VEERMATA JIJABAI TECHNOLOGICAL INSTITUTE

(VJTI)

MATUNGA, MUMBAI 400 019

(Autonomous Institute affiliated to University of Mumbai)

Curriculum

(Scheme of Instruction & Evaluation and Course contents)

For

Two Year Postgraduate Programme

Leading to Master of Technology

(M Tech) Degree in

Mechanical Engineering with specialization in CAD/CAM Robotics

Implemented from the batch admitted in Academic Year 2025-26

Mechanical Engineering with specialization in CAD/CAM Robotics

Program Outcomes (POs)

PO1: An ability to independently carry out research /investigation and development work to solve practical problems in the area of CAD/CAM Robotics.

PO2: An ability to write and present a substantial technical report/document in the area of CAD/CAM Robotics.

PO3: Students should be able to demonstrate a degree of mastery in the area of CAD/CAM Robotics. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

V J T I Veermata Jijabai Technological Institute
(Central Technological Institute, Maharashtra State, INDIA)
H. R. Mahajani Marg, Matunga, Mumbai 400019
Tel.No. +91 22 24198101-02 Fax +91 22 24102874
www.vjti.ac.in

(Autonomous Institute affiliated to University of Mumbai)

Curriculum

(Scheme of Instruction & Evaluation and Course contents)

For

Two Year Postgraduate Programme

Leading to Master of Technology

(M Tech)

In

Mechanical Engineering (with Specialization in CAD/CAM Robotics)

V J T I Veermata Jijabai Technological Institute
(Central Technological Institute, Maharashtra State, INDIA)
H. R. Mahajani Marg, Matunga, Mumbai 400019
Tel.No. +91 22 24198101-02 Fax +91 22 24102874
www.vjti.ac.in

M.Tech. in Mechanical Engineering (with specialization in CAD/CAM Robotics)

Scheme of Instruction and Evaluation

SEMESTER I

Scheme of Instruction					Scheme of Evaluation			
Sr. No	Course Code	Course Title	L-T-P	Credits	TA	MST	ESE	ESE hours
1.	MECR5001T	Computational Methods	3-0-0	3	20	30	50	3
2.	MECR5011T	Computer Aided Design	3-0-0	3	20	30	50	3
3.	MECR5012T	Smart Manufacturing	3-0-0	3	20	30	50	3
4.		Programme elective 1	3-1-0	4	20	30	50	3
5.		Programme elective 2	3-1-0	4	20	30	50	3
6.		Open elective 1	3-0-0	3	20	30	50	3
7.	MECR5071L	Laboratory-1 Computational Methods Laboratory	0-0-2	1	60%CIE		40	-
8.	MECR5072L	Laboratory-2 Computer Aided Design Laboratory	0-0-2	1	60%CIE		40	-
9.	MECR5073L	Laboratory-3 Smart Manufacturing Laboratory	0-0-2	1	60%CIE		40	-
10.		Liberal Learning	0-0-2	1	100%CIE		-	-
			28	24				

abbreviations **L** Lecture, **T** Tutorial, **P** Practical, **TA** Teacher Assessment / Term work Assessment, **MST** Mid Semester Test, **ESE** End Semester Written Examination, **CIE** Continuous In-semester Evaluation

V J T I Veermata Jijabai Technological Institute
(Central Technological Institute, Maharashtra State, INDIA)
H. R. Mahajani Marg, Matunga, Mumbai 400019
Tel.No. +91 22 24198101-02 Fax +91 22 24102874
www.vjti.ac.in

SEMESTER II

Scheme of Instruction					Scheme of Evaluation			
Sr. No	Course Code	Course Title	L-T-P	Credits	TA	MST	ESE	ESE hours
1.	MECR5002S	Research Methodology & IPR	3-0-0	3	20	30	50	3
2.	MECR5013T	Robotics & Automation	3-1-0	4	20	30	50	3
3.	MECR5014T	Advanced Finite Element Analysis	3-1-0	4	20	30	50	3
4.		Programme elective 3	3-0-0	3	20	30	50	3
5.		Programme elective 4	3-0-0	3	20	30	50	3
6.		Open elective 2	3-0-0	3	20	30	50	3
7.	MECR5074L	Laboratory-4 Robotics and Automation Laboratory	0-0-2	1	60%CIE		40	-
8.	MECR5075L	Laboratory-5 Advanced finite Element Analysis Laboratory	0-0-2	1	60%CIE		40	-
9.	MECR5076L	Laboratory-6 Advanced Composite Materials Laboratory	0-0-2	1	60%CIE		40	-
10.		Liberal Learning	0-0-2	1	100%CIE		-	-
			28	24				

abbreviations **L** Lecture, **T** Tutorial, **P** Practical, **TA** Teacher Assessment / Term work Assessment, **MST** Mid Semester Test, **ESE** End Semester Written Examination, **CIE** Continuous In-semester Evaluation

V J T I Veermata Jijabai Technological Institute
(Central Technological Institute, Maharashtra State, INDIA)
H. R. Mahajani Marg, Matunga, Mumbai 400019
Tel.No. +91 22 24198101-02 Fax +91 22 24102874
www.vjti.ac.in

List of Programme Elective 1

Sr. No.	Course Code	Course Title
1.	MECR5021S	Industry 4.0 and IIOT
2.	MECR5022S	Artificial Intelligence in Manufacturing

List of Programme Elective 2

Sr. No.	Course Code	Course Name
1.	MECR5031S	Characterization of Engineering Materials
2.	MECR5032S	Control System in Robotics

List of Programme Elective 3

Sr. No.	Course Code	Course Name
1.	MECR5041S	Mechatronics
2.	MECR5042S	Product Life Cycle Management
3.	MECR5043S	Advanced Robotics
4.	MECR5044S	Product Design and Development

List of Programme Elective 4

Sr. No.	Course Code	Course Name
1.	MECR5051S	Advanced Composite Materials
2.	MECR5052S	Design for Additive Manufacturing
3.	MECR5053S	Manufacturing System Simulation

List of Open Elective 1

Sr. No.	Course Code	Course Title
1.	MECR5061S	3D Printing

List of Open Elective 2

Sr. No.	Course Code	Course Title
1.	MECR5062S	Robotics

V J T I Veermata Jijabai Technological Institute
(Central Technological Institute, Maharashtra State, INDIA)
H. R. Mahajani Marg, Matunga, Mumbai 400019
Tel.No. +91 22 24198101-02 Fax +91 22 24102874
www.vjti.ac.in

SEMESTER III

Scheme of Instruction					Scheme of Evaluation
Sr. No	Course Code	Course Title	L-T-P	Credits	
1.	MECR5091D	Skill Based Course (Project Stage -I)	---	5	100% CIE
2.	MECR5092D	Skill Based Course (Project Stage -II)	---	5	100% CIE
3.		Self Learning Course -1	1-0-0	1	100% ESE of 3 hours or credit transfer
4.		Self Learning Course -2	1-0-0	1	100% ESE of 3 hours or credit transfer
5.		Mandatory Non Credit Course	2-0-0	0	100% ESE of 3 hours or credit transfer
				12	

SEMESTER IV

Scheme of Instruction					Scheme of Evaluation
S. No	Course Code	Course Title	L-T-P	Credits	
1.	METS5093D	Skill Based Course (Project Stage -III)	---	5	100% CIE
2.	METS5094D	Skill Based Course (Project Stage -IV)	---	7	100% CIE
				12	

SEMESTER-I

Programme Name	***Masters of Technology in Mechanical Engineering with Specialization in CAD/CAM Robotics***
Course Code	**MECR5001T**
Course Title	**Computational Methods**

Course Outcomes

After completion of course, students would be able to

1. Solve algebraic equations, Eigen value problems
2. Analyze data using interpolation and regression methods.
3. Solve ordinary and partial differential equations using numerical techniques

Course Contents

Introduction

Engineering problems and computational methods; Introduction to numerical methods and analysis.

Error Analysis

Approximations; Round-off and Truncation errors; Backward and Forward error analysis

Roots of Nonlinear Equations

Bisection method, Regula Falsi, Secant method, Fixed point Method; Newton-Raphson method; Multiple roots; Roots of system of non-linear equations; Analysis and order of convergence; Polynomials Mueller's method, Bairstow's method**.**

Solution of System of Linear Equations

Direct methods (Gauss Elimination, Gauss-Jordan, LU decomposition, Thomas Algorithm); Perturbation analyses of direct methods matrix and vector norms, condition number of matrix; Iterative methods (Jacobi and Gauss-Seidel); convergence criteria for Jacobi and Gauss Seidel iterative methods, rate of convergence of iterative methods. Successive over Relaxation.

Solution of System of Nonlinear Equations

Iterative methods, Fixed Point iteration, Newton-Raphson method.

Approximation of functions

Approximation using polynomials (Simple, least squares estimation, orthogonal basis functions, Tchebycheff and Legendre polynomials); Interpolation (Newton's divided difference and Lagrange interpolating polynomials, Spline interpolation); Regression

Eigen values and Eigen vectors

Power, inverse power, and inverse power method with shift, Fadeev-Leverrier method for the formulation of the Characteristic polynomials and QR decomposition

Numerical Differentiation

Introduction to finite difference approximations, Derivation of generalized finite difference approximation of any order and accuracy, truncation error analysis, Richardson's extrapolation

Numerical Integration

Newton-Cotes integration formula, Romberg integration and Gauss Legendre quadrature; Ordinary

Ordinary Differential Equations (Initial Value Problems)

Euler's method, Multi-step methods, Runge-Kutta methods, Predictor Corrector Methods. Stiff ODEs. System of IVPs, Stiff problems and Gear's method

Ordinary Differential Equations (Boundary Value Problems)
Decomposition into Linear System of ODEs, Shooting and direct methods;
Partial Differential Equations Introduction to solution of PDEs, Parabolic (diffusion equation and advective-diffusion equation), Elliptic (Laplace equation) and Hyperbolic (Wave equation) equations; Explicit and Implicit Methods, Crank Nicholson Method

Recommended Reading

1. Steven C. Chapra and Raymond P. Canale, Numerical Methods for Engineers, McGraw Hill
2. Santosh Gupta, Numerical Methods for Engineers, New age international publishers
3. J.B. Doshi, Differential Equations for Scientists and Engineers, Narosa, 2010
4. Kreyszig, Erwin, I.S., Advanced Engineering Mathematics, Wiley, 1999
5. C. F. Gerald and P.O. Wheatley, Applied Numerical Analysis, Pearson Education Asia, New Delhi, Sixth Edition, 2006.

Programme Name	***Master of Technology in Mechanical Engineering with specialization in CAD/CAM Robotics***
Course Code	**MECR5011T**
Course Title	**Computer Aided Design**

Course Outcomes

After completion of course, students would be able to

1. Evaluate mathematical transformations and projections of rigid bodies.
2. Design & model curves, surfaces & solids.
3. Represent objects realistically
4. Develop codes to solve engineering problems.

Course Contents

Introduction

Introduction to CAD. Role of CAD in Mechanical Engineering, Design process, software tools for CAD, Scan Conversion, Geometric modelling.

Transformations in Geometric Modelling

Introduction, Translation, Scaling, Reflection, Rotation in 2D and 3D. Homogeneous representation of transformation, Concatenation of transformations.

Representation of Curves

Analytic Curves, Composite Ferguson curves, Hermite Cubic Splines, curve Trimming and Blending, Bernstein polynomials, Bezier Curves, Bezier-subdivision, Degree elevation, Composite Bezier, Splines, B-spline basis functions, Properties of basic functions, Knot Vectors, NURBS.

Representation of Surfaces

Parametric representation, Planer, Sweep surfaces, Surface of revolution, Bi-linear , lofted, Coon‘s patch, Hermite, Bezier, B-Spline surfaces, Developable surfaces, Surfaces of revolution, Intersection of surfaces, Surface modelling.

Design of Solids

Solid entities, Boolean operations, B-rep of Solid Modelling, CSG approach of solid modelling, Data exchange formats, Geometric Modeling using Point Clouds, Reverse Engineering.

Feature Based Modeling

Feature recognition, types of features, feature recognition schemes, feature recognition methods, Artificial Intelligence for feature recognition.

Virtual Reality, Augmented Reality and Mixed Reality

Introduction to Geometric Modeling, Types of Geometric Modeling, Features of Wireframe, Surface and Solid models, Definition of VR , Features of VR, Real time Response, Optimization of the Rendering Process, Technologies used in VR, Stereo Displays, Interactions in VR, Tracking based interaction, Data Generation for VR, Haptic Rendering, Applications of VR, Simulation in VR, Augmented Reality, Mixed Reality.

Recommended Reading

1. Rogers & Adams , Mathematical Elements for Computer graphics, Tata McGraw –Hill, New Delhi, 2nd Edition, 2002
2. Michael E. Mortenson , Geometric Modeling, Tata McGraw Hill, 2013.
3. Saxena and B. Sahay, Computer-Aided Engineering Design, Anamaya Publishers, New Delhi, 2005
4. Ibrahim Zeid, R. Sivasubramanian, CAD/ CAM Theory & Practice, Tata McGraw Hill Publications, 5th edition, 2009
5. Kunwoo Lee, Principles of CAD/CAM/CAE systems, Addison-Wesley (1999).
6. Linda Jacobson, Garage Virtual Reality, Sams Publishing, 1994.
7. Ken Pimentel, Kevin Teixeira, Virtual Reality, Windcrest McGraw-Hill, 1st Edition, 2003.
8. John Vince, Virtual Reality Systems, Addison-Wesley. 1995.

Programme Name	***Masters of Technology in Mechanical Engineering with Specialization in CAD/CAM Robotics***
Course Code	**MECR5012T**
Course Title	**Smart Manufacturing**

Course Outcomes

After completion of course, students would be able to

1. Develop CNC programs for given part
2. Understand the techniques and process of reverse engineering
3. Understand different additive manufacturing techniques
4. To design complex geometries using design for additive techniques

Course Contents

Introduction to CNC machine tools:

Constructional features, drives and controls, feedback devices; interpolators: linear, circular interpolation and other emerging techniques; adaptive control systems; , Programming of CNC machines, Tool path generation, Direct Numerical Control. Automatically Programmed Tool (APT): post processors, use of various CAD/CAM software packages, CNC programming with CAD/CAM software, development of CNC programmes for special problems; micro/nano machining; additive manufacturing: recent developments

Reverse Engineering

Need for Reverse Engineering, Digitizing Methods and its Principles, Types measurements, Contact & Non-contact Types, Coordinate Measuring Machine (CMM), Capture devices, Sensors, Scanning Methods, 3D scanners, Data representation, Data processing and manipulation techniques. Applications.

Additive manufacturing (AM): overview of additive manufacturing, brief history of additive manufacturing, advantages and limitations of additive manufacturing, comparison with traditional manufacturing methods, ISO/ASTM definitions, classifications, applications of AM (medical, aerospace, automotive, molds and tooling, remanufacture and repair, scanning and reverse engineering, engineered structures, functionally graded structures, etc.,) hybrid additive/subtractive systems, process steps.

Data Processing for Additive Manufacturing: CAD Model Preparation, Part Orientation and Support Generation, STL File Generation, Defects in STL Files and Repairing Algorithms, Model Slicing: Slicing and various Slicing Procedures. Tool Path Generation, Additive Manufacturing Process Chain, Software for Additive Manufacturing Technology: MIMICS, MAGICS

Materials for AM: Atomic Structure and Bonding, Nature of Polymers, Thermoplastics and Thermosetting Polymers, Types of Polymerizations, Properties of Polymers, Degradation of Polymers, Metal and Ceramic Powders, Composites, Functionally Graded Materials (FGM's).

Liquid Based and Solid Based Additive Manufacturing Technologies: Classification, Liquid Based System, Stereolithography Apparatus (SLA): Principle, Process, Advantages and Applications. Solid Based System, Fused Deposition Modeling: Principle, Process, Advantages and Applications.

Laminated Object Manufacturing.

Powder Based Additive Manufacturing Technologies: Materials, Powder Fusion Mechanism, Process Parameters and Modeling, powder Handling, Selective Laser Sintering (SLS): Principle, Process, Advantages and Application of SLS, Three-Dimensional Printing: Principle, Process, Advantages and Applications of 3-D Printing, Laser Engineered Net Shaping (LENS), Electron Beam Melting.

Problem Areas of Additive Manufacturing: Accuracy and Strength Issues of AM Parts, Surface Roughness Problem in AM, Part Orientation and Other Issues like build time, support structure, cost etc.,

Design for additive Manufacturing, design guidelines for AM, Topology Optimization, AM materials, post processing: support removal, surface finish and geometry improvement, Aesthetic and property enhancement, safety considerations in AM, Introduction to hybrid AM systems. Introduction to various international (ISO/ASTM) and national standard (BIS) related to the AM. Recent advances in AM.

Introduction to Digital twin in manufacturing, Basics of Industrial IoT and 4.0

Recommended Reading

1. Chua Chee Kai and Leong Kah Fai, Rapid Prototyping Principles and Applications in Manufacturing, John Wiley & Sons, 1997.
2. K.P.Karunakaran, Rapid Product Development & Manufacturing, IIT, Bombay, 1st edition, 2013.
3. Peter D. Hilton and Paul F. Jacobs (Editors.), Rapid Tooling Technologies and Industrial Applications, Marcel Dekker. 4th edition, 2000.
4. P. N. Rao., CAD/CAM, Tata McGraw Hill Publications, 3rd edition, 2010.
5. Todd Grimm,User's Guide to Rapid Prototyping, Society of Manufacturing Engineers, 1st edition, 2004.
6. Paul F. Jacobs,Stereo-lithography and Other RP&M Technologies from Rapid Prototyping to Rapid Tooling, SME/ASME, 1996.
7. N. Hopkinson, R. J. M. Hague, and P.M. Dickens,Rapid Manufacturing , An Industrial Revolution for the digital age, John Wiley & Sons, Ltd, 2nd edition, 2006.
8. Ken Pimentel, Kevin Teixeira,Virtual Reality, Windcrest/McGraw-Hill, 1st edition, 2003.
9. Andreas Gebharatdt,Rapid Prototyping, Hanser Publishers,2nd edition – 2003.
10. Rafiq Noorani, Rapid Prototyping Principles and Applications, John Wiley & Sons -1st edition, 2006.
11. Wasim Ahmed Khan, Abdul Raouf, Kai Cheng, Virtual Manufacturing, Springer, 2011

Programme Elective-I

Programme Name	***Master of Technology in Mechanical Engineering with specialization in CAD/CAM Robotics***
Course Code	**MECR5021S**
Course Title	**Industry 4.0 and IIoT**

Course Outcomes

The student should be able to

1. Understand key concepts of Industry 4.0
2. Understand the drivers and enablers of Industry 4.o
3. Learn about various IIoT-related protocols
4. Build simple IIoT Systems using Arduino and Raspberry Pi

Course Contents

Fundamentals of Industry 4.0

Industry 4.0 Globalization and Emerging Issues, The Fourth Revolution, Lean Production Systems, Mass Customization, Smart and Connected Business Perspective, Smart Factories, Industry 4.0 Cyber Physical Systems and Next Generation Sensors, Collaborative Platform and Product Lifecycle Management, Augmented Reality and Virtual Reality, Big Data and Advanced Analysis, Data Analytics in Manufacturing such as Advanced Sensor Technologies, Artificial Intelligence, Internet of Robotic Things, Cloud Robotics.

Introduction to IIoT

Architectural Overview, Design principles and needed capabilities, IoT Applications, Sensing, Actuation, Basics of Networking, M2M and IoT Technology Fundamentals- Devices and gateways, Data management, Business processes in IoT, Everything as a Service (XaaS), Role of Cloud in IoT, Security aspects in IoT.

Elements of IIoT

Hardware Components- Computing (Arduino, Raspberry Pi), Communication, Sensing, Actuation, I/O interfaces. Software Components- Programming API's (using Python/Node.js/Arduino) for Communication Protocols-MQTT, ZigBee, Bluetooth, CoAP, UDP, TCP.

IIoT Application Development

Solution framework for IoT applications- Implementation of Device integration, Data acquisition and integration, Device data storage- Unstructured data storage on cloud/local server, Authentication, authorization of devices.

Smart Applications

Online Predictive Modeling, Monitoring and Intelligent Control of Machining/Manufacturing and Logistics/Supply Chain Processes; Smart Energy Management of manufacturing processes and facilities, Agriculture, Healthcare, Home Automation, applications in continuous manufacturing such as cement industry, AI enabled data analysis of continuous manufacturing.

Recommended Reading

1. Introduction to Industrial Internet of Things and Industry 4.0, Sudip Misra, Chandana Roy, Anandarup Mukherjee, CRC Press, 2020.
2. Industry 4.0 the industrial internet of things, Alasdair Gilchrist, Apress Publisher, 2016.
3. Industry 4.0 Managing The Digital Transformation, Alp Ustundag, EmreCevikcan, Springer, 2018.
4. Digital Manufacturing and Assembly Systems in Industry 4.0 (Science, Technology, and Management), Kaushik Kumar , Divya Zindani J,Paulo Davim, CRC Press.
5. Smart Manufacturing by Shoukat Ali; Publisher LAP LAMBERT Academic Publishing(10 August 2016)
6. Introduction to Internet of Things A practical Approach, Dr. SRN Reddy, Rachit Thukral and Manasi Mishra, ETI Labs,2010
7. The Internet of Things Enabling Technologies, Platforms, and Use Cases, Pethuru Raj and Anupama C. Raman, CRC Press, 2012
8. Designing the Internet of Things, Adrian McEwen, Wiley, 2015
9. A. McEwen and H. Cassimally, Designing the Internet of Things, 1st edition, Wiley, 2013, ISBN-10 111843062X.
10. Industry 4.0, AI, and Data Science Research Trends and Challenges, Vikram Bali,Kakoli Banerjee, Narendra Kumar , Sanjay Gour, Sunil Kumar Chawla
11. The concept Industry 4.0- An Empirical Analysis of Technologies and Applications in Production Logistics, Christoph Jan Bartodziej, Springer Gabler, 2017.

Programme Name	***Master of Technology in Mechanical Engineering with specialization in CAD/CAM Robotics***
Course Code	**MECR5022S**
Course Title	**Artificial Intelligence in Manufacturing**

Course Outcomes

The student should be able to

1. Describe and explain the basic concepts of Artificial Intelligence and its applications.
2. Identify suitable methods to collect data for Artificial Intelligence systems.
3. Apply various algorithms for developing neural networks.
4. Apply Artificial Intelligence techniques for manufacturing applications.

Course Contents

Fundamentals: Historical development, key concepts and terminology, ethical and societal considerations. Problem Solving by Search: Fundamentals, application to manufacturing scenarios, case studies in manufacturing. Key AI Technologies: Machine learning and deep learning. Applications in quality control, predictive maintenance, and process optimisation. Role of data in AI applications and its acquisition in manufacturing.

Data sources in manufacturing, sensors IoT devices: Techniques for data acquisition and real-time monitoring in industrial settings. Challenges in managing and storing manufacturing data. Data preprocessing techniques for cleaning and structuring data. Feature selection and engineering for AI model inputs. Data visualisation and analysis techniques for manufacturing insights.

Supervised and Unsupervised Learning: Fundamentals, Overview of supervised and unsupervised learning algorithms, Applications in quality control, anomaly detection, and process optimization, Model selection and evaluation for manufacture. Deep learning techniques, convolutional neural networks and recurrent neural networks, Integration of robotics and AI in manufacturing processes, Case studies of AI-driven improvements in manufacturing efficiency and quality.

Real-world Applications in Manufacturing: AI-driven process optimization and quality control, AI's role in supply chain management, demand forecasting, and production scheduling. Sustainable and green manufacturing through AI. Future Trends and Preparing for Industry 5.0: Challenges and opportunities in the evolving landscape of AI in manufacturing. The role of AI in fostering innovation and competitiveness. Preparing for the future of manufacturing with AI skills and knowledge.

References:

[1] Russell, S., and Norvig, 2022, Artificial Intelligence: A Modern Approach, Pearson India.

[2] Geron, A., 2019, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, O Reilly.

[3] Nilsson, N.J., 1998, Artificial Intelligence – A New Synthesis, Morgan Kaufmann Publishers, Inc.

[4] Tran, K.P., 2023, Artificial Intelligence for Smart Manufacturing - Methods, Applications, and Challenges, Springer.

[5] Chen, T.T., 2023, Explainable Artificial Intelligence (XAI) in Manufacturing - Methodology, Tools, and Applications, Springer.

Programme Elective-II

Programme Name	***Master of Technology in Mechanical Engineering with specialization in CAD/CAM Robotics***
Course Code	**MECR5031S**
Course Title	**Characterization of Engineering Materials**

Course Outcomes

The student should be able to

1. Identify advanced techniques available for characterization of materials.
2. Select a characterization technique to evaluate the behavior of materials
3. Analyze defects and failure surfaces of materials
4. Analyze the characterization results by various equipment

Course Contents

Introduction

Overview of the course; materials classification and their properties, Importance of materials selection, property classification, Criteria for selection of materials, Ashby charts for materials selection, Engineering Design process and the role of materials; material property charts; selection of materials based on function, objective, constraints and free variables; examples of material selection for typical applications.

Computer aided materials selection

Selection of process based on material classification; pencil curve approach; material selection for multiple constraints and multiple objective cases; multiple constraints and conflicting objectives. Co- selection of material and shape; concept of macroscopic and microscopic shape factors; Four quadrant method of material selection. General Properties of plastics, polymers and elastomers; visco-elastic properties; short-term and long-term properties of plastics.

High temperature materials

Families of super alloys and their characteristics; creep and fatigue resistance of super alloys; role of precipitates in strengthening of super alloys; repair of super alloys after creep damage; coatings for high temperature materials.

Fundamentals of ceramics

General properties, applications of ceramics for critical applications. Design considerations. Surface treatment of materials using coatings; type of coatings; PVD and CVD coatings. Basics of electro-plating and electro-less plating.

Physical characterization of materials

Optical Microscopy, SEM,TEM, Density, Void content in materials, Electron Probe Micro Analyzer (EPMA), Atomic Force Microscopy (AFM), Thermogravimetric analysis (TGA), nano indentation, NMR spectroscopy, EDAX, FTIR, XRD.

Mechanical characterization

Tensile test, flexural test, compression test, ILSS, creep, fatigue, Hardness, Impact test, Fracture toughness test, Principle, construction and operation working parameters, equipment operation. selection of plastics based on mechanical properties, degradation due to environment, of laminates, Characterization of corrosion and erosion of engineering materials.

Recommended Reading

1. M.F. Ashby, Materials Selection in Mechanical Design, Butterworth Heinemann, 4th Edition, 2010
2. Yang Leng, Materials Characterization-Introduction to Microscopic and Spectroscopic Methods, John Wiley & Sons (Asia) Pte Ltd, 2008
3. ASM Handbook Materials Characterization, ASM International, 2008.
4. V. T. Cherapin and A. K. Mallik, Experimental Techniques in Physical Metallurgy, Asia Publishing House, 1967.
5. Dieter, George E., Mechanical Metallurgy, McGraw Hill, 2nd Edition, 2005
6. Crawford, R. J., Plastics Engineering, Butterworth-Heinemann, 3rd Edition, 2002.
7. Donachie, M. J. and Donachie, S. J., Super alloys A technical guide, ASM International, 2002.

Programme Name	***Master of Technology in Mechanical Engineering with specialization in CAD/CAM Robotics***
Course Code	**MECR5032S**
Course Title	**Control Systems in Robotics**

Course Outcomes

After completion of the course the student should be able to

1. Demonstrate the knowledge of basic control theories used in the robotic systems
2. Apply proper PID control techniques when designing smart devices or robotics that show proper dynamic behaviors.
3. Establish mathematical models based on the electrical and mechanical principles
4. Demonstrate ability to communicate effectively and work as contributing partners for group projects

Course Contents

Overview and Brief History of Feedback Control. A Perspective on Feedback Control; A Simple Feedback System; A First Analysis of Feedback; Feedback System Fundamentals.

Dynamic Models. Dynamics of Mechanical Systems; Translational Motion; Rotational Motion; Combined Rotation and Translation; Complex Mechanical Systems; Distributed Parameter Systems; Summary: Developing Equations of Motion for Rigid Bodies; Models of Electromechanical Systems; Heat and Fluid-Flow Models

Dynamic Response. Review of Laplace Transforms; Response by Convolution; Transfer Functions and Frequency Response; The L− Laplace Transform; Properties of Laplace Transforms; Inverse Laplace Transform by Partial-Fraction Expansion; The Final Value Theorem; Using Laplace Transforms to Solve Differential Equations; Poles and Zeros; Linear System Analysis Using Matlab; System Modeling Diagrams; The Block Diagram; Block-Diagram Reduction Using Matlab; Mason's Rule and the Signal Flow Graph; Effect of Pole Locations; Time-Domain Specifications; Rise Time; Overshoot and Peak Time; Settling Time; Effects of Zeros and Additional Poles; Stability; Bounded Input—Bounded Output Stability; Stability of LTI Systems; Routh's Stability Criterion; Obtaining Models from Experimental Data: System Identification; Amplitude and Time Scaling.

A First Analysis of Feedback. The Basic Equations of Control; Stability; Tracking; Regulation; Sensitivity; Control of Steady-State Error to Polynomial Inputs: System Type; System Type for Tracking; System Type for Regulation and Disturbance Rejection; The Three-Term Controller: PID Control; Proportional Control (P); Integral Control (I); Derivative Control (D); Proportional Plus Integral Control (PI); PID Control; Ziegler—Nichols Tuning of the PID Controller.

The Root-Locus Design Method. Root Locus of a Basic Feedback System; Guidelines for Determining a Root Locus; Rules for Determining a Positive Root Locus; Summary of the Rules for Determining a Root Locus; Selecting the Parameter Value; Selected Illustrative Root Loci; Design Using Dynamic Compensation; Design Using Lead Compensation; Design Using Lag Compensation; Design Using Notch Compensation; Analog and Digital Implementations; A Design Example Using the Root Locus; Extensions of the Root-Locus Method; Rules for Plotting a Negative Root Locus; Consideration of Two Parameters; Time Delay.

The Frequency-Response Design Method. Frequency Response; Bode Plot Techniques; Steady-State Errors; Neutral Stability; The Nyquist Stability Criterion; The Argument Principle; Application of The Argument Principle to Control Design; Stability Margins; Bode's Gain—Phase Relationship; Closed-Loop Frequency Response; Compensation; PD Compensation; Lead Compensation; PI Compensation; Lag Compensation; PID Compensation; Design Considerations.

State-Space Design. Advantages of State-Space; System Description in State-Space; Block Diagrams and State-Space; Analysis of the State Equations; Block Diagrams and Canonical Forms; Dynamic Response from the State Equations; Control-Law Design for Full-State Feedback; Finding the Control Law; Introducing the Reference Input with Full-State Feedback; Selection of Pole Locations for Good Design; Dominant Second-Order Poles; Symmetric Root Locus (SRL).

Digital Control. Digitization; Dynamic Analysis of Discrete Systems; z-Transform; z-Transform Inversion; Design Using Discrete Equivalents; Tustin's Method; Zero-Order Hold (ZOH) Method; Matched Pole—Zero (MPZ) Method; Modified Matched Pole—Zero (MMPZ) Method; Applicability Limits of the Discrete Equivalent Design Method; Hardware Characteristics; Sample-Rate Selection.

Recommended Reading

1 Feedback Control of Dynamic Systems, 7th Edition Gene F. Franklin, J. David Powell, and Abbas Emami-Naeini Pearson, 2015

2 Control Systems Engineering, Sixth Edition, Norman S. Nise Publisher, John Wiley & Sons., Inc. 2011

3 Modern Control Systems, 12th Edition Richard C. Dorf and Robert h. Bishop Prentice Hall, 2011

Open Elective-I

Programme Name	**Masters of Technology in Mechanical Engineering with Specialization in CAD/CAM Robotics**
Course Code	**MECR5061S**
Course Title	**3D Printing**

Course Outcomes

After completion of course, students would be able to

1. Understand and evaluate various existing Product Development processes
2. Develop new technologies in the field Rapid Prototyping Manufacturing
3. Generate innovative ideas to reduce time and cost by developing new methods and materials for the modern manufacturing industry.

Course Contents

Introduction to additive manufacturing (AM): overview of additive manufacturing, brief history of additive manufacturing, advantages and limitations of additive manufacturing, comparison with traditional manufacturing methods, ISO/ASTM definitions, classifications, applications of AM (medical, aerospace, automotive, molds and tooling, remanufacture and repair, scanning and reverse engineering, engineered structures, functionally graded structures, etc.,) hybrid additive/subtractive systems, process steps.

Data Processing for Additive Manufacturing: CAD Model Preparation, Part Orientation and Support Generation, STL File Generation, Defects in STL Files and Repairing Algorithms, Model Slicing: Slicing and various Slicing Procedures. Tool Path Generation, Additive Manufacturing Process Chain, Software for Additive Manufacturing Technology: MIMICS, MAGICS

Materials for AM: Atomic Structure and Bonding, Nature of Polymers, Thermoplastics and Thermosetting Polymers, Types of Polymerizations, Properties of Polymers, Degradation of Polymers, Metal and Ceramic Powders, Composites, Functionally Graded Materials (FGM's).

Liquid Based and Solid Based Additive Manufacturing Technologies: Classification, Liquid Based System, Stereolithography Apparatus (SLA): Principle, Process, Advantages and Applications. Solid Based System, Fused Deposition Modeling: Principle, Process, Advantages and Applications. Laminated Object Manufacturing.

Powder Based Additive Manufacturing Technologies: Materials, Powder Fusion Mechanism, Process Parameters and Modeling, powder Handling, Selective Laser Sintering (SLS): Principle, Process, Advantages and Application of SLS, Three-Dimensional Printing: Principle, Process, Advantages and Applications of 3-D Printing, Laser Engineered Net Shaping (LENS), Electron Beam Melting.

Problem Areas of Additive Manufacturing: Accuracy and Strength Issues of AM Parts, Surface Roughness Problem in AM, Part Orientation and Other Issues like build time, support structure, cost etc.,

Design for additive Manufacturing, design guidelines for AM, Topology Optimization, AM materials, post processing: support removal, surface finish and geometry improvement, Aesthetic and property enhancement, safety considerations in AM, Introduction to hybrid AM systems.

Introduction to various international (ISO/ASTM) and national standard (BIS) related to the AM. Recent advances in AM, 4D printing, bioprinting, case studies, hands on experience in designing and fabricating AM parts.

Recommended Reading

1. Chua Chee Kai and Leong Kah Fai, Rapid Prototyping Principles and Applications in Manufacturing, John Wiley & Sons, 1997.
2. K.P.Karunakaran,Rapid Product Development & Manufacturing, IIT, Bombay, 1st edition, 2013.
3. Peter D. Hilton and Paul F. Jacobs (Editors.), Rapid Tooling Technologies and Industrial Applications, Marcel Dekker. 4th edition, 2000.
4. Todd Grimm,User's Guide to Rapid Prototyping, Society of Manufacturing Engineers, 1st edition, 2004.
5. Paul F. Jacobs,Stereo-lithography and Other RP&M Technologies from Rapid Prototyping to Rapid Tooling, SME/ASME, 1996.
6. N. Hopkinson, R. J. M. Hague, and P.M. Dickens,Rapid Manufacturing , An Industrial Revolution for the digital age, John Wiley & Sons, Ltd, 2nd edition, 2006.
7. Ken Pimentel, Kevin Teixeira,Virtual Reality, Windcrest/McGraw-Hill, 1st edition, 2003.
8. Andreas Gebharatdt,Rapid Prototyping, Hanser Publishers,2nd edition – 2003.
9. RafiqNoorani, Rapid Prototyping Principles and Applications, John Wiley & Sons -1st edition, 2006.
10. Wasim Ahmed Khan, Abdul Raouf, Kai Cheng, Virtual Manufacturing, Springer, 2011

Laboratory Courses

Programme Name	***Masters of Technology in Mechanical Engineering with Specialization in CAD/CAM Robotics***
Course Code	**MECR5071L**
Course Title	**Laboratory-1 Computational Methods Laboratory**

Course Outcomes

After completion of course, students would be able to

1. Write codes that use computational methods to numerically solve problems in a variety of disciplines in Mechanical Engineering.
2. Learn open source packages that implement popular computational methods.
3. Apply the mathematical concepts the Computational Methods course.

Course Contents

The lab will involve development of programs based on numerical methods using Python/Matlab/Scilab etc. for solving variety of common Mechanical Engineering problems.

1. Program for solving system of linear equations
2. Program for regression analysis and curve / function fitting to a given data set
3. Program for root finding on non-linear equation
4. Program for Numerical Differentiation and Integration
5. Program for solving differential equations based on Runge-Kutta formulation
6. Program for Boundary Value Problems in Ordinary and Partial Differential Equations

Programme Name	***Master of Technology in Mechanical Engineering with specialization in CAD/CAM Robotics***
Course Code	**MECR5072L**
Course Title	**Laboratory-2 Computer Aided Design Laboratory**

Course Outcomes

After completion of course, students would be able to

1. Plot geometric entities using scan conversion algorithm
2. Develop computer codes for curves and surfaces
3. Model the part and geometries using commercial CAD software
4. Understand use of AI in CAD modeling & VR/AR/MR applications

List of experiments

1. Development of computer code for scan conversion algorithms
2. Development of computer code for transformations
3. Development of computer code for curves
4. Development of computer code for surfaces
5. Sketching and Part modelling using CAD software
6. Surface modelling using CAD software
7. Assembly modelling and drafting using CAD software
8. Creating VR/AR/MR applications using Unity software
9. Case studies on use of AI in CAD modeling

Programme Name	***Master of Technology in Mechanical Engineering with specialization in CAD/CAM Robotics***
Course Code	**MECR5073L**
Course Title	**Laboratory-3 Smart Manufacturing Laboratory**

Course Outcomes

After completion of course, students would be able to

1. Process 'STL' files from 3D models and Assemblies
2. Build rapid prototyping parts using FDM process
3. Apply surface finish enhancement techniques on FDM parts.
4. Develop CNC part programmes.

List of Experiments

1. Development of 3D CAD models and Assemblies using CAD Software to generate STL files.
2. Processing of STL files of 3D modelled parts/assemblies
3. Building Rapid Prototyping (FDM) parts/assemblies
4. Modeling of Engineering components and conversion of STL/OBJ/STEP format
5. 3D printing of modeled component by varying infill pattern, layer thickness, orientation on build time using a slicing software.
6. Tool path generation using CAM software Introduction to 'CAM' software, Importing and modifying 3D geometry, Selecting tools, Generating operation, specific tool path, Generating G-codes and M-codes in 'CAM' software
7. CNC part programming on CNC machine Introduction to existing CNC machine in the lab, Introduction and details of its corresponding control software, Machining parts, as per given drawings.
8. Using Coordinate Measuring Machine Demonstration on existing CMM machine, Introduction and details of controlling software, Measuring various components.
9. Modeling of component using 3d scanner real life object of unknown dimension in reverse engineering.

SEMESTER-II

Programme Name	***Master of Technology in Mechanical Engineering with specialization in CAD/CAM Robotics***
Course Code	**MECR5002S**
Course Title	**Research Methodology and IPR**

COURSE OUTCOMES:

The student should be able to

1. Understand research problem formulation and approaches of investigation of solutions for research problems.
2. Design and validate the hypothesis
3. Develop a research design for a specific problem
4. Understand the Discover importance of Intellectual Property Rights.
5. Develop a skill to organize and write a research reports

Course Contents

Research Problem

Meaning of research problem, Types of research: descriptive, analytical, empirical research. 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, Scaling Techniques.

Research Process:

Problem formulation, planning research study, research design, instruments/techniques of data collections, analysis and presentation of data, conclusions.

Introduction to Probability Theory and statistics

Probability Theory and Sampling Distributions. Basic probability theory along with examples. Standard discrete and continuous distributions like Binomial, Poisson, Normal, Exponential etc. Central Limit Theorem and its significance. Some sampling distributions like $\chi 2$, t, F.

Research Methodology:

Research methodology and research methods. Basic principles of experimental design. Hypothesis Formulation. Hypothesis Testing. Sampling: Different types of sample design and steps in sampling. Design of Experiments. Softwares for data analysis.

Technical Writing:

Effective literature studies approaches. Plagiarism. Research ethics. Effective technical writing. Content and Outline of report, Research Proposals, Format of research proposal, a presentation and assessment by a review committee. Citations. Proof reading.

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, Patenting under PCT.

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

Introduction to Technology Readiness Levels

Nine levels of TRL

References:

1. Ranjit Kumar, Research Methodology: A Step by Step Guide for beginners, SAGE Publisher, 3rd Edition
2. C.R. Kothari, Research Methodology: Methods and Techniques, New Age International Publisher, 2nd Revised Edition.
3. Dbora Halbert, Resisting Intellectual Property, Taylor & Francis, 1st Edition.
4. Mayall, Industrial Design, McGraw Hill, 1992.

Programme Name	***Master of Technology in Mechanical Engineering with specialization in CAD/CAM Robotics***
Course Code	**MECR5013T**
Course Title	**Robotics & Automation**

Course Outcomes

After completion of course, students would be able to

1. Analyze various types Robots and their applications
2. Understand terminologies related to Kinematics of Robotics.
3. Analyze basics of motion programming as per kinematics
4. Apply logic for selection of robotic systems and its application in automation.

Course Contents

Introduction to Robotics

Brief History, Basic Concepts of Robotics such as Definition , Three laws, Elements of Robotic Systems i.e. Robot anatomy, DOF, Misunderstood devices etc., Classification of Robotic systems on the basis of various parameters such as work volume, type of drive, etc., Associated parameters i.e. resolution, accuracy, repeatability, dexterity, compliance, etc., Introduction to Principles & Strategies of Automation, Types & Levels of Automations, Need of automation, Industrial applications of robot. Robotics application current and future.

Grippers and Sensors for Robotics

Grippers for Robotics - Types of Grippers, Guidelines for design for robotic gripper, Force analysis for various basic gripper systems. Sensors for Robots - Types of Sensors used in Robotics, Classification and applications of sensors, Characteristics of sensing devices, Selections of sensors. Need for sensorsand vision system in the working and control of a robot.

Drives and Control for Robotics

Drive - Types of Drives, Types of transmission systems, Actuators and its selection while designing a robot system. Control Systems Types of Controllers, Introduction to closed loop control

Robot Kinematics

Spatial Descriptions positions, orientations, and frame, mappings changing description from frame to frame, Operators translations, rotations and transformations, transformation arithmetic, compound Transformations, inverting a transform, transform equations, Euler Angles, Fixed Angles, Euler Parameters. Manipulator Kinematics, Link Description, Link to reference frame connections, Denavit-Hartenberg Approach, D-H Parameters, Position Representations, Homogeneous Transformation Matrix, Forward Kinematics. Inverse Kinematics, Geometric and analytical approach.

Trajectory Planning

Introduction, path vs trajectory, joint space vs Cartesian space description, basics of tractor planning, joint space trajectory planning Third order polynomial, Fifth order polynomial, linear segment with parabolic blends, linear segment with parabolic blends and via points, higher order trajectories, etc.

Computer vision for robotic system

Imaging Components, Image Representation, Hardware Considerations, Picture Coding, Object Recognition and Categorization, Software Considerations, Need for Vision Training and

Adaptations, Review of Existing Systems, etc.

Computer Considerations for Robotic Systems

Objectives, Motivation, Architectural Considerations, Hardware Considerations, Computational Elements in Robotic Applications, Real-Time Considerations, Robot Programming, Path Planning, etc.

Manufacturing Systems

Fundamentals of Manufacturing systems, Group Technology(GT), Flexible Manufacturing Systems(FMS), Transfer lines, Material handling systems, Automated Guided Vehicles (AGVs), Automated Storage & Retrieval Systems(ASRS).

Related Topics in Robotics

Socio-Economic aspect of robotisation. Economical aspects for robot design, Safety for robot and standards, Introduction to Artificial Intelligence, AI techniques, Need and application of AI, New trends & recent updates in robotics.

Recommended Reading

1. Robert J Schilling, Fundamentals of Robotics Analysis & ControlPearson Education, Inc., 2007.
2. S. B. Niku, Introduction to Robotics – Analysis, Control, Applications, 3rd edition, JohnWiley & Sons Ltd., 2020
3. R. K. Mittal, I. J. Nagrath, Robotics and Control, TATA McGraw Hill Publishing Co Ltd,New Delhi, 2003.
4. Groover, M. P., Automation production systems, and computer-integrated manufacturing, second edition, Prentice-Hall of India, New Delhi, 3rd edition, 2007.
5. R. D. Klafter, Thomas A. Chmielewski, and Mechael Negin, Robotic Engineering – An Integrated Approach, EEE, Prentice Hall India, Pearson Education Inc., 2009.
6. Vajpayee, S. K., Principles of computer-integrated manufacturing, Prentice-Hall of India, New Delhi, 2005.
7. J. Angeles, Fundamentals of Robotic Mechanical Systems Theory Methods and Algorithms, Springer,1997
8. S. K. Saha, Introduction to Robotics 2nd edition, TATA McGraw Hills Education, 2014.
9. Ashitava Ghosal, Robotics Fundamental Concepts and Analysis, Oxford University Press, 2006.
10. T. C. Manjunath, Fundamentals of Robotics, Nandu Printers and Publishers, 2010.

Programme Name	***Masters of Technology in Mechanical Engineering with Specialization in CAD/CAM Robotics***
Course Code	**MECR5014T**
Course Title	**Advanced Finite Element Analysis**

Course Outcomes

After completion of course, students would be able to

1. Formulate numerical model for a given system.
2. Obtain numerical Solutions for boundary value problems.
3. Solve mechanical engineering problems using Finite Element Methods.

Course Contents

Introduction to Finite Element Analysis

Introduction, Basic concept of Finite Element analysis, Discretization of continuum, Stiffness Matrix and Boundary Conditions, Introduction to elasticity, Plane Stress and Plain strain Problem

Finite Element Formulation Techniques

Virtual Work and variational principle, Variational Formulation of Boundary Value problem, Variational Method such as Ritz and weighted Residual methods. Galerkin Method Potential Energy Approach, Displacement Approach

Element Properties

Natural coordinates, Triangular Elements, Rectangular Elements, Lagrange and Serendipity Elements, Solid Elements, Isoparametric Formulation, Stiffness Matrix for Isoparametric Elements, Numerical Integration

Displacement Models

Convergence requirements, Shape functions, Element stresses and strains, Strain-Displacement Matrix for Bar Element, Strain Displacement Matrix for CST Element, Strain Displacement Relation for Beam Element

Analysis of Frame Structure

Stiffness of Truss Members, Analysis of Truss, Stiffness of Beam Members, Finite Elements analysis of Beam

FEM for Two Dimensional Solids

Constant and Linear Stain Triangle, Rectangular Elements, Finite Element Formulation for 2D elements. Axisymmetric Elements. Finite Element Formulation of Axisymmetric Elements Heat Transfer by conduction and convection for one dimensional and two-dimensional elements

Dynamic Analysis Using FEA

Introduction, Vibration Problems, Equation of motion Based on weak form and Lagrange's Approach, Consistent and Lumped ass Matrices, Properties and Solution of Eigen Value Problems, Transient Vibration Analysis, Thermal transient-Unsteady heat Transfer in a Pin-Fin

Nonlinear Analysis

Introduction, Geometric and Material Nonlinearity, Stability Problems, Elastoplastic analysis by FEM

Recommended Reading

1. Finite Elemenet Analysis By S.S.Bhavikatti, New Age International Publication.
2. Introduction to FEM by Desai and Abel
3. The Finite Element Method for Solid and Structural Mechanics –Zienkiewicz & Taylor, Elsevier Publications
4. Finite Element Analysis by J.N. Reddy, McGraw Hill Book Co.
5. Finite Element Method in Engineering by S.S.Rao, Pergamon Press
6. Textbook on Finite Element Analysis by P. Seshu, Prentise Hall Publications
7. Finite Element Analysis by Bathe and Wilson
8. Introduction to Finite Element Analysis by T. *Chandrupatla* and A. D. Belegundu, Prentice Hall
9. Finite Element Modeling For Stress Analysis for Robert D.Cook , John Wiley & Sons.
10. Computational Elasticity by Mohammad Ameen, Narosa Publishing House.

Programme Elective-III

Programme Name	***Master of Technology in Mechanical Engineering with specialization in CAD/CAM Robotics***
Course Code	**MECR5041S**
Course Title	**Mechatronics**

Course Outcomes

After completion of course, students would be able to

1. Enable the student to understand the modern mechatronics components
2. Present the underlying principles and alternatives for mechatronics systems design
3. Evaluate the design and programming for Microprocessor,. Microcontroller,. PLC and application of control theory

Course Contents

Introduction of Mechatronics and its block diagram representation

Key elements of mechatronics, Applications of Mechatronics domestic, industrial etc. Representation of mechatronic system in block diagram and concept of transfer function for each element of mechatronic system, Reduction methods and its numerical treatment for represented block diagram

Selection of Sensors & Actuators

Sensors Criteria for selection of sensors based on requirements, principle of measurement, sensing method, performance chart etc. (Displacement, temperature, acceleration, force/pressure) based on static and dynamic characteristics.

Actuators Selection of actuators based on principle of operation, performance characteristics, maximum loading conditions, safety etc. Principle and selection of mechano-electrical actuators

Low cost Automation circuits

Pneumatic devices Different types of valves, Actuators and auxiliary elements in Pneumatics their applications and use of their ISO symbols, Synthesis and design of circuits (up to 2 cylinders)–pneumatic, electro- pneumatics, Electro-pneumatic actuator, control valves, valve sizing valve selection. Electrical actuating systems solid-state switches, solenoids.

Microprocessor & Microcontroller System Theory

Microprocessor Introduction to Microprocessors, microcomputer and single chip microcomputer, Components of Microprocessor Registers, ALU and control & timing, CPU, I/O devices, clock, memory, bussed architecture, tri-state logic, address bus, data bus and control bus,. Architecture of 8085 Microprocessor,. Instruction Set,. Assembly Language Programming,. Advanced Microprocessors (RISC and CISC Architecture, Intel advanced microprocessors, ARM and SUN SPARC)

Microcontroller Introduction to Microcontroller and its families, Criteria for Choosing Microcontroller. Microcontroller Architecture, Programming model, Addressing modes, Instruction sets, Assembly and C programming for Microcontroller, I/O programming using assembly and C language, Interrupt Controller, I/O interfacing, Timers, Serial Communication, LCD Controller. Different types of Sensors. Microcontroller Interfacing Introduction to Microcontroller Interfacing and applications case studies Display Devices, Data Acquisition Systems, controllers and Drivers for DC, Servo and Stepper Motor

Control System
Control system design and analysis by Root Locus Method, P, I and D control actions, P, PI, PD and PID control systems, Transient response- Percentage, overshoot, Rise time, Delay time, Steady state error, PID tuning (manual)

Discrete Control System PLC (Programming Logic Control)Theory
Introduction to PLC, Architecture, Ladder Logic programming for different types of logic gates, Latching, Timers, Counter, Practical Examples of Ladder Programming.

Research Assignment

Each team of 4-5 students will submit a case study of a mechatronics device. The research assignment will constitute collection of literature, model of the device, development of the mathematical model and its controller design for different control tasks. Finally, each team has to submit a detailed report along with a presentation. The team can demonstrate the case. SIMULINK is a graphical environment for modelling, simulation, and analysis of dynamic systems, and is available as an extension to MATLAB.

Recommended Reading

1. Mechatronics by W. Bolton; Addison Wesley Longman Pvt. Ltd.
2. Gaonkar R. S., Microprocessor Architecture, Programming and Applications
3. Automation Production System and CIMS by Mikel P Groover; Prentice Hall.
4. Mechatronics by Hegde; Jones and Bartlett
5. Applied Mechatronics by Samili and Mrad Oxford University Press
6. Design with Microprocessors for Mechanical Engineers by Stiffler McGraw-Hill
7. C.W.De Silva, Mechatronics An Integrated Approach, Publisher CRC

Programme Name	***Master of Technology in Mechanical Engineering with specialization in CAD/CAM Robotics***
Course Code	**MECR5042S**
Course Title	**Product Lifecycle Management**

Course Outcomes

After completion of course, students would be able to

1. Understand the different element of PLM system.
2. Evaluate and select the proper PLM system as per the need of organization
3. Apply and design the various strategies for process and product data management

Course Contents

Introduction

Introduction, What is a product?, PLM What is it?, Product Lifecycle Management background Corporate challenges Product data or Product information.

Product Lifecycle Management (PLM), Product lifecycle management concept, Items, Product lifecycle management systems, System architecture, Information models and product structures, Information model, The product information (data) model, The product model, Reasons for the deployment of PLM systems

Product lifecycle management systems

Functionality of the systems, Use of product lifecycle management systems in different, organization verticals, Product development and engineering, Production, After sales, Sales and marketing, Sub-contracting, Sourcing and procurement. Product structures Product structure of a ship, Product structure of a cellular telephone, Product structure of a customizable product, Product structure of a configurable service product

Integration and Deployment of the PLM system

Different ways to integrate PLM systems, Transfer file, Database integration, System roles, ERP, CAD, Configurators, EAI etc. Different stages of deployment, Study of present and objective processes (AS IS and TO BE), Choosing a system, Realization stage of the project, Accomplishing change in the organization.

Challenges of product management in manufacturing industry

Special challenges of product management in the high tech industry, Case 1 Electronics manufacturer, Case 2 An engineering product, Frame of reference for product management, Developing product lifecycle management in project workshop Plc, The advantages and development potential brought by the product lifecycle management system, Case 3 Capital goods manufacturer and customer-specifically variable product

Service industry and the role of product information management in collaborative business development

Introduction, What is a service?, PLM in service business, Case 4 An IT-service (managed services) provider and a customer-specifically variable product. CIM Computer integrated manufacturing, CE

Concurrent engineering, Product lifecycle management as an enabler of cooperation between companies, Contents of collaboration, Successful cooperation, Tools of collaboration, CPC, ePDM, etc.

Recommended Reading

1. Antti Saaksvuori, AnselmiImmonen, Product Life Cycle Management - Springer, 1st Edition (Nov.5, 2003)
2. Grieves, Michael, Product Lifecycle Management, McGraw-Hill, 2006. ISBN 0071452303
3. Stark, John. Product Lifecycle Management Paradigm for 21st Century Product Realization, SpringerVerlag, 2004. ISBN 1852338105

Programme Name	*Master of Technology in Mechanical Engineering with specialization in CAD/CAM Robotics*
Course Code	**MECR5043S**
Course Title	**Advanced Robotics**

Course Outcomes

After completion of course, students would be able to

1. Analyze various components of machine tool and their applications
2. Understand fundamental concepts in machine tool design
3. To know about various common techniques used in design of machine components.

Course Contents

Introduction: Review, forward and inverse kinematics, dynamics

Robots with Flexible Elements: Robots with Flexible Joints, Robots with Flexible Links

Parallel Mechanisms and Robots: Definitions, Type Synthesis of Parallel Mechanisms, Kinematics, Velocity and Accuracy Analysis, Singularity Analysis, Workspace Analysis, Static Analysis and Static Balancing, Dynamic Analysis, Design Mobile Robots:

Wheeled mobile robots: mobile robot kinematics, Mobility of Wheeled Robots, State-Space Models of Wheeled Mobile Robots, Wheeled Robot Structures, sensors for mobile robots, planning and navigation

Legged robots: Analysis of Cyclic Walking, Control of Biped Robots Using Forward Dynamics, Biped Robots in the ZMP Scheme, Multilegged Robots, Performance Indices

Cooperative Manipulators: Kinematics and Statics, Cooperative Task Space, Dynamics and Load Distribution, Task-Space Analysis, Control

Advanced Robots: Modeling and control of space robots, underwater robots

Control of Manipulators: Manipulator control problem; Linear and non linear control schemes; PID control scheme; Force control.

Image Processing and Analysis with Vision Systems: Acquisition of images, digital images, image processing techniques, noise reduction, edge detection, image analysis, object recognition by features, application of vision systems

Fuzzy Logic Control: Crisp values v/s fuzzy values, fuzzy sets: Degrees of membership and truth, fuzzification, fuzzy inference rule base, defuzzification, simulation of fuzzy logic controller, application of fuzzy logic in robotics

Recommended Reading

1. Niku, S. B., “Introduction to Robotics: Analysis, Systems, Applications”, Prentice Hall., 2001
2. Angeles, J., “Fundamentals of Robotic Mechanical Systems: Theory, Methods and Algorithms”, Springer , 2003
3. Craig, J. J., “Introduction to Robotics: Mechanics & Control”, Addison Wesley., 1989
4. Siegwart, R., Nourbakhsh, I. R., “Introduction to Autonomous Mobile Robots”, MIT Press., 2004
5. Xu, Y. and Kanade, T., “Space Robotics: Dynamics and Control”, Kluwer Academic Publishers., 1993

6. Robotics, Vision and Control: Fundamental Algorithms in MATLAB, Springer, 2013
7. Merzouki R., Samantaray A. K., Pathak P.M., Bouamama B. Ould, Intelligent Mechatronic Systems: Modeling, Control and Diagnosis, Springer , 2013

Programme Name	***Master of Technology in Mechanical Engineering with specialization in CAD/CAM Robotics***
Course Code	**MECR5044S**
Course Title	**Product Design and Development**

Course Outcomes

After completion of the course students will be able to

1. Students should be able to design a product using computer aided design.
2. Students should be able to carry out product development and planning process.
3. Students should be able to understand the concept of prototyping.

Course Contents

Introduction

Definition of Product Design, Design by Evolution, Design by Innovation, Essential Factors of Product Design, Production-Consumption Cycle.

Product Design Practice and Industry

Introduction, Product Strategies, Time to Market, Analysis of the Product, The Three S's Standardization, Renard Series (Preferred Numbers) Simplification, The Designer and His Role, The Designer Myth and Reality, The Industrial Design Organization, Basic Design Considerations, Problems faced by Industrial Designer, Procedure adopted by Industrial Designers, Types of Models designed by Industrial Designers, What the Designer contributes, Role of Aesthetics in' Product Design, Functional Design Practice.

Economic Factors Influencing Design

Product Value, Design for Safety, Reliability and Environmental Considerations Manufacturing Operations in relation to Design, Economic Analysis, Profit and Competitiveness, Break-even Analysis, Economics of a New Product Design (Samuel Eilon Model).

Human Engineering Considerations in Product Design

Introduction, Human Being as Applicator of. Forces, Anthropometrics Man as Occupant of Space The Design of Controls, The Design of Displays, Man/Machine Information Exchange.

Recommended Reading

1. A. K. Chitale, & R.C. Gupta, Product Design & Manufacturing, 2nd Ed 2002, Prentice Hall of India
2. Karl T. Ulrich, Steven D. Eppinger, Maria C. Yang, Product Design and Development , Mc Graw Hill, 7th Edition, 2020

Programme Elective-IV

Programme Name	***Master of Technology in Mechanical Engineering with specialization in CAD/CAM Robotics***
Course Code	**MECR5051S**
Course Title	**Advanced Composite Materials**

Course Outcomes

After completion of the course students will be able to

1. Identify the properties of fiber and matrix materials used in composites.
2. Select an appropriate manufacturing process for composite parts.
3. Analyse the performance of fiber composites based on the constituent properties.
4. Model the behaviour of composite materials
5. To study nanocomposites processing and properties

Course Contents

Introduction to Composites

Introduction to material selection in design, Types of composite materials, general characteristics of composite materials, applications of composites

Constituents of Composite

Materials Reinforcement and fillers glass fibers, carbon fibers, organic fibers, boron fibers, natural fibers, ceramic fibers Matrix thermoset matrix and thermoplastic matrix, metal matrix materials, ceramic matrix materials

Manufacturing of Composites

Bag-molding, compression molding, pultrusion, filament winding, liquid composite molding, resin film infusion, additive manufacturing of short fiber and long fiber composites, metal matrix composite manufacturing, ceramic matrix composite manufacturing, selection of manufacturing method

Mechanics of Fiber Reinforced Composite Materials

Fiber matrix interaction, micromechanics of composite materials, Laminate Analysis, Failure theories for composite materials, introduction to world-wide failure exercise of composites

Characterization of Fiber Reinforced Composite Materials

Static mechanical properties, fatigue properties, impact properties, methods of characterization of fiber-matrix interphase, quality inspection methods, different ASTM standards

Fracture and Fatigue of Fiber Reinforced Composite Materials

Failure of composites, delamination in composites, modes of fracture, composite damage mechanics, S-N diagram for composite materials

Polymeric Nanocomposite

Introduction to nanomaterials, nanoplatelete/nanoparticles/nanofibers reinforced composites, CNT/Graphene reinforced composites, processing of nanocomposites, prediction of properties of nanocomposites, applications of nanocomposites

Modeling of Composite Materials

Empirical models for prediction of mechanical properties of composites, finite element based modelling of short fiber and long fiber composites, Introduction to ANSYS ACP module for composite analysis, Simulation of short fiber reinforced composites using Digimat

Recommended Reading

1. P.K. Mallick, Fiber-Reinforced Composites Materials, Manufacturing, and Design, Third Edition, CRC Press, 2007
2. K. K. Chawla, Composite Materials Science and Engineering, Springer, 2012
3. Ever Barbero, Finite Element Analysis of Composite Materials using ANSYS, CRC Press, 2013
4. Hussain, Farzana, et al., Review article polymer-matrix nanocomposites, processing, manufacturing, and application an overview. Journal of composite materials 40.17, 2006 1511-1575
5. M. Ashby, Material Selection in Mechanical Design, 4th Edition, Elsevier, 2010

Programme Name	***Master of Technology in Mechanical Engineering with specialization in CAD/CAM Robotics***
Course Code	**MECR5052S**
Course Title	**Design for Additive Manufacturing**

Course Outcomes

After completion of the course students will be able to

1. Select appropriate material during design process
2. Identify the need of design for additive manufacturing
3. Identify design constraints and choose a polymer and metal AM process
4. Develop lattice structures using topology optimization
5. Apply design for AM guidelines in designing products
6. Apply design for AM techniques for manufacture of composites

Course Contents

Materials Selection in Design

The families of Engineering materials, the selection strategy, attribute limits and material indices, the selection procedure, computer-aided selection, shape factors, Microscopic or micro-structural shape factors, limits to shape efficiency, exploring and comparing structural sections, material indices that include shape, co-selecting material and shape, case studies

Introduction to Design for Additive Manufacturing (DfAM)

Introduction to geometric modelling, Modelling of Synthetic curves like Hermite, Bezier and B- spline, Parametric Representation of freeform surfaces, Design freedom with AM, Need for Design for Additive Manufacturing (DfAM), CAD tools vs. DfAM tools, Requirements of DfAM methods, General Guidelines for DfAM, The Economics of Additive Manufacturing, Design to Minimize Print Time,Design to Minimize Post-processing.

Design Guidelines for Part Consolidation

Design for Function, Material Considerations, Number of Fasteners, Knowledge of Conventional DFM/DFA, Assembly Considerations, Moving Parts, Part redesign, Opportunities for part consolidation, challenges with part consolidation.

Design for Improved Functionality

Multi scale design for Additive manufacturing, Mass customization, Biomimetics, Generative design, Design of multi-materials and functionally graded materials.

Design for Minimal Material Usage

Topology Optimization, Modelling of Design space, defining design and manufacturing constraints, performing analysis for weight reduction, maximize stiffness, minimize displacement, Post- processing and Interpreting Results, Applications of TO, TO tools, Design of cellular and lattice structures, Design of support structures.

Computational Tools for Design Analysis

Considerations for Analysis of AM Parts, Material Data, Surface Finish, Geometry, Simplifying Geometry, Mesh-Based Versus Parametric Models, Build Process Simulation Model Slicing, Contour Data Organization, Layer-by-Layer Simulation, Hatching Strategies, Scan Pattern Simulation and Tool Path Generation

Design for Polymer AM

Anisotropy, Wall Thicknesses, Overhangs, Support Material, Accuracy, Tolerances, Layer Thickness, Resolution, Print Orientation, Warpage, over sintering, Hollowing Parts, Horizontal Bridges, Connections, Fill Style, holes, fillets, ribs, font sizes and small details.

Design for Metal AM

Powder Morphology, Powder Size Distribution, Material Characteristics,Designing to Minimize Stress concentrations, Residual Stress, Overhangs, shrinkage, warpage and Support Material, Design Guidelines for Wall Thickness, Clearance Between Moving Parts, Vertical Slots, Circular Holes, fillets, channels, vertical Bosses, circular pins, External Screw Threads and part positioning.

Design for Additive Manufacturing of Composites

Additive manufacturing of polymeric composites using different processes, Design for AM of composites, Digital Composites, AI-driven/data-driven approaches for AM fabricated polymeric composite process

Introduction to DfAM using softwares

Introduction to additive manufacturing simulation tools of commercial softwares such ANSYS Additive Suite, Digimat AM-eXtreme, and Solidworks, Case studies on DfAM using commercial softwares

Recommended Reading

1. A Practical Guide to Design for Additive Manufacturing, Diegel, Olaf, Axel Nordin, and Damien Motte, Springer, 2020.
2. The 3D Printing Handbook Technologies, Design and Applications, Redwood, Ben, Filemon Schoffer, and Brian Garret, 3D Hubs, 2017.
3. Design for Advanced Manufacturing Technologies and Process, Laroux K, Gillespie, McGrawHill, 2017.
4. Additive Manufacturing Technologies, Gibson, Ian, David W. Rosen, Brent Stucker, and Mahyar Khorasani, Springer, 2021.
5. Additive Manufacturing Technologies, Gibson, Ian, David W. Rosen, Brent Stucker, and Mahyar Khorasani, Springer, 2021.
6. Laser-Induced Materials and Processes for Rapid Prototyping, L.Lu, J. Y. H. Fuh and Y.S. Wong, Springer, 2001.
7. Mathematical Elements for Computer Graphics, David F. Rogers, J. A. Adams, TMH,2008.
8. Materials Selection in Design, Michel Ashby, 2011
9. ANSYS Granta, Edupack Manual
10. Hangqin Yuan, Shaoying Li, Jihong Zhu, Yunlong Tang, Additive manufacturing of polymeric composites from material processing to structural design, Composites Part B Engineering, Volume 219, 2021,

Programme Name	***Master of Technology in Mechanical Engineering with specialization in CAD/CAM Robotics***
Course Code	**MECR5053S**
Course Title	**Manufacturing System Simulation**

Course Outcomes

At the end of the course, the student will be able to

1. Classify analytical and simulation models used in manufacturing system environment
2. Apply probability and simulation languages
3. Design and evaluate a given manufacturing system using simulation
4. Generate random numbers and variants to execute a simulation model
5. Evaluate queuing networks and Markov chains in the context of manufacturing

Course Contents

Introduction to System and simulation

Concept of system and elements of system, Discrete and continuous system, Models of system and Principles of modeling and simulation, Monte carlo simulation, Types of simulation, Steps in simulation model, Advantages, limitations and applications of simulation, Applications of simulation in manufacturing system

Review of statistics and probability

Types of discrete and continuous probability distributions such as Geometric, Poisson, Uniform, Normal, Exponential distributions with examples.

Random numbers

Need for RNs, Technique for Random number generation such as Mid product method, Mid square method, and Linear congruential method with examples

Test for Random numbers

Uniformity - Chi square test or Kolmogorov Smirnov test, Independency- Auto correlation test Random Variate generation Technique for Random variate generation such as Inverse transforms technique or Rejection method

Analysis of simulation data

Input data analysis, Verification and validation of simulation models, Output data analysis

Simulation languages

History of simulation languages, Comparison and selection of simulation languages

Design and evaluation of simulation experiments

Development and analysis of simulation models using simulation language with different manufacturing systems

Queueing models

An introduction, M/M/1 and M/M/m Models with examples, Open Queueing and Closed queueing network with examples

Markov chain models and others

Discrete time markov chain with examples, Continues time markov chain with examples, stochastic process in manufacturing, Game theory

Recommended Reading

1. Discrete Event System Simulation, J.Banks, J.S. Carson, B. L. Nelson and D.M. Nicol, PHI, New Delhi, 2009.
2. Simulation Modeling and Analysis, A.M. Law and W.D.Kelton, Tata McGraw Hill Ltd, New Delhi, 2008.
3. Performance Modeling of Automated Manufacturing Systems, N. Viswanadham and Y. Narahari, PHI, New Delhi, 2007.

Open Elective-II

Programme Name	***Master of Technology in Mechanical Engineering with specialization in CAD/CAM Robotics***
Course Code	**MECR5062S**
Course Title	**Robotics**

Course Outcomes

After completion of course, students would be able to

1. Analyze various types Robots and their applications
2. Understand terminologies related to Kinematics of Robotics.
3. Analyze basics of motion programming as per kinematics
4. Apply logic for selection of robotic systems and its application.

Course Contents

Introduction to Robotics

Brief History, Basic Concepts of Robotics such as Definition, Three laws, Elements of Robotic Systems i.e. Robot anatomy, DOF, Misunderstood devices etc., Classification of Robotic systems on the basis of various parameters such as work volume, type of drive, etc., Associated parameters i.e. resolution, accuracy, repeatability, dexterity, compliance, etc., Introduction to Principles & Strategies of Automation, Types & Levels of Automations, Need of automation, Industrial applications of robot. Robotics application current and future.

Grippers and Sensors for Robotics

Grippers for Robotics - Types of Grippers, Guidelines for design for robotic gripper, Force analysis for various basic gripper systems. Sensors for Robots - Types of Sensors used in Robotics, Classification and applications of sensors, Characteristics of sensing devices, Selections of sensors. Need for sensorsand vision system in the working and control of a robot.

Drives and Control for Robotics

Drive - Types of Drives, Types of transmission systems, Actuators and its selection while designing a robot system. Control Systems Types of Controllers, Introduction to closed loop control

Robot Kinematics

Spatial Descriptions positions, orientations, and frame, mappings changing description from frame to frame, Operators translations, rotations and transformations, transformation arithmetic, compound Transformations, inverting a transform, transform equations, Euler Angles, Fixed Angles, Euler Parameters. Manipulator Kinematics, Link Description, Link to reference frame connections, Denavit-Hartenberg Approach, D-H Parameters, Position Representations, Homogeneous Transformation Matrix, Forward Kinematics. Inverse Kinematics, Geometric and analytical approach.

Trajectory Planning

Introduction, path vs trajectory, joint space vs Cartesian space description, basics of tractor planning, joint space trajectory planning Third order polynomial, Fifth order polynomial, linear segment with parabolic blends, linear segment with parabolic blends and via points, higher order trajectories, etc.

Computer vision for robotic system

Imaging Components, Image Representation, Hardware Considerations, Picture Coding, Object Recognition and Categorization, Software Considerations, Need for Vision Training and

Adaptations, Review of Existing Systems, etc.

Computer Considerations for Robotic Systems

Objectives, Motivation, Architectural Considerations, Hardware Considerations, Computational Elements in Robotic Applications, Real-Time Considerations, Robot Programming, Path Planning, etc.

Related Topics in Robotics

Socio-Economic aspect of robotisation. Economical aspects for robot design, Safety for robot and standards, Introduction to Artificial Intelligence, AI techniques, Need and application of AI, New trends & recent updates in robotics.

Recommended Reading

1. Robert J Schilling, Fundamentals of Robotics Analysis & ControlPearson Education, Inc., 2007.
2. S. B. Niku, Introduction to Robotics – Analysis, Control, Applications, 3rd edition, JohnWiley & Sons Ltd., 2020
3. R. K. Mittal, I. J. Nagrath, Robotics and Control, TATA McGraw Hill Publishing Co Ltd,New Delhi, 2003.
4. R. D. Klafter, Thomas A. Chmielewski, and Mechael Negin, Robotic Engineering –An Integrated Approach, EEE, Prentice Hall India, Pearson Education Inc., 2009.
5. J. Angeles, Fundamentals of Robotic Mechanical Systems Theory Methods and Algorithms, Springer,1997.
6. S. K. Saha, Introduction to Robotics 2nd edition, TATA McGraw Hills Education, 2014.
7. Ashitava Ghosal, Robotics Fundamental Concepts and Analysis, Oxford University Press, 2006.
8. T. C. Manjunath, Fundamentals of Robotics, Nandu Printers and Publishers, 2010.

Laboratory Courses

Programme Name	***Masters of Technology in Mechanical Engineering with Specialization in CAD/CAM Robotics***
Course Code	**MECR5074L**
Course Title	**Laboratory-4 Advanced Finite Element Analysis Laboratory**

Course Outcomes

After completion of course, students would be able to

1. To acquire basic understanding of Modeling and Analysis software ·
2. Be able to use the commercial Finite Element packages to build and solve selected problems.
3. To understand the different kinds of static analysis, find out the stress and other related parameters.
4. To learn to apply the basic principles to carry out dynamic analysis.

List of Experiments/Assignments

1. 1-D Element Problems –Linear Static Analysis
2. 2-D Element Problems – Linear Static Analysis
3. 3-D Element Problems – Linear Static Analysis
4. Free Vibration Analysis on Beam, Bars, Plates
5. Non-Linear Analysis of 1-D Element Problems Like Beams, Bars
   Thermal Analysis(Conduction, Convection and Insulation Boundary Conditions.
6. 1-D Element Problems-Steady state And Transient Analysis
7. 2-D Element Problems of Homogeneous and Composite Slap in Steady State and Transient Analysis
8. 3-D Element Problems Steady State Analysis
9. Project-Creating or Importing and Map Meshing of 3-D component /Assembly of practical application and FEA Analysis of Same component /Assembly

Recommended Reading

1. Finite Element Analysis using Ansys 11.0 by PaletiShrinivas, Krisha Chaitnay Sambana, Rajesh Kumar Datti.
2. Finite Element Analysis Theory and Applications with ANSYS by Saeed Moaveni
3. Engineering Analysis with ANSYS Software by Y. Nakasone and S. Yoshimoto
4. The finite element method And applications in Engineering using Ansys® by Erdogan Madenci, Ibrahim Guven
5. Practical Finite Element Analysis by Nitin Gokhale of M/S Finite to Infinite.
6. Reference Manual of Hypermesh Software
7. Online Tutorial HyperMesh Software
8. Tutorial of Ansys Software.

Programme Name	***Master of Technology in Mechanical Engineering with specialization in CAD/CAM Robotics***
Course Code	**MECR5075L**
Course Title	**Laboratory-5 Robotics and Automation Laboratory**

Course Outcomes

After completion of course, students would be able to

1. Understand terminologies related to Kinematics of Robotics.

2. Understand manipulator positioning and motion planning using ROBO ANYLYZER software

3. Estimate the forward and inverse transformation using MATLAB program and ROBO ANYLYZER software

4. Customize assembly programming for 8085 micro-processor and 8051μc.

List of experiments

1. Minimum 04 exercise on ROBO ANALYZER and MATLAB Programs should be covered.
2. Minimum 03 Exercise on 5 Axis articulated robot should be covered.
3. Programming Assembly programming on 8085 for addition, substraction and with carry etc.
4. Experiments on Pneumatic Trainer and on trial version of FESTO Software
5. Experiment on PLC Trainer
6. Interfacing with the 8051 using ADC, DAC, DC motor.

Programme Name	***Master of Technology in Mechanical Engineering with specialization in CAD/CAM Robotics***
Course Code	**MECR5076L**
Course Title	**Laboratory Advanced Composite Materials Laboratory**

Course Outcomes

After completion of the course students will be able to

1. Develop composite manufacturing process for the given part
2. Evaluate the performance of composite structure
3. Design the optimal composite structure

List of experiments

1. Resin Preparation and cure cycle
2. Manufacture of composite material using hand layup process
3. Manufacture of natural fibers composite materials
4. Open mold composite manufacturing process
5. Vacuum assisted resin transfer molding process
6. Manufacture of sandwich composite
7. Testing of polymeric composite materials
8. Finite element analysis of composite materials
9. Design optimization of composite structure
10. Manufacture of electrospun nanofibers reinforced composites

Text Books

1. P.K. Mallick, Fiber-Reinforced Composites Materials, Manufacturing, and Design, CRC Press, Third Edition, 2007
2. ANSYS Composite PrepPost User's Guide, http//www.ansys.com