Apps to Amplify Training Programs, Mass Customization.

Safety with Future Factory:

Introduction to cyber security, security principles, risk and opportunities in cyber security technology, Safety and Security in networked Production Environments, Safety with Industry 4.0, Safety for connected Machines and Systems, Safety in Human Robot cooperation

Unit IV Virtual and Augmented Reality, Machine Learning in Industry 4.0 (10 Hrs.)

Introduction, Difference in AR and VR, Hardware and Software Technology, Industrial

Applications of Augmented reality and Virtual reality. Basics of Machine Learning, The Machine Learning Process, Into Machine Learning working cycle, Preparing Data, Running Experiments, Finding the Model, Training the Model, Deploying and using a Model, Machine Learning in practice Automotive Cloud, warehouse operations, Augmented reality.

Virtualization, Cloud Platforms, Big data in production, Cloud-based ERP and MES solutions, Connected factory applications, IT security for cloud applications.

Unit V Digital Twins (10 Hrs.)

Introduction to Digital Twins, Benefits, impact and challenges, Features and Implementation of Digital Twins, Computational tools, Types of Digital Twins, Applications for digital twins in production (examples of existing or future applications in the field of manufacturing), digital twin in dynamical systems, Data-driven digital twins, methods in digital twin technology, Deep learning in digital twin technology.

Reference Books

1. Solanki, Kumar, Nayyar, Emerging Trends and Applications of Machine Learning, IGIGlobal, 2018.
2. Mohri, Rostamizdeh, Talwalkar, Foundations of Machine Learning, MIT Press, 2018.
3. Kumar, Zindani, Davim, Artificial Intelligence in Mechanical and Industrial Engineering,CRC Press, 2021.
4. Zsolt Nagy - Artificial Intelligence and Machine Learning Fundamentals-Apress (2018)
5. Artificial Intelligence by Elaine Rich, Kevin Knight and Nair, TMHWeb

Textbooks

1. Deisenroth, Faisal, Ong, Mathematics for Machine Learning, Cambridge University Press,2020
2. B Joshi, Machine Learning and Artificial Intelligence, Springer, 2020.
3. Parag Kulkarni and Prachi Joshi, “Artificial Intelligence – Building Intelligent Systems”, PHI learning Pvt. Ltd., ISBN – 978-81-203-5046-5, 2015
4. Stuart Russell and Peter Norvig (1995), “Artificial Intelligence: A Modern Approach,” Third edition, Pearson, 2003
5. Groover M.P., “Automation, Production Systems and Computer Integrated Manufacturing”, Prentice Hall of India Pvt., New Delhi, 1996.
6. Kalpakjian, “Manufacturing Engineering and Technology”, Addison-Wesley Publishsing Co., 1995.
7. Radhakrishnan P. and Subramanyan S., “CAD/CAM/CIM”, Wiley Eastern Ltd., New AgeInternational Ltd., 1994.
8. Raouf, A. and Ben-Daya, M., Editors, “Flexible manufacturing systems: recent

development", Elsevier Science, 1995.

9. Taiichi Ohno, "Toyota Production System: Beyond large-scale Production", Productivity Press (India) Pvt. Ltd. 1992.
10. Smid P., CNC Programming Handbook, Industrial Press, 2005
11. Leong W., Nine pillars of technologies for Industry 4.0, IET publishers, 2020
12. Gilchrist A., Industry 4.0: The Industrial Internet of Things, Apress, 2017

AUTOMATIC CONTROL SYSTEM

Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: - 04 Hours/ Week	End Semester Examination	50 Marks	04
	Total	**100 Marks**	**04**

Course Prerequisites: -

The students should have knowledge of

1. Mathematics & Science
2. Basic Electrical Engineering.
3. Sensors and Measurement System

Course Objectives: -

1. Familiarization with Control System Principles and Applications of Control System.
2. Calculate and Estimate the Stability Measures, Time Response Measures from the Analysis of Mathematical Models of Some Simple Engineering Systems.
3. Develop Data Acquisition System using Controllers and apply it for Industrial Automation Application

Course Outcomes: -

The students should be able to–

1. Understand the basic concepts of automatic control systems
2. Obtain an overall transfer function of control system by using block diagram algebra methods
3. Determine the time and frequency response of control systems
4. Determine the (absolute) stability of a closed-loop control system using Routh Hurwitz's stability criterion.
5. Apply fundamentals of PID controllers and use it in industrial automation
6. Select and use control system components for industrial automation.

Course Contents

Unit I Introduction to Automatic Control systems (08 Hrs.)

Open Loop system, Closed Loop system, Conversion of an Open Loop system to a Closed Loop system, Servo Mechanism, Feed Forward Systems, Adaptive Control Systems, Classification of Control Systems, the design process. Transfer Function, Concept of Poles &

Zeros of a Transfer Function, Properties of Transfer Function, Transfer Function of Basic Devices; Mathematical Modeling of Mechanical and Electrical Systems. Mechatronics System & Its Examples, Mechatronics System Components.

Unit II Block Diagram Representation (10 Hrs.)

Block Diagram Definitions, Generating a Block Diagram from a Physical System, Canonical Form,

Rules for Block Diagram Reduction, Reduction of Block Diagram, Reducing to Unity Feedback Systems,

Examples on Block Diagram Reduction

Unit III Time Response and Frequency Response Analysis (10 Hrs.)

Time response of control system, standard test signal, Time Response, Analysis of First and Second order system, Time Domain specifications. Step response of second order system. Steady-state errors, static error constants, steady state, analysis of different type of Systems using step. Ramp and parabolic inputs, Frequency Response Specification, Co-relation between Time and Frequency Domain

Unit IV Stability Analysis and Controllers (10 Hrs.)

Stable system, Unstable System, Marginally Stable System, Time Response of Poles, Hurwitz Stability Criterion, Routh Stability Criterion, Routh Criterion Special Cases, Relative Stability, Application of Routh's Criterion.

Controllers: Introduction, Control System Parameters, Controller Modes, Control Actions, Types of Controllers-ON-OFF Controller, Proportional Controller (P-Controller), Proportional + Integral

Controller (P-I Controller), Proportional + Derivative Controller (P-D Controller), Proportional

+Integral+ Derivative Controller (P-I-D Controller), Effect of Proportional, Integral, and derivative

control on the Time Response of the System

Unit V Control System Components (10 Hrs.)

Data Acquisition: Elements of a Data Acquisition and Control System, Overview of the Input/Output Process, Analog to Digital (A/D) Conversion, Digital to Analog (D/A) Conversion, Data Acquisition Case Studies. Variable Frequency Drive, Servomotor.

Switches: Construction, symbolic representation, working, application of Toggle switch, Slide switch, DIP switch, Rotary switch, Thumbwheel switch, Selector switch, Push button, Drum switch, Limit switch, Temperature switch, Pressure switch, Level switch, Flow switch.

Relays: Construction, working, specifications/selection criteria and applications of electromechanical relay, Reed relay, hermetically sealed relay, Solid state relays.

Contactors: Construction, working, specifications and applications of contactors. Comparison between relay& contactor.

Text Books/Reference Books:

1. K. Ogata, Modern Control Engineering, Prentice Hall of India, 3rd edition, 1998
2. J. Nagarath and M. Gopal, Control Systems Engineering, New Age International (P) Ltd.
3. M. Gopal, Digital Control and State Variable Methods, Tata Mc Graw-Hill Companies, 1997.
4. Stainslaw H. Zak, Systems and Control, Oxford Press, 2003.
5. M. Gopal Modern Control System Theory, New Age International Publishers, 2nd edition, 1996.
6. W. Bolton, “Mechatronics”, Pearson Education.
7. Ramchandran K. P., Vijyaraghavan G. K., Balasundaram M. S., “Mechatronics: Integrated Mechanical Electronic Systems”, John Wiley & Sons, 2008.

RESEARCH METHODOLOGY

Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: - 04 Hours/ Week	End Semester Examination	50 Marks	04
	Total	**100 Marks**	**04**

Course Prerequisites: -

The students should have knowledge of

1. Basic Statistics

Course Objectives: -

1. To illustrate what is the exact meaning of research and a correct way to define it.
2. To develop the understanding of the basic frame work of research process.
3. Explore small and large data-sets to create testable hypotheses and identify appropriate statistical test
4. Perform correlation, regression analysis and appropriate statistical tests

Course Outcomes: -

After the completion of course, students will be able to

1. Interpret the meaning of research problem and methodology for research
2. Apply research process in designing of research problem
3. Utilize experimental error analysis for quality research

Course Contents

Unit I Getting Started: Ideas, Resources, and Ethics (8 Hrs.)

Selecting a Problem

Reviewing the Literature: Library Research, Journals, Psychological Abstracts, PsycINFO and PsycLIT, Social Science Citation Index and Science Citation Index, Other Resources

Reading a Journal Article: Abstract, Introduction, Method, Results, Discussion

Ethical Standards in Research

Unit II Introduction and Descriptive Statistics (10 Hrs.)

Introduction to Frequency Distributions, Frequency Distribution Tables, Frequency Distribution Graphs, The Shape of a Frequency Distribution

Central Tendency : Mean, Median, Mode, Selecting a Measure of Central Tendency, Central Tendency and the Shape of the Distribution

Variability : The Range, Standard Deviation and Variance for a Population, Standard Deviation and Variance for Samples

Unit III Foundations of Inferential Statistics (10 Hrs.)

Introduction to z-Scores, z-Scores and Location in a Distribution, Using z-Scores to Standardize a Distribution, Other Standardized Distributions Based on z-Scores, Computing z-Scores for a Sample.

Unit IV Probability and Samples (10 Hrs.)

Introduction to Probability ,Probability and the Normal Distribution ,Probabilities and Proportions for Scores from a Normal Distribution Probability and the Binomial Distribution

Samples and Populations ,The Distribution of Sample Means ,Probability and the Distribution of Sample Means

Unit V Introduction to Hypothesis Testing (10 Hrs.)

The Logic of Hypothesis Testing ,Uncertainty and Errors in Hypothesis Testing ,An Example of a Hypothesis Test ,Directional (One-Tailed) Hypothesis Tests Concerns About Hypothesis Testing: Measuring Effect Size

Reference Books

1. Research Methodology: Methods and Trends, by Dr. C. R. Kothari, New Delhi: New Age International (P) Ltd., 2nd Rev. Edition, 2004.
2. Research Methodology: An Introduction by Wayne Goddard and Stuart Melville, Juta and Company Ltd, 2004.
3. Statistical Methods by S.P. Gupta, Sultan Chand and Sons, New Delhi, 44th Revised Edition 2014.
4. Theory and Design for Mechanical Measurements by Richard S. Figliola, Donald E.

Beasley John Wiley & Sons, Inc, 6th Edition, 2015.

5. Research methodology: an Introduction for Science & Engineering students, by Stuart Melville and Wayne Goddard, Kenwyn, South Africa: Juta& Co. Ltd., 1st Edition, 1996.

INTRODUCTION TO INTERNET OF THING

Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: - 04 Hours/ Week	End Semester Examination	50 Marks	04
	Total	**100 Marks**	**04**

Course Prerequisites: - Systems in Mechanical Engineering, Programming and Problem Solving, Basic Electronics Engineering, Solid Mechanics, Solid Modeling and Drafting, Electrical and Electronics Engineering, Mechatronics, Measurement Laboratory, Fluid Power & Control Laboratory

Course Objectives:-

1. Introduction to IoT, Overview of IoT Building Blocks
2. Build small applications in IoT for Mechanical Engineering Applications using Sensors, Actuators, Microcontrollers and Cloud
3. Learn commonly used IoT Simulation Hardware platforms
4. Understand different Communication Technologies used in IoT
5. Development of application level protocol and Security of IoT Ecosystem
6. Understand IoT applications in different domains

Course Outcomes: - On completion of the course the learner will be able to;

1. EXPLAIN the Applications/Devices, Protocols and Communication Models of IoT
2. DEMONSTARTE small Mechanical Engineering IoT oriented applications using Sensors, Actuators, Microcontrollers and Cloud
3. SELECT commonly used IoT Simulation Hardware platforms
4. APPLICATION of Interfacing and Communication Technologies for IoT
5. ILLUSTRATE IoT Application Development and Security of IoT Ecosystem
6. EVALUATE Present and Future Domain specific Applications of IoT Ecosystem

Course Contents

Unit I Introduction to the Internet of Things (08Hrs.)

Overview, History, Definition and Characteristics, Connectivity Terminologies, Building blocks, Types of technologies used in IoT System, Baseline Technologies (Machine-to-Machine (M2M) communications, Cyber-Physical-Systems (CPS)), IoT Vs M2M, IoT enabled Technologies, IoT Levels and Templates, Design Methodology, The Physical Design Vs Logical Design of IoT, Functional blocks of IoT and Communication Models/Technologies, Development Tools used in IoT, IoT Architecture and Protocols, Various Platforms for IoT, Real time Examples of IoT, Challenges in IoT, The process flow of an IoT application, Evolution of Connected Devices, Applications of IoT, IoT Enablers, Overview of Governance, Privacy and Security Issues.

Unit II Sensors, Actuators and Microcontrollers (10 Hrs.)

Measuring physical and virtual quantities in digital world, Overview of Sensors working, Analog Vs Digital Sensors, Wired Vs Wireless Sensors, Types of Sensors, Types of Converters Types of Transducers and Actuator, Controlling Hardware, Types of Controller, Role of microcontroller as gateway to interfacing sensors and actuators, Microcontroller Vs Microprocessor, Type of microcontrollers in embedded System

Unit III IoT Simulation Environment Hardware platforms and Endpoint Interfacing (10 Hrs.)

IoT supported Hardware platforms:

Introduction to IoT Simulation Environment and Devices (Raspberry Pi, Espressif Processors, Arduino), Architecture, Setup, IDE, Installation, Interfaces (serial, SPI, I2C), Programming with focus on interfacing for reading input from pins, connecting external gadgets/sensors/actuators, Controlling and Displaying Output, Libraries, Basics of Embedded C programming,

Interfacing:

Interfacing Input, Intermediate, Output and Display Sensors, Converters, Actuators, Controlling Hardware, Controllers and Network Devices

IoT Architecture:

Building architecture and Open source architecture (OIC), Main design principles and needed

capabilities, An IoT architecture outline, Standards Considerations

Unit IV Interfacing and Communication for Building IoT Applications (10 Hrs.)

Communication:

Overview and Working of Controlled Systems, Connectivity models - TCP/IP Vs OSI model, IoT Communication Models, IoT Communication APIs, Serial Vs Parallel Communication, Wires Vs Wireless Communication, their Technologies and Hardware

IoT Communication Protocols:

Protocol Standardization for IoT, Role of M2M in IoT, M2M Value Chains, IoT Value Chains, M2M and WSN Protocols (SCADA and RFID)

Physical Servers and Cloud Platforms:

Web server, Posting sensor(s) data to web server, Introduction to Cloud Storage models and Communication APIs Webserver, API Virtualization concepts and Cloud Architecture, Advantages and limitations of Cloud computing, IoT Cloud platforms, Cloud services

Unit V IoT Application Development and Security of IoT Ecosystem (10 Hrs.)

Application Protocols:

MQTT, REST/HTTP, SQL Back-end Application Designing (Designing with Apache, MySQL, HTML, CSS), Non SQL Back-end Application Designing (MongoDB Object Type Database, jQuery for UI Designing), JSON lib for data processing

Security:

Need of security in IoT, Security & Privacy during development, Privacy for IoT enabled devices, IoT security for consumer devices, Security levels, protecting IoT devices, Security, Privacy and Trust in IoT-Data-Platforms

Reference Books

1. Bahga, A. and Madisetti, V., (2015), “Internet of Things - A Hands-on Approach,” Universities Press, ISBN: 9788173719547
2. Hajjaj, S S H. and Gsangaya, K. R., (2022), “The Internet of Mechanical Things: The IoT Framework for Mechanical Engineers,” CRC Press, ISBN: 9781032110950

3. Raj, P. and Raman, A. C., (2017), “The Internet of Things: Enabling Technologies, Platforms, and Use Cases,” Auerbach Publications/CRC Press, ISBN: 9781498761284
4. Adrian McEwen, A. and Cassimally, H., (2013), “Designing the Internet of Things,” John Wiley and Sons, ISBN:
5. Veneri, G., Capasso, A., (2018), “Hands-On Industrial Internet of Things: Create a powerful Industrial IoT infrastructure using Industry 4.0,” Packt Publishing, ISBN: 9781789537222
6. Hersent, O, Boswarthick, D., Elloumi, O., (2012), “The Internet of Things: Key Applications and Protocols”, Wiley, ISBN: 9781119994350 7. Uckelmann, D., Harrison, M., Michahelles, F., (2011), “Architecting the Internet of Things,” Springer, ISBN: 9781119994350

Text Books

1. daCosta, F., (2013), “Rethinking the Internet of Things: A Scalable Approach to Connecting Everything”, Apress Publications, ISBN: 9781430257417
2. Waher, P., (2015), “Learning Internet of Things,” Packt Publishing, ISBN: 9781783553532
3. Ovidiu, V. and Friess, P., (2014), “Internet of Things - From Research and Innovation to Market Deployment,” River Publishers, ISBN: 9788793102941,
4. Ida, N., (2020), “Sensors, Actuators and Their Interfaces,” SciTech Publishers, ISBN: 9781785618352
5. Pfister, C., (2011), “Getting Started with the Internet of Things,” O’Reilly Media, ISBN: 9781449393571

INDUSTRIAL ROBOTICS AND AUTOMATION

Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: - 04 Hours/ Week	End Semester Examination	50 Marks	04
	Total	**100 Marks**	**04**

Course Prerequisites: -

The students should have knowledge of

1. Mathematics & Theory of Machines, Mechanical Engineering Systems
2. Fluid, Turbo machinery
3. Basic Electrical and Electronics

Course Objectives: -

To impart knowledge on

1. Understand automation technologies and identify advantages, limitations and applications of the same.
2. Develop ability to recognize, articulate and solve industrial problems using automation technologies.
3. To provide students with knowledge of the applications of fluid power systems in process, construction, robotics and manufacturing industries and able to design and implement automated systems using pneumatics.
4. To make the students acquainted with the conceptual as well as practical knowledge of the PLC programs & latest technologies being used to achieve PLC Industrial Automation.

Course Outcomes: -

The students should be able to–

1. Understand & apply fundamentals of industrial automation
2. Understand concepts of control system and apply it for automation
3. Understand concepts related to Fundamentals of Robot Technology
4. Understand concepts related to Control of fluid power and Control valves
5. Understand concepts related to Hydraulics and Pneumatics – Actuators and Circuits and its application, PLC and Develop ladder diagram for industrial applications

Course Contents

Unit I Introduction to Industrial Automation and Robotics (08Hrs.)

Introduction of Automation and Robotics, Historical Development, three laws of robotics by Isaac Asimov, Broad classes of industrial automation-Fixed, flexible and programmable and their comparative study, Automation Principles and Strategies, USA Principle, Ten Strategies for Automation and production systems, Automation Migration Strategy-Manual Production, Automated Production, Automated integrated production

Unit II Automatic Control Systems and Control Actions (08Hrs.)

Introduction to control systems: mechatronics system & its examples, mechatronics system components. Open loop and closed loop system, effects of feedback and basic characteristic of feedback control systems, classification of control systems.

Introduction to Controllers: Control System Parameters, Controller Modes, Control Actions, Types of Controllers-ON-OFF Controller, Proportional Controller (P-Controller), Proportional + Integral Controller (P-I Controller), Proportional + Derivative Controller (P-D Controller), Proportional + Integral + Derivative Controller (P-I-D Controller), Effect of Proportional, Integral, and derivative control on the Time Response of the System

Control System Components: Elements of a Data Acquisition and Control System, Overview of the Input/output Process, Data Acquisition Case Studies. Variable Frequency Drive, Servomotor, switches, Relays and Contactors.

Unit III Fundamentals of Robot Technology (08Hrs.)

Fundamentals of Robotics: Robot Definitions, Laws of Robotics, Basic Structure of Robots, links and Joints, types of Joints, types of links, types of end effectors, Wrist configuration: concept of: yaw, pitch and roll. Robot Anatomy, work volume, work envelope, robot manipulator. Specifications of robot: degrees of freedom (DOF), accuracy, repeatability, spatial resolution, compliance, loads carrying capacity, speed of response. Classification of Robots- 1) Co-ordinate system: Cartesian,

Cylindrical, spherical, SCARA, articulated 2) Control Method: Servo controlled and non-servo controlled, their comparative study 3) Form of motion: P-T-P (point to point), C-P (continuous path), pick and place etc. and their comparative study 4) Drive Technology: Hydraulic, Pneumatic, Electric (stepper motor, D.C. servo motor) in detail with selection criteria. Motion conversion: Rotary to rotary, rotary to linear and vice versa.

Unit IV Fluid Power Control (08Hrs.)

Necessity of fluid control through pressure control, directional control and flow control valves. Control valves: i) Principle of pressure control valves, direct operated and pilot operated pressure relief valves, pressure reducing valve, sequence valve. ii) Principle of flow control valves, pressure compensated and non-compensated flow control valves. iii) Principle of directional control valves, types of directional control valves, two-way, three-way, four-way valves, check valve and shuttle valve. Open center, close center, tandem center valves. Actuating devices- manually operated, mechanically operated, solenoid operated, pilot operated, lever operated.

Unit V Hydraulic & Pneumatic Circuits (08Hrs.)

Linear and rotary actuators: Types, construction and characteristics. Cylinder mountings, cushioning of cylinders.

Hydraulic & Pneumatic circuits: Simple reciprocating, regenerative, speed control (meter in, meter out and bleed off), sequencing, synchronization, traverse and feed, automatic reciprocating, fail safe circuit, counter balance circuit, actuator locking, unloading circuit, motor breaking circuit etc.

Development of Electro-hydraulic Circuits and Electro-pneumatic Circuits.

Programmable Logic Controller

Introduction to PLCs, Basic Structure of a PLC, Principles of Operation, PLC Programming Languages, Ladder diagram, Latching and internal relays, Timers and Counters, Selection of a PLCs for Control System, Application of PLCs for Automatic Control System. Concept of SCADA and its Applications,

Reference Books

1. Automation, Production Systems and Computer Integrated Manufacturing M.P.Groover, Pearson Education.5th edition, 2009
2. Majumdar S.R, Pneumatics Systems Principles and Maintenance ,Tata McGraw Hill
3. R. K. Mittal, I. J. Nagrath, "Robotics and Control", Tata McGraw Hill Publishing Company Ltd., New Delhi.
4. Majumdar S.R, Oil Hydraulic system- Principle and maintenance ,Tata McGraw Hill
5. Esposito Anthony, Fluid Power with application, Prentice Hall
6. Stuart A Boyer: SCADA supervisory control and data acquisition, International Society of Automation, 2010.
7. Stewart H. L, Hydraulics and Pneumatics , Taraporewala Publication

DESIGN AND ANALYSIS OF EXPERIMENT

Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: - 04 Hours/ Week	End Semester Examination	50 Marks	04
	Total	**100 Marks**	**04**

Course Prerequisites: -

The students should have knowledge of

2. Basic Statistics

Course Objectives: -

By the end of the class students are expected to

1. Formulate statistical questions for a real-life problem.
2. Plan and design an appropriate experiment to test the hypothesis,
3. Choose the appropriate statistical methods for data analysis and justify the choice.
4. Describe and present the data analysis results.

Course Outcomes: -

After the completion of course, students will be able to

1. Determine the type of experiment and select the appropriate experiment method.
2. Analysis and interpret the hypothesis for means, proportions and variance.
3. Do statistical analysis of experimental solutions.
4. Calculate and analysis the ANOVA and define the effective factors and their levels.
5. Check the model adequacy.

Course Contents

Unit I *t* Statistic (8 Hrs.)

Introduction to the t Statistic, The t Statistic: An Alternative to z, Hypothesis Tests with the t Statistic.

Two Independent Samples: Introduction to the Independent-Measures Design , The t Statistic for an Independent-Measures Research Design ,Hypothesis Tests and Effect Size with the

Independent-Measures t Statistic

Two Related Sample: The t Statistic for a Repeated-Measures Research Design, Hypothesis Tests and Effect Size for the Repeated-Measures Design

Unit II Introduction to Analysis of Variance (10 Hrs.)

Introduction, The Logic of ANOVA, ANOVA Notation and Formulas, The Distribution of F-Ratios

Examples of Hypothesis Testing and Effect Size with ANOVA, Post Hoc Tests, The Relationship Between ANOVA and t Tests

Unit III Repeated-Measures Analysis of Variance (10 Hrs.)

The Repeated-Measures ANOVA, Hypothesis Testing and Effect Size with the Repeated-Measures

ANOVA, Advantages and Disadvantages of the Repeated-Measures Design, Repeated-Measures ANOVA and Repeated-Measures t Test

Unit IV Two-Factor Analysis of Variance (10 Hrs.)

An Overview of the Two-Factor, Independent-Measures ANOVA, Main Effects and Interactions

Notation and Formulas for the Two-Factor ANOVA, using a Second Factor to Reduce Variance Caused by Individual Differences

Unit V Correlation and Regression (10 Hrs.)

Introduction, The Pearson Correlation, Using and Interpreting the Pearson Correlation, Hypothesis Tests with the Pearson Correlation, Alternatives to the Pearson Correlation

Linear Regression: Analysis of Regression, Testing the Significance of the Regression Equation,

Introduction to Multiple Regression with Two Predictor, Variables Evaluating the Contribution of Each Predictor Variable

Reference Books

1. Montgomery, D.C., “Design and Analysis of Experiments”, 5 Ed., John Wiley and Sons Inc., New York, 2006
2. George. E. P. Box, J. Stuart Hunter, William G. Hunter, “Statistics for Experimenters: Design, Innovation, and Discovery”, 2nd Edition, Wiley, 2005.
3. Frederick J Gravetter, Larry B. Wallnau “Statistics for the Behavioral Sciences”, Wadsworth, Cengage Learning

INTRODUCTION TO ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory: - 04 Hours/ Week	End Semester Examination	50 Marks	04
	Total	**100 Marks**	**04**

Course Prerequisite:-

1. Engineering mathematics-III, Statistics and Numerical Methods, Sensors Technology

Course Objective:- To provide Knowledge about

1. To understand the artificial intelligence algorithms to robotics problems.
2. To understand the performance of AI algorithms
3. To compute the complex problems in flexible automation

Course Outcomes:- On completion of the course, students will be able to

1. Use different machine learning techniques.
2. Apply basic principles of AI in solutions that require problem solving, inference, perception, knowledge representation and learning.
4. Demonstrate awareness and a fundamental understanding of AI techniques in intelligent agents, artificial neural networks
5. Demonstrate proficiency in developing applications in AI and Machine Learning.
6. Demonstrate an ability to share in discussions of AI, its current scope and limitations, and societal implications.

Course Content

Unit I Introduction to artificial intelligence techniques (08 Hrs)

Evolutionary computation, Goals of AI in manufacturing, tools for AI such as Search algorithm, Mathematical optimization, Agents and Environments, the concept of rationality, the nature of environments, structure of agents, problem solving agents, problem formulation, programming in AI environment, developing artificial intelligence system, natural language processing.

Unit II Introduction to fuzzy logic & Handling uncertainty (10 Hrs)

Basic concepts in fuzzy set theory, operations of fuzzy sets, fuzzy relational fuzzy logic principles, fuzzy inference, fuzzy rule-based systems, Fuzzy logic controllers, fuzzy decision making, various industrial applications of fuzzy logic control, Probabilistic methods for uncertain reasoning such as Bayesian network, Hidden Markov model, Kalman filter, Decision theory and Utility theory, statistical learning methods, support vector machines, expert systems.

Unit III Introduction to artificial neural networks (10 Hrs)

Fundamentals of neural networks, neural network architectures, Neural Learning, Supervised Learning, Unsupervised Learning, taxonomy of neural network architectures, standard back propagation algorithms, Linear Association, Basic Concepts of recurrent Auto associative memory: retrieval algorithm, storage algorithm; By directional associative memory, Architecture, Association encoding & decoding, Stability.

Unit IV Expert systems & Intelligent systems (10 Hrs)

Introduction, basic concepts, structure of expert systems, the human element in expert systems, how expert systems works, problem areas addressed by expert systems, expert systems success factors, types of expert systems, expert systems and the internet interacts web, knowledge engineering, scope of knowledge, difficulties, in knowledge acquisition methods of knowledge acquisition, machine Learning, Robotic vision systems, image processing techniques, application to object recognition and inspection, automatic speech recognition.

Unit V Industrial application of AI and expert systems (10 Hrs)

Recent advances: Fundamentals of genetic algorithms, hybrid systems, meta heuristic techniques like simulated annealing, Tabu search, ant colony optimization, artificial immune systems, applications in design and manufacturing, Path Planning Robot Control in Dynamic Environments, Accurate Motion Control of Fast Mobile Robots.

Reference Books:-

1. S. Russel and P. Norvig, “Artificial Intelligence – A Modern Approach”, Second Edition, Pearson
Education

2. David Poole, Alan Mackworth, Randy Goebel, ”Computational Intelligence : a logical approach”,
Oxford University Press.
3. G. Luger, “Artificial Intelligence: Structures and Strategies for complex problem solving”, Fourth
Edition, Pearson Education.
4. J. Nilsson, “Artificial Intelligence: A new Synthesis”, Elsevier Publishers

Text Book:-

1. Luger " Artificial Intelligence", Edition 5, Pearson, 2008
2. Bhattacharya S., Artificial Intelligence, Laxmi Publications, Ltd., 2008, ISBN: 9788131804896
3. Chopra Rajiv, Artificial Intelligence, S. Chand Publishing, 2012, ISBN9788121939485
4. Pawar P. J., Evolutionary Computations for Manufacturing, Studium Press, 2019, ISBN: 978- 93-85046-52-0

DISSERTATION STAGE I

Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Practical : 6 Hrs./Week	Term Work	100 Marks	15
	Oral	50 Marks	
	Total	**150 Marks**	**15**

Course Objectives: - At the end of the course students will

1. Exposed to self-learning various topics**.**
2. Learn to survey the literature such as books, national/international refereed journals and contact resource persons for the selected topic of research.
3. Address issues of research design, methodology, ethics and theoretical arguments, and locate a piece of research within these
4. Apply the knowledge about research design and methods that have gained from the taught components to develop your dissertation project

Course Outcomes: - The students should be able to

1. Students will learn to survey the relevant literature such as books, national/international refereed journals and contact resource persons for the selected topic of research.
2. Students will be able to use different experimental techniques.
3. Students will be able to use different software/ computational/analytical tools.
4. Students will be able to design an experimental setup.

Course Contents

The Project Work should preferably be a problem with research potential and should involve scientific research, design, generation/collection and analysis of data, determining solution and must preferably bring out the individual contribution. The examination shall consist of the preparation of report consisting of a detailed problem statement and a literature review. The preliminary results (if available) of the problem may also be discussed in the report. The work must be presented in front of the examiners panel set the university. The candidate must be in regular contact with his guide and the topic of dissertation must be mutually decided by the guide and student.

DISSERTATION STAGE II

Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Practical : 8 Hrs./ Week	Term Work	150 Marks	20
	Oral	100 Marks	
	Total	**250 Marks**	**20**

Course Objectives: - At the end of the course students will

Course Outcomes: - The students should be able to

1. Students will be able to design and develop an experimental set up/ equipment/test rig.
2. Students will be able to conduct tests on existing setups/equipment's and draw logical conclusions from the results after analyzing them.
3. Students will be able to either work in a research environment or in an industrial environment.
4. Students will develop attitude of lifelong learning and will develop interpersonal skills to deal with people working in diversified field.
5. Students will learn to write technical reports and research papers to publish at national and international level.
6. Students will develop strong communication skills to defend their work in front of technically qualified audience

Course Contents

It is a continuation of Dissertation Stage I work started in semester III. He has to submit the report in prescribed format. The dissertation should be presented in standard format as provided by the department. The candidate has to prepare a detailed project report consisting of introduction of the problem, problem statement, literature review, objectives of the work, methodology (experimental set up or numerical details as the case may be) of solution and results and discussion. The report must bring out the conclusions of the work and future scope for the study. The work must be presented in front of the examiners panel consisting of an approved external examiner, an internal examiner and a guide, co-guide etc. as decided by the University. The candidate must be in regular contact with his guide.

SEMINAR

Teaching Scheme:	Examination Scheme:		Credits Allotted
Practical : 2 Hrs	Term Work	50 Marks	5
	Oral	50 Marks	
	Total	**100 Marks**	**5**

Course Objectives: - At the end of the course students will

1. Develop self-learning attitude.
2. Interact with various libraries, resource persons to get information about a selected topic.
3. Be familiar with various refereed national/international journals.
4. Improve their oral and written communication skills and will be conversant with technical writing**.**

Course Outcomes: - The students should be able to–

1. To read, understand and outline an advanced information in the related field
2. Prepare and build a problem statement and undertake the research work.
3. Present and elaborate the work before the experts in conferences, meetings, etc.

Course Contents

Seminar shall consists of the in depth study of a topic, related to the field of CAD/CAM and should have research orientation. The student should know recent developments and applications in the chosen field of study. The topic of study/research is mutually decided by the student and the supervisor and a detailed technical report will be prepared. The study is to be presented in front of the committee of examiners, faculty and students of the department.