Proposed PG Specialization

M. Tech. (Production and Industrial Engineering)

1. Proposed Semester wise PG Scheme to be implemented w.e.f. 2022-23 session

SEMESTER-I					SEMESTER-II			
S.N.	Code	Courses	Credits		S.N.	Code	Courses	Credits
1.	PR5002	Finite Element Analysis (In place of Mathematics)	3		1.	PR1104	Quality and Reliability Engineering (DCC-IV)	3
2.	PR1101	Industrial Robotics (DCC-I)	3		2.	PR1105	Advanced Manufacturing Processes (DCC-V)	3
3.	PR1102	Supply Chain Management (DCC-II)	3		3.	PR1106	Manufacturability and Characterization (DCC-VI)	3
4.	PR1103	Additive Manufacturing (DCC-III)	3		4.		Dept. Elective Course (DEC-II)	3
5.		Dept. Elective Course(DEC-I)	3		5.		Open Elective-I	3
6.	PR1001	Research Methodology	3		6	PR4001	Industrial Tour*	0
					7.	SCR1001	Soft-Computing/Soft Skill& Management	3
		Total	18				Total	18

SEMESTER-III					SEMESTER-IV			
S.N	Code	Courses	Credits		S.N.	Code	Courses	Credits
1	PR5001	Seminar and Report Writing	2		1.	PR8001	Dissertation-II	18
2.	RPR6001	Research and Publication Ethics	2					
3.	PR7001	Dissertation-I	14					
		Total	18				Total	18

Total Credits = 18+18+18+18=72

Note:

* Industrial tour will be held in winter vacation after 1st semester and it will be recorded in 2nd semester.

**In the first and second semester, at least one of the Department Core Courses should have laboratory component

Department Core Course (DCC)

Sr. No.	Core Course	Course Code	Course Name
1	Dept. Core Course(DCC-I)	PR1101	Industrial Robotics
2	Dept. Core Course(DCC-II)	PR1102	Supply Chain Management
3	Dept. Core Course(DCC-III)	PR1103	Additive Manufacturing
4	Dept. Core Course (DCC-IV)	PR1104	Quality and Reliability Engineering
5	Dept. Core Course (DCC-V)	PR1105	Advance Manufacturing Processes
6	Dept. Core Course (DCC-VI)	PR1106	Manufacturability and Characterization

Department Elective Course (DEC)

Sr. No.	Dept. Elective Courses	Course Code	Course Name
1	DEC- 1	PR1201	Design and Manufacturing of Mechanical Assemblies
2	DEC- 2	PR1202	Sustainable Materials and Processing
3	DEC- 3	PR1203	Advanced Foundry Technology
4	DEC- 4	PR1204	Applied Ergonomic
5	DEC- 5	PR1205	Non Destructive Testing
6	DEC- 6	PR1206	Surface Engineering
7	DEC- 7	PR1207	Modelling and Simulation
8	DEC- 8	PR1208	Industry 4.O and Mechatronics
9	DEC- 9	PR1209	Industrial Process Automation
10	DEC- 10	PR1210	Data Mining and Big Data
11	DEC- 11	PR1211	Optimization Techniques in Manufacturing
12	DEC- 12	PR1212	Integrated Product Design and Development
13	DEC- 13	PR1213	Digital Manufacturing
14	DEC- 14	PR1214	Computer Integrated Manufacturing
15	DEC-15	PR1215	CAD CAM

Open Elective (OE)

Sr. No.	Open Elective (OE)	Course Code	Course Name
1	Open Elective-I	PR3001	Computer Graphics and Product Modelling
2	Open Elective-II	PR3002	Quality and Reliability
3	Open Elective-III	PR3003	Finite Element Analysis
4	Open Elective-IV	PR3004	Knowledge Based System in Engineering

5	Open Elective-V	PR3005	Project Management
6	Open Elective-VI	PR3006	Value Engineering
7	Open Elective-VII	PR3007	Computer Integrated Manufacturing
8	Open Elective-VIII	PR3008	Industry 4.O and Mechatronics
9	Open Elective-IX	PR3009	Non Destructive Testing

PROPOSED CREDITS BREAK-UP FOR M.TECH PROGRAMME (2022-23 onwards)

CURRICULAR COMPONENTS	**Credits**
A) Department Core Courses (DCC)	18
B) Department Elective Courses (DEC)	6
C) Institute Open Elective Courses	3
D) Research Methodology	3
E) Seminar and Report Writing	2
F) Engineering Mathematics	3
G) Soft Computing/ Soft Skills & Management	3
H) Industrial Tour	0
I) Research and Publication Ethics	2
H) Dissertation/Industry Project	32
Grand Total	**72**

Course Name	**:**	**Industrial Robotics**
Course Code	**:**	**PR1101**
Credits	**:**	**3**
L T P	**:**	**2-0-2**

Course Objectives:

The main objectives of this course are:	
1.	To introduce the students to components of a robot and underlying mechanics
2.	To introduce students to the modelling of an industrial robotics workcell and different techniques of trajectory generation.

Total No. of Lectures:28
Total No. of Lab Hours: 28

Course Contents:

S. No.	Course contents	No. of Lect.
1.	**Robot Fundamentals** Robot components, robot classification and specification, work envelopes, Other basic parameters of robots	2
2.	**Robot End-Effectors** Types, mechanical grippers, gripper force analysis, gripper selection, process tooling, compliance	2
3.	**Modelling of robotic workcell** Mathematical representation of coordinate frames, Homogeneous transformations for translations and rotations, Composite homogeneous transformations, Inverse homogeneous transformations, Developing a mathematical model for a robotic workcell	3
4.	**Robot Kinematics** Robot kinematics, approaches of kinematic modelling, Introduction to an algorithmic approach for robot kinematic modelling, Robot coordinate frames, DH representation, Arm equation , inverse robot kinematics– solvability, algebraic vs geometric solutions, examples of inverse manipulator kinematics.	6
5.	**Differential motions** Differential motion and velocities - Differential motions of a robot and its hand frame, Tool configuration Jacobian, Resolved motion rate control, Manipulator Jacobian, Static forces and moments	3
6.	**Robot Dynamics** Lagrangian mechanics, Effective moments of inertia, Dynamic equations for multi-degree of freedom robots.	2
7.	**Trajectory generation** Joint space trajectories and their implementation, Polynomial trajectories, Cubic and quintic interpolation, Higher order trajectories, 4-3-4 trajectory, Cartesian space trajectories.	3
8.	**Robot Sensors** Robot sensors and sensor classification, Proximity sensors, Rotary position sensors, Force and torque sensors, Tactile sensors, Vision sensors	2
9.	**Trajectory planning for industrial applications** Layout of workspace fixtures – part feeders, conveyors, fixed tools, Trajectory generation for various robot manipulation tasks	2

10.	**Robot Applications** Robot applications – Material handling, processing, Assembly, Inspection applications, Evaluating the potential of a robot application.	3

Lab Work

S. No.	Lab Content	No. of Hour
1.	To freeze robot specifications for an industrial application.	4
2.	To model an industrial robot in a CAD environment.	12
3.	To run simulation of a robot for an industrial application.	8
4.	To develop a robot program for a pick and place operation	4

Course Outcomes:

At the end of the course, students will be able to:	
1.	Apply their knowledge to specify a robot for an industrial application.
2.	Evaluate a robot work cell using homogeneous transformations
3.	Analyse kinematics of an industrial robot
4.	Evaluate differential motions of an industrial robot.
5.	Understand dynamic analysis of an industrial robot
6.	Design robot motion for an industrial task

Bibliography

Sr. No.	Book Detail	Year of Publication
1.	Groover. Weiss, Nagel and Ordrey, "Industrial Robotics", McGraw Hill	2012
2.	John J. Craig, "Ïntroduction to Robotics Mechanics and Control", Pearson Edition.	2008
3.	J G Keramas, "Robot Technology Fundamentals", Delmar Publications	1999
4.	KS Fu, RC Gongzalez, CSG Lee, "Robotics Control, Sensing, Vision and Intelligence", Tata McGraw-Hill Publishing Company Ltd.	2008
5.	R.J. Schilling, "Fundamentals of Robotics – Analysis & Control", PHI.	2011

Course Name:	**Supply Chain Management**
Course Code:	**PR1102**
Credits:	**3**
L T P:	**2-0-2**

Course Objectives:

The main objectives of this course are:	
1	To provide foundation for design, analysis and performance metrics and to frame a sound supply chain network in the country.
2	To provide an insight into functioning and networking of supply chain decisions for the success of a business.
3	Study on Various key Drivers of supply chain performance and how these drivers can be used in practical level.
4	To understand the role of e-businesses in supply chain management

Sr. No	Course contents	No. of Lectures
1	**Introduction:** Objectives of supply chain, stages of supply chain, supply chain process cycles, Understanding supply chains, supply chain performance; supply chain drivers and obstacles, push/pull view of supply chain processes, importance of supply chain flows, and examples of supply chain.	3
2	**Supply Chain Performance:** supply chain strategies, achieving strategic fit, product life cycle, the minimize local cost view, the minimize functional cost view, the maximize company profit view, the maximize supply chain surplus view.	3
3	**Planning Demand and Supply in a Supply Chain:** Demand forecasting in supply chain, aggregate planning in supply chain, planning supply and demand; managing predictable variability, Economic Order Quantity Models, Reorder Point Models, Multi-echelon Inventory Systems	4
4	**Planning and Managing inventories in a Supply Chain:** Managing economies of supply chain, managing uncertainty in a supply chain, determining optimal levels of product availability	4
5	**Transportation, Network Design and Information Technology:** Transportation aspects in a supply chain, facility Decision, Network design in a supply chain, Information technology and its use in supply chain.	4
6	**Network Design:** Factors influencing distribution in network design, distribution networks in practice, framework for network design decisions, models for facility location and capacity allocation, making network design decisions in practice.	4
7	**Coordination in Supply Chain and effect of E- Business:** Role of Coordination and E-business in a supply chain; financial evaluation in a supply chain.	3
8	**Modern Supply Chain Management:** Reverse supply chain strategies, Green supply chain management, Sustainable practices in Supply chain, Case studies and examples.	3

Lab Work

The objective of this lab is to enable students to understand practical applications of Supply Chain Management

Sr No.	Lab Content	No. of lab hours
1	To study the network design and operations	3
2	To learn designing and planning distribution networks	3
3	To make value stream mapping – Develop Current and Future State Maps	4
4	To study the Decision Making in Supply Chains	4
5	To prepare supply chain restructuring	3
6	To carry out detailed Supply chain performance measures	3
7	To learn inventory optimization in supply chain	4
8	To study the forecasting models in supply chain	4

Course Outcomes:

At the end of the course, the students would be able to:	
CO1.	Apply the knowledge of Programming to find optimal solutions of Supply Chain related problems.
CO2.	Interpret and apply the concepts of supply chain management in improving other functional areas of business organizations.
CO3.	Understand different types of distribution networks and design a network for meeting a particular strategy of an organization.
CO4.	Gain sufficient knowledge to develop models and solve problems by using modern tools such and develop interest for research and higher education.
CO5.	Improve the performance of existing Supply Chains by developing a better decision support system
CO6.	Save resources for the organizations and make Supply Chains environmental friendly

Bibliography:

Sr. No.	Book Detail	Year of Publication
1	Handfield R.B. and Nichols E.L., Jr., "Introduction to Supply Chain Management", Prentice-Hall Inc, 2000.	**2000**
2	Sunil Chopra And Peter Meindl, "Supply Chain Management, strategy, planning, and operation"6/e –PHI, second edition, 2	**2014**
3	V.V.Sople, "Supply Chain Management, text and cases", Pearson Education South Asia	**2012**
4	Balkan Cetinkaya, Richard Cuthbertson, Graham Ewer, "Sustainable Supply Chain Management: Practical ideas for moving towards best practice", Springer	**2011**
5	Arnold J. R. T. and Chapman S. N., "Introduction to Materials Management", 4th Edition, Pearson Education Asia	**2001**

Course name	**:**	**Additive Manufacturing**
Course code	**:**	**PR 1103**
Credits	**:**	**3**
L T P	**:**	**2-0-2**

Total no of lectures: 28
Lab hours: 28

Course Objectives: The main Objectives of this course are:	
1.	The students would be able to describethe different process applications of AM in various sectors.
2.	The students would be able to select appropriate materials, construct some components of the CAD models and get accustomed with AM software's.

Sr. No	**Course Contents**	**No. of Lectures**
1.	**Introduction to Additive Manufacturing** (AM): Introduction to AM, Need of AM, Classification of AM processes,Advantages and limitation of AM. **Rapid Prototyping Process Chain**, Fundamental Automated Processes Process Chain, 3D Modelling, Data Conversion and Transmission, Checking and Preparing.	**6**
2.	**Solid state-based 3D printing Processes:** Laminated object manufacturing (LOM) Process, Working principle, Case studies. Fused Deposition Modelling (FDM) Working principle, Case studies. Friction stir additive manufacturing: process, Ultrasonic Consolidation (UC), LOM and UC applications. **Liquid state-based 3D printing Process:** Stereo lithography apparatus (SLA): process, working principle, Photo polymerization working principle application, Solid ground curing (SGC):process, working principle case studies.	**8**
3.	**Powder Based 3D printing Processes:** Selective laser Sintering (SLS), Materials, Powder fusion mechanism and powder handling, Process Modelling, Electron Beam melting (EBM), Process Benefits and Drawbacks, Applications of Powder Bed Fusion Processes. **Directed Energy Deposition Processes:** Laser Engineering Net Shaping (LENS), Direct Metal Deposition (DMD), Electron Beam Based Metal Deposition, Applications of Directed Energy Deposition Processes, case studies, Binder Jetting AM process, applications.	**8**
4.	**Design for Minimal Material Usage AM Applications:** Topology Optimization, Modelling of Design space, defining design and manufacturing constraints, performing analysis for weight reduction, maximize stiffness, Applications of TO, TO tools, Design of cellular and lattice structures, Design of support structures Applications in prototyping, concept models, visualization aids, Industrial Applications in aerospace, automobile, medical, jewellery etc. **Post Processing of AM Parts:** Support Material Removal, Surface Texture Improvement, Accuracy Improvement, Aesthetic Improvement, Property Enhancements using Thermal and Non-Thermal Techniques.	**6**

Lab work

Sr. No.	Lab contents	No. of Hrs.
1	Development of an idea for given product with the following points -Design from utility/ease/Aesthetic -Design from Manufacturing	06
2	Development of CAD Model for given product	06
3	Slicing of a developed model	04
4	Study of Additive printer Raise 3d & Mark forged printer	06
5	**Exercise on selection of process parameters and programming on RP Machine to**produce developed Model	06

Course Outcomes:

CO1	To understand the working principle and process parameters of AM processes
CO2	To identify the need and make basic designsin additive manufacturing
CO3	To apply the suitable processes and material for fabricating the given products
CO4	To analyse and explore the applications of AM processes in various fields
CO5	To evaluate efficient use of raw materials in processing based on its application.
CO6	To design and create some application based products using Rapid Prototyping software's.

Text / Reference Books:

No.	**Title and Authors**	**Year, Edn.**
1	Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, Ian Gibson, David W Rosen, Brent Stucker, Springer	2015, 2nd Edition.
2	3D Printing and Additive Manufacturing: Principles & Applications, Chua Chee Kai, Leong Kah Fai, World Scientific,.	2015, 4th Edition
3	Additive Manufacturing 3D Printing for Prototyping and Manufacturing, Andreas Gebhardt, Hanser Gardner Publications,	2022.
4	Rapid Prototyping: Laser-based and Other Technologies, Patri K. Venuvinod and Weiyin Ma, Springer.	2004
5	Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, D.T. Pham, S.S. Dimov, Springer.	**2001**
6	Rapid Prototyping: Principles and Applications in Manufacturing, RafiqNoorani, John Wiley &Sons, 2006.	**2006**
7	Additive Manufacturing, Second Edition, Amit BandyopadhyaySusmita Bose, CRC Press Taylor & Francis Group, 2020.	**2020**
8	Additive Manufacturing: Principles, Technologies and Applications, C.P Paul, A.N Junoop, Mc GrawHill, 2021.	**2021**

Course Name	**:**	**Quality & Reliability Engineering**
Course Code	**:**	**PR1104/ PR3002**
Credits	**:**	**3**
L T P	**:**	**2-0-2**

Total No. of Lectures: 28

Course Objectives:

The main Objectives of this course are:	
1.	To review quality management systems, statistical processes and its application
2.	To review the various mathematical, physical and logical modelling tools for estimation and evaluation of component and system level reliability.
3.	To appraise failure phenomena and there by provide valuable inputs for product design to achieve higher levels of reliability standards. Assessment and evaluation of reliability goals and their improvements.

Sr. No.	Course contents	No. of lectures
1.	**Introduction:** Quality – Concept, Different Definitions and Dimensions, Inspection, Quality Control, Quality Assurance and Quality Management, Quality as Wining Strategy, Views of different Quality Gurus, Impact of variability in competitive environment, Statistical Process Control, Acceptance sampling Concept of variation, cause of variation: Common Cause & Special Cause of variation, Natural control limits of process, stable v/s capable process.	**04**
2.	**Control Charts:- for Variables and Attributes** - X Bar-R Charts, X Bar-s Charts, Moving Range (MR),Individual Moving Range (IMR) Charts, Exponentially Weighted Moving Average (EWMA) for Attributes - p- Charts, np-Charts, c-Charts, u-Charts	**04**
5.	**Process Capability Analysis, Process capability indices-** Cp, Cpk, Cpm Process performance analysis from short pre- production; Pp, Ppk Process capability for attribute data.	**02**
6.	**Introduction to ISO 9000, ISO 14000 and QS 9000**: Basic Concepts, Scope, Implementation, Benefits, Implantation Barriers	**02**
5	**Total Quality Management TQM**: Introduction, Definitions and Principles of Operation, Tools and Techniques, such as, Quality Circles, 5 S Practice, Total Quality Control (TQC), Kizen, Poka-Yoke, QC Tools, PDCA Cycle, Quality Improvement Tools, TQM Implementation and Limitations.	**03**
7.	**Reliability Concepts**: Reliability engineering fundamentals; Failure data analysis; Failure rate; mortality curve; Concept of burn in period; Useful life and wear out phase.	**03**
8	**Failure distribution, Reliability function** – Mean time to failure – Hazard rate function – Bathtub curve – Life Testing and Reliability, Failure Terminated Tests, Time Terminated Tests, Sequential Reliability Testing, Constant failure rate models (Exponential reliability function), Weibull distribution – Normal distribution – Lognormal distribution. Reliability estimation using Median Rank	**05**

	Method and Weibull distribution .	
9	**System reliability**- Basics of redundancy – Standby redundancy systems, Use of reliability block diagrams, System with components in series, System with components in parallel, mixed system, k-out-of-n redundancy, Fault tree construction and analysis, Design for reliability: Basic parameters, reliability allocation, Redundancy, Failure analysis	**05**

List of Experiments:-	**Turns**
Construct X bar and R control charts for a given operation	02 X 02
Construct p and np chart for variable and fixed sample size for a given problem	02 X 02
Construct the c and u control charts for any industrial application	02 X 02
Estimation of capability indices Cp, Cpk and Cpm	02 X 02
Distribution analysis and failure data analysis	03 X 02
Accelerated Life Testing	03 X 02

Course Outcomes:

By the end of the course, the students will be able to:	
1.	**Understand** basic terminologies as applied to quality and reliability engineering.
2.	**Apply** Probability distributions to find failure rate, failure density and reliability
3.	**Design** a system for desired reliability
4.	**Design** and applying an appropriate control chart for an ongoing manufacturing process
5	**Evaluate** the existing manufacturing Process in context of its capability to meet customer needs
6.	**Understand** the Concept of TQM and ISO

Bibliography:

Sr. No.	**Name of Book / Authors / Publishers**
1.	"Fundamentals of Quality Control and Improvement", Amitava Mitra, 3rdEdition Wiley and Prentice Hall and Pearson low cost. 2012
2.	Statistical Quality Control by Eugene L. Grant, McGraw-Hill Series in Industrial Engineering and Management 2017
3.	Total Quality Management by Dale H. Besterfield, Carol Besterfield-Michna, Glen H. Besterfield and Mary Besterfield-Sacre, Pearson Educaiton 2011
4.	An introduction to reliability engineering by L. Shrinath 2000
5.	An Introduction to Reliability and Maintainability Engineering by Charles E.Ebeling, Tata McGraw-Hill 2005

Course Name	**:**	**Advanced Manufacturing Processes**
Course Code	**:**	**PR 1105**
Credits	**:**	**3**
L T P	**:**	**2-0-2**

Total No. of Lectures: 28
Total No. of Practical: 28

Course Objectives:

The main objectives of this course are:	
1.	To impart knowledge on the principles of material removal mechanism of different advanced Manufacturing processes.
2.	To provide in depth knowledge in selection of advanced manufacturing process to fabricate intricate and complex shapes in difficult to machine materials.
3	To encourage the students for studying and developing models on Advanced Manufacturing Processes

Sr. No.	**Course contents**	**No. of Lectures**
1.	**Introduction** Evolution of Precision processes, need, classification and comparison between conventional, precision and modern manufacturing processes. Advances in machining processes: Diamond turning, Hybrid machining, Micro machining and accuracies involved in it.	6
2.	**Non-Conventional Machining** Mechanical processes: Abrasive Jet Machining; Ultrasonic Machining; Abrasive Flow Finishing; Magnetic Abrasive Finishing; Abrasive Water Jet Machining. Thermoelectric processes: EDM; Wire EDM; Laser beam Machining; Plasma Arc Machining; Electron Beam Machining, Ion beam Machining. Electrochemical and Chemical Processes: ECM; ECG; Electro stream Drilling; Electrochemical Deburring; Chemical Machining. Hybrid Machining Processes: Rotary Ultrasonic Machining, Electro-Chemical discharge Machining (ECDM), hybrid EDM-USM.	12
3.	**Rapid Prototyping** Working principle, methods-Stereolithography, Laser sintering, Fused deposition method, applications and limitations.	4
4.	**Other Advanced processes** High Energy Rate Forming Processes: principle, working and applications of high energy forming processes such as explosive forming, electromagnetic forming, electro-discharge forming, water hammer forming, explosive compaction etc. Microwave processing of materials: Conventional vs Microwave heating, Polarization and conduction, unique benefits and distinctive features of Microwave processing, applications and new trends.	6

Course Outcome:

At the end of the course, students will be able to:	
1	Explain the working concepts of various Advanced Manufacturing Processes.
2	Understand the material removal phenomenon of different advanced manufacturing processes.
3	Apply an appropriate process for the given materials.
4	Analyze different process parameters and its effects on response parameters.
5	Evaluate the performance and failure modes of different processes.
6	Distinguish the advantages and limitations of different advanced manufacturing processes and suggesting a suitable process for a particular application.

Sl. No.	**Lab Content**	**Hours**
1	Experimental Study of MRR, TWR, SR on EDM	4
2	Exercise on Hybrid machining such as ECDM/ WECDM/ ECH	4
3	Experimental/ Simulation Study on MRR, SR on AFM	5
4	Exercise on selection of process parameters and programming on RP Machine	5
5	Experiment on Hydroforming machines	5
6	Exercise on Laser Cutting machine.	5

Sr. No.	**Book Details**	**Year of Publication**
1.	Micro machining by VK Jain, Narosa Publishing	2018
2.	Pandey P. C. and Shan H.S., “Modern Machining Processes”, Tata McGrawHill Publishing Company Ltd, New Delhi.	1980
3.	Advanced Machining Processes, Hassam Abdel- Gawad, El-Hofy, Mc Graw Hall	2005
4.	“New Technology” A Bhattacharyya, Institution of Engineers	2000

Course Name	**:**	**Manufacturability and Characterization**
Course Code	**:**	**PR1106**
Credits	**:**	**3**
LTP	**:**	**2-0-2**

Total No. of Lectures: 28, Lab Hrs.28

Course Objectives:

The main objectives of this course are:	
1.	To understand about various Materials Characterization Techniques
2.	ToabletoselecttheMaterialsCharacterizationTechniquesforagivenapplication

Sr. No.	**Course contents**	**No. of Lectures**
1.	**Manufacturability:** Concept of manufacturability and its importance. Design for manufacturability and its relevance	**03**
2.	**Optical Microscopy** Introduction, Optical principles, Instrumentation, Specimen preparation-metallographic principles, Imaging modes, Applications, Limitations.	**02**
3.	**Transmission Electron Microscopy (TEM)**: Introduction, Instrumentation, Specimen preparation- pre-thinning, final thinning, Image-modes- mass density contrast, diffraction contrast, phase contrast, Applications, Limitations;	**02**
3.	**Scanning Electron Microscopy (SEM)**: Introduction, Instrumentation, Contrast formation, Operational variables, Specimen preparation, imaging modes, Applications, Limitations.	**02**
4.	**X-Ray Diffraction (XRD):** Introduction, Basic principles of diffraction, X -ray generation, Instrumentation, Types of analysis, Data collection, Applications and Limitations.	**02**
5.	**Scanning Probe Microscopy (SPM) &Atomic Force Microscopy (AFM)**: Introduction, Instrumentation, Scanning Tunneling Microscopy-Basics, probe tips, working environment, operational modes, Applications and Limitations.	**03**
6.	**Thermal Analysis:** Instrumentation, experimental parameters, Differential thermal analysis, Thermo-gravimetry, Dilatometry, Applications and Limitations	**03**
7.	**Dispersive Spectroscopy:** Instrumentation, working procedure, Applications, Limitations; Energy Dispersive Spectroscopy-Instrumentation Applications and Limitations.	**03**
8.	**X-Ray Spectroscopy for Elemental Analysis-** Introduction,CharacteristicsofX-rays,X-rayFluorescenceSpectrometry, Wavelength	**02**
9.	**Mechanical Characterization -** Hardness measurements: Brinell, Vickers, Rockwell and Micro Hardness Test; Tensile Test: Stress – Strain plot – Proof Stress; Torsion Test: Ductility Measurement; Charpy Impact Test – Fracture Toughness Test, Tribology Characterization using pin on disk wear test. Fatigue – Low & High Cycle Fatigues – Rotating Beam & Plate Bending HCF tests – S-N curve – LCF tests – Crack Growth studies – Creep Tests, Applications of Dynamic Tests. Case studies on engineering failure analysis: Automotive/Aerospace applications	**06**

Course Outcomes:

At the end of the course, students will be able :	
1.	To study the fundamentals of materials characterization
2.	To understand the various Materials Characterization Techniques
3.	To learn procedure/applications of different Materials Characterization Techniques
4.	To perform sample preparation and microstructure analysis of metallographic specimens
5.	To apply the appropriate Materials characterization technique for a given problem
6.	To understand the mechanical characterization techniques in engineering failure analysis

Lab Experiments:

S. No.	Experiment
1	To perform sample preparation and microstructure analysis of metallographic specimens for material characterization.
2	To examine the microstructures of metal specimens using optical microscopy.
3	To analyze the composition and microstructure of metals/metallic alloy specimens using SEM.
4	To perform the surface topography measurements of a sample using Surface Roughness Tester and Stereo microscope.
5	To calculate wear rate and COF of a given specimen using pin on disk tribometer.
6	To measure the specified dimensions of the given component using Coordinate measuring machine (CMM).

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Raj Baldev, Practical Non–Destructive Testing, Narosa Publishing House (1997).	1997
2.	Hull B.and John V.,Non-Destructive Testing, Macmillan(1988)	1988
3.	Krautkramer,JosefandKrautkramerHebert,UltrasonicTestingofMaterials,NewYork,Springer-Verlag(1983).	1983

Course Name	**:**	**Finite Element Analysis**
Course Code	**:**	**PR5002/ PR 3003**
Credits	**:**	**3**
L T P	**:**	**2-0-2**

Total number of lectures: 28

Course Objectives: The main objectives of this course are:	
1.	To understand the concept of designing & development of products.
2.	To understand modelling & analysis of a system using finite element analysis.

Sr. No.	Course contents	No. of Lectures
1.	**Introduction and Basic Concepts of FEM** Fundamental concepts, Stresses and Equilibrium, Boundary Conditions, Strain–Displacement Relations, Stress–Strain Relations, Temperature Effects, Potential Energy and Equilibrium: The Rayleigh–Ritz Method, Potential Energy, Galerkin's Method.	**02**
2.	**One-Dimensional Analysis** Finite Element Modelling, Element Division, Shape Functions and Local Coordinates, The Potential-Energy Approach, Element Stiffness Matrix, Force Terms, Assembly of the Global Stiffness Matrix and Load Vector, The Finite Element Equations: Treatment of Boundary Conditions, Elimination Approach, Penalty Approach, Quadratic Shape Functions, Temperature Effects, Problem Modelling and Boundary Conditions, Problem with a Closing Gap.	**07**
3.	**Trusses** Plane Trusses, Local and Global Coordinate Systems, Element Stiffness Matrix, Stress Calculations, Temperature Effects, Three-Dimensional Trusses, Assembly of Global Stiffness Matrix for the Banded and Skyline, Assembly for Banded Solution, Skyline Assembly, Problem Modelling and Boundary Conditions, Inclined Support in Two Dimensions**.**	**05**
4	**Two-Dimensional Problems Using Constant Strain Triangles** Constant Strain Triangle (CST), Isoparametric Representation, Potential-Energy Approach, Element Stiffness, Force Terms, Stress Calculations, Temperature Effects, Problem Modelling and Boundary Conditions.	**06**
5	**Two-Dimensional Isoparametric Elements** The Four-Node Quadrilateral, Shape Functions, Element Stiffness Matrix, Element Force Vectors, Numerical Integration, Two-Dimensional Integrals, Stiffness Integration, Stress Calculations, Higher Order Elements, Nine-Node Quadrilateral, Eight-Node Quadrilateral, Six-Node Triangle.	**06**
6	**Three-Dimensional Problems in Stress Analysis** Mesh Preparation, Problem Modelling and case studies.	**02**

Total number of hours: 28

At the end of the course, students will be:	
1	Able to understand the various applications of finite element method in engineering.
2	Able to understand the concept of finite element method and its advantage over mechanics method used for analyzing the problems.
3	Able to apply their learnings to develop various discretizing models for simple structural and thermal problems.
4	Able to analyze the structural and thermal problems in two-dimensional and three-dimensional methods.
5	Able to evaluate the solutions of the problems solved by using various computational methods.
6	Able to find out most optimal analysis method for handling the problems in 2D and 3D analysis.

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Chandrupatla and Belegundu, Finite Elements in Engineering, Prentice Hall of India Pvt. Ltd., 2012	2012
2.	Rao, S. S., "The Finite Element Method in Engineering", 4th Ed., Elsevier Science, 2005	2005
3.	Reddy, J.N., "An Introduction to Finite Element Methods", 3rd Ed., Tata McGraw-Hill,2005	2005
4.	Fish, J., and Belytschko, T., "A First Course in Finite Elements", 1st Ed., John Wiley and Sons, 2007	2007

Lab work	**28 hour**
1. To perform the thermal analysis of the cylinder with convective heat transfer process.	**03x2**
2. Probabilistic Design of a Simple Plate with a Single Force Load.	**03x2**
3. To perform the structural static analysis of a corner Bracket. To perform the structural static analysis of a different beams.	**04x2**
4. To perform the structural static analysis of a 2D and 3D trusses.	**04x2**

Course Name	**:**	**Design and Manufacture of Mechanical Assemblies**
Course Code	**:**	**PR 1201**
Credits	**:**	**3**
L T P	**:**	**2-0-2**

Total No. Lectures: 28
Total No. of Lab Hours: 28

Course Objectives:

The main objectives of this course are:	
1.	To understand product life cycle and the relevance of assemblies in this cycle.
2.	To understand design and manufacture of assemblies.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Product Requirements and Top-Down Design** Chain of delivery of quality, Key characteristics, Variation risk management, Examples, Key characteristics conflict, Assembly in the context of product development, Assembling a product, Present status of assembly.	2
2.	**Mathematical and Feature Models of Assemblies** Types of assemblies: Distributive systems, Mechanism and structures, Types of assembly models, Matrix transformations: Nominal location transforms, Variation transforms, Assembly features and feature-based design, Mathematical models of assemblies, Examples of assembly models.	6
3.	**Constraint in Assembly** Kinematic design, Features as carriers of constraints, Use of screw theory to represent and analyze constraints, Design and analysis of assembly features using screw theory, Constraint analysis	5
4.	**Dimensioning and Tolerancing Parts and Assemblies** Dimensional accuracy in manufacturing, KCs and tolerance flow down from assemblies to parts, Geometrical dimensioning and tolerance, Statistical and worst-case tolerancing, Modelling and managing variation buildup in assemblies	5
5.	**Assembly Sequence Analysis** Assembly sequence design process, Bourjault method of generating feasible sequencies, Cutset method, Checking stability of sub-assemblies	4
6.	**Datum Flow Chain** DFC definition, Mates and contacts, KC conflict and its relation to assembly sequence and KC priorities, Assembly precedence constraints, DFCs, tolerances and constraints, Design procedure for assemblies	3
7.	**Design For Assembly and Design For Manufacturing** Sequential versus concurrent engineering, understanding interactions between design and manufacturing, benefits of concurrent engineering, concurrentengineering techniques, design for assembly, design for manufacturing	3

Lab Work:

Sr. No.	Lab contents	No. of Hrs
1.	To develop a toolkit for motion and constraint analysis of various assembly features.	8
2.	To develop mathematical model for the KCs related to a car door.	4
3.	To perform tolerance analysis for the KCs related to car door.	2
4.	To study existing patents related to a consumer product.	6
5.	To carry out detailed syntactic, pragmatic and semantic analysis of the existing consumer product.	4
6.	To carry out detailed syntactic, pragmatic and semantic analysis of the proposed consumer product	4

Course Outcomes:

At the end of the course, students will be able to:	
1.	Develop liaison diagrams of and mathematically model a product.
2.	Apply principles of constraint analysis to an assembly.
3.	Evaluate the steps of tolerance analysis and synthesis.
4.	Analyze assembly sequence of a product.
5.	Develop datum flow chain of a product.
6.	Apply principles of DFA/DFM to consumer products.

Educational Material Referred:

Sr. No.	Book Detail	Year of Publication
1.	Whitney D.E., Mechanical assemblies: Their design, manufacture and role in product development, Oxford University Press.	2004
2.	Zeid Ibrahim, CAD/CAM Theory and Practice, Tata Mcgraw Hill.	2009
3.	Singh Nanua, Systems Approach to Computer Integrated Design and Manufacturing, John Wiley & Sons.	1996
4.	GeofferyBoothroyd, Peter Dewhurst, Winston Knight, Product Design for Manufacturing and Assembly, Marcel Dekker ,New York, 2nd edition.	1994

Course Name	**:**	**Sustainable Materials and Processing**
Course Code	**:**	**PR1202**
Credits	**:**	**3**
LTP	**:**	**3-0-0**

Course Objectives:

The main objectives of this course are:	
1.	To provide basic knowledge and details of Sustainable Materials.
2.	To understand need for recycling critical materials and its various processing techniques.

TotalNo.Lectures:42

Sr. No.	**Course Contents**	**No. of Lectures**
1.	**Introduction:** Sustainable materials, classification and types of sustainable materials, sustainable use of materials, Fundamentals of Sustainability, Future durable Sustainable materials	**04**
2.	**Sustainable Materials:** Systems-focused basis for selecting sustainable alternatives; eco-efficient alternatives including technologies to reduce material intensity, renewably sourced materials, recyclable materials and its solutions	**05**
3.	**Nano/MicroscaleMaterialBehaviour:**Atomicarrangementsincrystallinesolids,imperfectionsincrystallinesolids,therelationshipbetween Nano-/micro-structure and materials properties, the synthesis andbehaviorofnanomaterials,andthecharacterizationattheNano-/micro-scales;materialsbehaviorattheNano/micro-scaleusingX-raydiffraction.	**05**
4.	**ReinforcedCompositeMaterials:**Introductiontofibrouscomposites:materials,propertiesandfabricationprocesses,types/classificationofcomposites(MMC,PMC,CMC),fabricationmethodsofcomposites,advantagesandapplications;physicalandmechanicalpropertycharacterization, stress analysis and design of material systems; destructive and NDE test techniques.	**06**
5.	**Alternative materials strategies:** Recycling and reuse of materials, advance and engineering materials, renewable materials, bio-based materials.	**06**
6.	**Recyclingofe-wastematerials:**Differenttypesofe-waste(wasteelectronic equipment i.e., flat screens, notebooks, smart phones, Materialrecyclingandmaterialsrecoveryfromcomplexproducts,LEDs,circuit boards etc. Criticalmetals ine-Waste	**07**
7.	**Production Process Techniques:** Stir casting for composites (magnesium composites etc.), forging (Aluminium and magnesium & its alloys, fluxes, recycling of welding slag to flux), Solid-state recycling of light metals (powder metallurgy approach)	**09**

Course Outcomes:

At the end of the course, students will be able to:	
1.	Learn the need for sustainable materials.
2.	Understand various processing techniques in recycling critical materials.
3.	Implement knowledge on applications of sustainable materials.
4.	Analyzing the need for sustainability and recycling e-waste.
5.	Evaluate the alternative materials strategies.
6.	Develop a new sustainable material

Bibliography:

Sr. No.	**Book Detail**
1.	K.K.Chawla,CompositeMaterials,Science&Engineering,Springer-Verlag
2.	F. L.Matthews and R.D.Rawlings, Composite Materials: Engineering and Science, Chapman & Hall
3.	Recyclingof(critical)metals,ChristianHagelken,GermanyCriticalMetals Handbook,FirstEdition.EditedbyGusGunn.©2014JohnWiley&Sons,Ltd.Published2014 byJohnWiley&Sons,Ltd.
4.	Solid-state recycling of light metals: A review, Shazarel Shamsudin, MA Lajis andZWZhong;AdvancesinMechanicalEngineering2016,Vol. 8(8)1–23,2016DOI:10.1177/1687814016661921
5.	Bioplastics-classification,productionandtheirpotentialfoodapplications,Satish Kumar
6.	Kenneth Geiser, Barry Commoner, Materials matter: toward a sustainable materials policy. Edition 1st Year 2001

Course Name	**:**	**Advance Foundry Technology**
Course Code	**:**	**PR 1203**
Credits	**:**	**3**
L T P	**:**	**2-0-2**
Segment	**:**	

Total No. of Lectures: 28
Lab Hours: 28

Course Objectives:

The main objectives of this course are:	
1.	To understand about the safety, different molding methods, sand ingredients and their properties.
2.	To understand the process of design of gating and risering for different metals.
3.	To gain knowledge about the operating procedures, applications, advantages and inspection of various casting processes.

Course Contents:

Sr. No.	**Course contents**	**No. of Lectures**
1.	**Introduction:** Safety aspects, pollution control considerations, automation in foundry, fluidity testing, Ferrous and non-ferrous materials and their properties, metallurgical consideration of cast iron, SG iron, steel and Aluminium for casting process.	4
2.	**Sand Control:** Types of sand, significance, ingredients of the moulding sand, special sand additives, testing and control: measurement and control of AFS no., permeability, moisture and green strength on the shop floor. Effect of dextrin, iron oxide coal dust on the soundness of the castings.	4
3.	**Methods:** Applications of CAD/ CAM in foundry, application of additive manufacturing in pattern making, casting design considerations, design of gating system for ferrous and non-ferrous materials, effect of gate design on aspiration, turbulence and dross entrapment. Different methods of riser design, different methods for improvement of yield of casting. Riser design for gear blank, valve and slab.	6
4.	**Moulding And Casting Processes:** Machine, shell, investment, vacuum, full mould, CO2, injection, die and centrifugal casting processes, magnetic moulding process, hot box and cold box moulding squeeze and press casting, Shaw process, Anitoch process	5
5.	**Internal Stresses and Defects:** Residual stresses, hot cracks, stress relief, defects and their causes and remedies, gasses in metal-method of elimination and control of dissolved gases in casting	5

6.	**Testing, Inspection and Quality Control:** X-Ray and gamma ray radiography, magnetic particle, die penetrant and ultrasonic inspection, use of statistical quality control in foundry.	4

Lab Work:

Sr. No.	Lab contents
1.	To prepare a standard sand sample by using different sand ingredients and analyze the effects of ingredients.
2.	To design and fabricate some parts of the gating systems (Riser, Runner, Sprue) or patterns.
3.	To prepare a mould for a given pattern and characterize it.
4.	To cast the job by pouring the metal in the given mould and clean the casting.
5.	To inspect the casting, prepare the inspection reports and suggest remedial measures to improve the quality of the casting.
6.	To analyze the solidification time of a casting using CFD simulation in ANSYS fluent.

Course Outcomes:

At the end of the course, students will be able:	
1.	To understand the metallurgical aspects of metal casting
2.	To understand the effect of sand ingredients on mould properties
3.	To design pattern, gating and riser for a given casting.
4.	To study and understand the various casting processes.
5.	To analyze the causes and remedies of casting defects
6.	To test and prepare inspection reports for a given casting

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Principles of metal casting. Heine and Rosenthal , Tata McGraw Hill , 2011	2011
2.	Metal Casting, P.L Jain, Tata McGraw Hill, 2013	2013
3.	ASM handbook ,Vol. 15 Casting, ASM Publication, 1998	1998

Course Name	**:**	**Applied Ergonomics**
Course Code	**:**	**PR1204**
Credits	**:**	**3**
L T P	**:**	**2 0 2**

Total No. of Lectures:-28
Total No. of Lab Hrs: 28

Course Objectives:

The main objectives of this course are:	
1.	To understand the concept of designing a job for a worker.
2.	To consider various ergonomic factors affecting a human while designing a job for a worker.

Course Contents:

Sr. No.	Course Contents	No. of Lectures
1.	**Introduction** Focus of Ergonomics, Human Machine System, Brief History of Ergonomics, Modern Ergonomics, Generic Tools in Ergonomics, Status of Risk Assessment and Design Tools, Effectiveness and Cost Effectiveness of Ergonomics, Future Direction for Ergonomics	**3**
2.	**Body Mechanics at work: Risk Assessment and Design** Postural Stability, Some basic Body Mechanics, Anatomy of Spine and Pelvis related to Posture, Postural Stability and Postural Adaptation, Low back pain, Bio Mechanics of Spinal Loading, Ergonomics and the Musculoskeletal System-in-general.	**3**
3.	**User – Centered Work Space Design using Anthropometric Data** Designing for a Population of Users, Statistical essentials, Types of Anthropometric Data, How to use Anthropometric Data, Applications of Anthropometry in Design, Multiple workspace Configurations, Status of Anthropometry in Ergonomics.	**3**
4.	**Static Work : Principles for Risk Assessment and Design** Static Posture, Fundamental aspects of Sitting and Standing, Physiology of Standing, Working posture, Spinal Problem in Standing workers and Sitting, Seated work in vehicle operation, Ergonomics approach to Workstation Design, Design for standing workers and Seated Workers, Work surface Design, Visual display Terminals, Static Work: Risk Assessment Tools.	**5**
5.	**Repetitive Task : Risk Assessment and Task Design** Introduction to work-related Musculoskeletal Disorders, Injuries to upper body at work, Review of Tissue Pathomechanics and WMSDs, Disorders of the Neck, Carpal Tunnel Syndrome, Tennis elbow, Disorders of the Shoulders, Lower Limbs, Ergonomics Design and the Management of WMSDs.	**4**
6.	**Design and Evolution of Manual Handling Task :** Anatomy and Bio-mechanics of manual handling, Prevention of Manual handling injuries in the work place, Design of Manual Handling task, Carrying, Status of Ergonomics Tools in Manual Handling Risk assessment and Task Design.	**4**
7.	**Physical Demanding work : Stress and Fatigue :** Stress and Fatigue, Muscles, Structure and Function, Capacity, Cardiovascular System, Respiratory System, Physical Work Capacity, Factor Affective Work Capacity.	**3**

8.	**Job Demand, Work Place Stress and Health:** Physiological Demands, Fitness for work, Working hours and Shift Work, Psychological work Demands, Status of Physiological Methods in Risk Assessment and Task Design.	**3**

Lab Work

Sr. No.	**Lab. Contents**	**No. of Hours**
1.	To carry out anthropometric investigation of student population.	4
2.	To carry out posture analysis of industrial worker using RULA and REBA.	6
3.	To carry out assessment of MMH task using NIOSH equation.	6
4.	To carry out ergonomics evaluation of office workstation.	6
5.	To carry out ergonomics evaluation of a factory/workshop work cell.	6

Course Outcomes

At the end of the course, students will be able to:	
1	Understand human factors , tools in ergonomics and body mechanics at workplace.
2	Design a workplace and also design for a population of users by using anthropometric data.
3	Analyse various work-related musculoskeletal disorders and manage them using ergonomics design.
4	Carry out design and evolution of manual handling tasks.
5	Apply concepts of physical demanding work, workplace stress and fatigue
6	Carry out an assessment of physiological and psychological work demands.

Bibliography:

Sr. No.	**Book Detail**	**Year of Publication**
1	Mark Sanders, Ernest McCormick, Human Factors In Engineering and Design, 7th edition, McGraw-Hill International Editions.	1993
2	Martin Helander, A Guide to human factors and ergonomics, Taylor and Francis.	2005
3	Stanton, N.A., Hedge, A., Brookhuis, K., Salas, E. and Hendrick, H.W. eds, Handbook of human factors and ergonomic methods, CRC press.	2004
4	Gallwey, Timothy Joseph, and Leonard O'Sullivan, Ergonomics Laboratory Exercises, CRC Press.	2009
5	R.S. Bridger, Introduction to Ergonomics – Third Edition, CRC Press	2009

Course Name	**:**	**Non Destructive Testing**
Course Code	**:**	**PR1205/ PR3009**
Credits	**:**	**3**
L T P	**:**	**2-0-2**
Segment	**:**	

Total No. of Lectures: 28, Lab Hours: 28

Course Objectives:

The main objectives of this course are:	
1.	To gain knowledge about inspection procedures, applications, and advantages of various NDT techniques.
2.	Appropriate knowledge about causes and remedies of defects and their inspection.

Course Contents:

Sr. No.	**Course contents**	**No. of Lectures**
1.	**Introduction:**Selection of ND methods, Visual Inspection:Tools, Applications and limitations. Liquid Penetrant Inspection -principles, types and properties of penetrants and developers. Advantages and limitations of various methods of LPI.	5
2.	**Magnetic Particle Inspection-** Methods of generating magnetic field, types of magnetic particles and suspension liquids steps in inspection, Principles, Applications, Advantages and limitations.	6
3.	**Ultra-Sonic Testing (UT)**- Nature of sound waves, Wave propagation, modes of sound wave generation, Various methods of ultrasonic wave generation, Types of UT Principles, Applications, advantages, Limitations, A, Band C scan, Time of Flight Diffraction (TOFD).	6
4.	**Radiography Testing(RT)-** Principles, Applications, Advantages and limitations of RT. Types and characteristics of X ray and Gamma radiation sources, Principles and applications of Fluoroscopy/Real-time radioscopy, Advantages and limitations, Recent advances.	6
5.	**Eddy Current Testing-** Principles, types, applications, advantages and limitations of eddy current testing.	3
6.	**Case Studies-** Weld, Cast and Formed components.	2

Lab Work:

Sr. No.	Lab contents
1.	Detection of surface flaws of a given sample using visible/fluorescent dye penetrant test.
2.	Detection of sub-surface flaws using Ultrasonic testing in weld component.
3.	Detection of surface flaws using Magnetic Particle Testing using dry/wet powder.
4.	Infrared Thermography for temperature measurement on weld specimen to measure the peak temperature
5.	To investigate the surface/sub surface casting defects using different NDT techniques.

Course Outcomes:

At the end of the course, students will be able to:	
1.	To understand the fundamentals of non-destructive testing
2.	To learn about the NDT techniques used for internal defects
3.	To learn about the NDT techniques used for External defects
4.	To study the applications and advantages/disadvantages of various NDT techniques.
5.	To analyse the inspection procedures for different NDT techniques.
6.	To apply the suitable NDT inspection technique for a given problem

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Raj Baldev, Practical Non –Destructive Testing, Narosa Publishing House (1997).	1997
2.	Hull B. and John V., Non-Destructive Testing, Macmillan (1988)	1988
3.	Krautkramer, Josef and Krautkramer Hebert, Ultrasonic Testing of Materials, New York, Springer-Verlag (1983).	1983

Course Name	**:**	**Surface Engineering**
Course Code	**:**	**PR1206**
Credits	**:**	**3**
LTP	**:**	**3-0-0**

Course Objectives:

The main objectives of this course are:	
1.	Exposure to the analysis of various concepts of surface engineering; friction and wear behavior of materials and industrial applications.
2.	Identifying and distinguishing the corrosion problems and their controls.

Total No. of Lectures:42

Sr. No.	Course Contents	No. of Hours
1.	**Introduction**: Concept and Importance, classification of surface modification Techniques, advantage ,and their limitations. **Surface Degradation**: Causes, types and consequences of surface degradation, Forms of wear – adhesive, abrasive, surface fatigue, corrosive, fretting and erosive wear, Classical governing laws related to wear, techniques to evaluate the wear damage.	**06**
2.	**Thermalspraycoating**:Definition,History,CoatingBuild-up,Marketsegmentation,Materialusedforspraying,Methodofpowdersproduction,Methodsofpowdercharacterization,Spraydrying,Cladding,Mechanicalalloying, Self-propagating high temperature synthesis; Pre-spray treatment,Thermalsprayprocess,Postspraytreatment,Propertiesofcoatings:Mechanicalproperties,Thermo-physicalproperties,Electricproperties,Magnetic properties, Optical properties, Corrosion resistance, Application ofcoatings:Newcoatingconceptsincludingmulti-layerstructures,functionallygradient materials (FGMs), intermetallic barrier coatings and thermal barrier coatings.	**08**
3.	**DiffusionbasedSurfaceModificationTechniques:**Ionimplantation,chemicalvapordeposition(CVD)andphysicalvapordeposition(PVD),carburizing,nitriding,plasmanitriding,cyaniding.Surface modification of steel and ferrous components: Pack carburizing (principle and scope of application); Surface modification of ferrous and nonferrous components: Aluminizing, calorizing, diffusional coatings (principle and scope of application); Surface modification using liquid/molten bath: Cyaniding, liquid carburizing (diffusion from liquid state) (principle and scope of application); Surface modification using gaseous medium: Nitriding carbonitriding (diffusion from gaseous state) (principle and scope of application).	**08**
4.	**IrradiationbasedandLaserAssistedSurfaceEngineering(LASE)Techniques**: Laser cladding, alloying, glazing, laser and induction hardening,heattreatmentofsteelandre-meltingbylaser/TIG.Microwaveglazing.	**06**

5.	**Characterization of coatings and surfaces:** Measurement of coatings thickness; porosity & adhesion of surface coatings; Measurement of residual stress & stability; Surface microscopy & topography by scanning probe microscopy; Spectroscopic analysis of modified surface	**07**
6.	**Functional Coatings & Applications:** Functional and nano-structured coatings and their applications in photovoltaics, bio- and chemical sensors; Surface passivation of semiconductors & effect on electrical properties; Surface engineering of polymers and composites; Thin film technology for multilayers & superlattices for electronic, optical and magnetic devices; Modelling	**07**

Course Outcomes:

At the completion of this course, students would be able to:	
1.	Explain the fundamentals of tribology and related contact mechanics.
2.	Understand the principles of coating, deposition methods and their applications
3.	Apply appropriate testing approaches to evaluate service performance.
4.	Analyze reasons for corrosion and suggest solutions for its protection and prevention.
5.	Evaluate the micro mechanism failure and to optimize surface engineered microstructures.
6.	Understand failure micro mechanisms occurring in different service conditions.

Bibliography:

Sr. No	Name of Book/ Authors/Publisher	Year of Publication/ Reprint
1.	Introduction to surface engineering and functionally engineered materials By Peter Martin, JohnWiley and Sons	2011
2.	Burakowski and Wierzchon, "Surface Engineering of Metals: Principles, Equipment, Technologies", CRC Press, Boca Raton, Florida	1999
3.	Tribology and Surface Engineering by Paulo Davum, Nova Science Publishers.	2012
4.	Raja and Shoji, Stress corrosion cracking 302226 Theory and Practice, Wood haed Publishing Limited, Oxford.	2011
5	Material and Surface Engineering in Tribology by Jamal Taka doum, Wiley	2008
6.	K.G. Budinski, Surface Engineering for Wear Resistances, Prentice Hall, Englewood Cliffs	1998

Course Name	**:**	**Modelling and Simulation**
Course Code	**:**	**PR1207**
Credits	**:**	**3**
L T P	**:**	**2-0-2**

Total No. of Lectures– 28

Course Objectives:

The main Objectives of this course are:	
1.	The main objective of this course is to provide an understanding of methods, techniques and tools for modelling, simulation and performance analysis of complex systems such as communication and computer networks
2.	Modelling and simulation approaches with emphasis on applications using MATLAB.
3.	Generate random numbers and random variates using different techniques. Develop simulation model using heuristic methods. Analysis of Simulation models using input analyzer,

Sr. No.	**Course contents**	**No. of lectures**
1.	A review of basic probability and statistics; Physical Modelling: Concept of System and environment, Continuous and discrete systems, Linear and non-linear systems	**06**
2.	Principles of modelling, Basic Simulation modelling, Role of simulation in model evaluation and studies, advantages of simulation;	**05**
3.	Modelling of Physical System Dynamics: A Unified Approach: Physical systems. Introduction to Bond graphs, Ports, Bonds and Power; Elements of Bond graphs	**06**
4.	Mechanical Systems, Translation and rotation (about a fixed axis);System Simulation: Techniques of simulation	**04**
5	OptimizationsandDesignofSystems:SummaryofgradientbasedtechniquesNontraditional Optimizations techniques (1) genetic Algorithm (GA)- coding, GA operationselitism,ApplicationusingMATLAB	**04**
6	NeuralNetworkModellingofSystemsonlywithInput-outputDatabase:Neurons,architecture of neural networks, knowledge representation, learning algorithm. Multilayerfeed forward network and its back propagation learning algorithm,	**03**

List of Experiments:-	**Number of Turns**
Introduction to programming with MATLAB	03 X 02
Use of Simulink in MATLAB for engineering problems	03 X 02
Use of Neural Network in MATLAB for engineering problems	03 X 02
Application of Genetic and non-traditional algorithm using MATLAB	03 X 02

Course Outcomes:

By the end of the course, the students will be able to :	
1.	**Understand** the role of important elements of discrete event simulation and modelling Paradigm
2.	**Knowledg**e of real world situations related to systems development decisions, originating from source requirements and goals.
3.	Develop skills to **apply** simulation software to construct and execute goal-driven system Models
4.	**Interpret/Evaluate** the model and apply the results to resolve critical issues in a real world environment.
5	**Design a** model using Non-traditional Optimizations tool
6	**Understand and Analyze** of various techniques of neural networks

Bibliography:

Sr. No.	**Name of Book / Authors / Publishers**
1	System Simulation by Geoffrey Gordon, Prentice Hall
2	System Simulation: The Art and Science by Robert E. Shannon, Prentice Hall
3	Modelling and Analysis of Dynamic Systems by Charles M Close and Dean K. Frederick Houghton Mifflin
4	Bond Graph in Modelling, Simulation and Fault Identification by Amalendu Mukherjee, RanjitKarmakar, ArunSamantary, I.K. Int. Pub. house
5	JangJ.S.R.sunC.TandMizutaniE,,"Neuro-FuzzyandsoftComputing",3rd edition,PrenticehallofIndia

Course Name	**:**	**Industry 4.0 & Mechatronics**
Course Code	**:**	**PR1208/ PR3008**
Credits	**:**	**3**
L T P	**:**	**2-0-2**

Course Objectives:

The main Objectives of this course:	
1	To provide students an introduction to Industry 4.0 (or the Industrial Internet) and its applications in the business world.
2	The students are able to get hands on experience to work on the Raspberry Pi, Sensors, Actuators, design of mechatronic systems, computer hardware and control software used for customized/need base problem.

Course contents: Total lectures: 28 Hours

Sr. No.	Course Contents	No. of Lectures
1.	**Introduction to Industry 4.0:** The Various Industrial Revolutions, Digitalization and the Networked Economy, Drivers, Enablers, Compelling Forces and Challenges for Industry 4.0, Comparison of Industry 4.0 Factory and Today's Factory,Trends of Industrial Big Data and Predictive Analytics for Smart Business Transformation, Internet of Things (IoT), Cyber Physical Systems, Cybersecurity in Industry 4.0,:Support System for Industry 4.0.The Journey so far: Developments in USA, Europe, China, India and other countries, Strategies for competing in an Industry4.0 world. Future of Works and Skills for Workers in the Industry 4.0 Era, Strategies for competing in an Industry 4.0 world	**04**
2.	**Industrial Internet of Things (IIoT**):Basics of Industrial IoT, Internet of Services, Smart Manufacturing, Smart Devices and Products, Smart Logistics, Predictive Analytics. Industrial IoT- Layers. Role of data, information, knowledge and collaboration in future organizations, Industrial IoT Application	**04**
3.	**Introduction to Raspberry Pi:** Comparison of various Rpi Models, Pin Description of Raspberry Pi, On-board components of Rpi, Raspberry pi Installation Projects using Raspberry Pi. **Sensors & Actuators**: Application of Sensors - Temperature - Vibration - Humidity, Ultrasonic sensor, Gas detection sensor, Examples for sensor, actuator, control circuits with sensors.	**05**
4.	**Overview of Mechatronics:** Historical perspective, Definition, Applications, Block diagram of Mechatronic system, Functions of Mechatronics Systems, Sensors and transducers: Characterization, sensors for position, velocity, proximity, force,	**04**

	pressure, temperature and light, Signal conditioning: Amplification, filtering, multiplexing, and telemetry. Data acquisition with A/D, D/A and digital I/O.	
5.	**Mechanical components:** Types of motion, kinematic chains, cams, gears and other power transmission mechanisms, Benefits of mechatronics in manufacturing.	**03**
6.	**Software development**: program structures for embedded systems, software design process, inter-processor communication, microcontrollers and peripherals, Pneumatic and hydraulic actuators: Basics of fluid flow, control valves, cylinders and rotary actuators for pneumatics and hydraulics, Microcontrollers: Introduction to use of open source hardware (Arduino & Raspberry Pi); shields/modules for GPS, GPRS/GSM, Bluetooth, RFID, and XBEE, integration with wireless networks, databases and web pages; web and mobile phone apps.	**04**
7.	**Design and Mechatronics**: Input/output systems, computer based modular design, system validation, remote monitoring and control, designing, possible design solutions, detailed case studies of mechatronics systems used in photocopier, automobile, robots.	**04**

Lab Work: **Total hours: 28**

Sr. No	Lab Contents	No. of Hours
1	Using IoT devices small systems like classroom automation, smart parking, environment monitoring can be designed and implemented Also, Hadoop cluster can be setup and studied.	**10**
2	Cloud computing with IoT for logistic, manufacturing & industrial automation	**09**
2	Arduino microcontroller I/O and interfacing, Basic sensors interfacing with Arduino, GPS and data logging with Arduino, Networking with Arduino: GSM and Bluetooth, Raspberry Pi microcomputer I/O and interfacing	**09**

Course Outcomes:

By the end of the course, the students will be able to:	
1.	Outline the various systems used in a manufacturing plant & their role in an Industry 4.0 world
2.	Understand the drivers and enablers of Industry 4.0
3.	Understand the various enabling IoT concepts, application areas of IOT
4.	Understand the basic concepts of the main sensors used in manufacturing systems
5.	Understand the fundamental concepts of mechanical power transmission components, and pneumatic and hydraulic actuators
6.	Understand the integration of mechanisms, sensors, actuators, interfaces and software in the design of mechatronic systems.

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Alasdair Gilchrist, "Industry 4.0: The Industrial Internet of Things", Apress, by Alasdair Gilchrist	2017
2.	A. Bahga and V. Madisetti, Internet of Things, A hands-on approach, CreateSpace Independent Publishing Platform, 1st edition, ISBN: 978-0996025515.	2014
3.	T. Erl, Z. Mahmood, and R. Puttini, Cloud Computing: Concepts, Technology & Architecture, Prentice Hall, 1st edition, ISBN: 9780133387520.	2013
4.	The Fourth Industrial Revolution, Portfolio Penguinby Klaus Schwab	2017
5.	J. Edward Carryer, et al., Introduction to Mechatronic Design, Prentice Hall, 1st edition, ISBN: 978-8131788257	2010
6.	Mahalik, N., "Principles, Concept and Applications: Mechatronics", Tata McGraw	2003
7.	W.Bolton, Mechatronics, Electronic control systems in Mechanical and Electrical Engineering Pearson Education	2003
8.	D. G. Alciatore and M. B. Histand, Introduction to Mechatronics and Measurement Systems, McGraw-Hill, 4th edition, ISBN: 9789339204365.	2014

Course Name	**:**	**Industrial Process Automation**
Course Code	**:**	**PR1209**
Credits	**:**	**3**
LTP	**:**	**2-0-2**

Total No. of Lectures: 28 Total No.of Lab hrs.: 28

Course Objectives: The main objectives of this course are:	
1.	The students would be able to describe the importance of automation in industries using different techniques like hydraulic, pneumatic, electrical and PLC's.
2.	The students would be able to develop skills and competence to control various processes and systems.

Sr. No.	**Course Contents**	**Lectures**
1.	**Introduction**: Automation overview, Requirement of automation systems, Architecture of Industrial Automation system, Introduction of PLC and supervisory control, Industrial bus systems: Modbus &Profibus, types of automation systems.	03
2.	**Automation components:** Sensors for temperature, pressure, force, displacement, speed, flow, level, humidity and pH measurement. Actuators, process control valves, power electronics devices.	03
3.	**Pneumatic Control:** Production, distribution and conditioning of compressed air, Pneumatic control components, Pneumatic actuators, Pneumatic valves, Basic Electronic system components , Pneumatic control system design, Logic control circuits, Pneumatic and electro pneumatics circuit design for various applications.	04
4.	**Hydraulic Control :** Components of hydraulic control system, Hydraulic actuators, Hydraulic valves, Accumulators, Hydraulic circuit design and analysis.	04
5.	**Electrical Control:** Introduction of DC and AC servo drives for motion control and their selection.	04
6.	**Programmable logic controllers:** Programmable controllers, analog digital input and output modules, PLC programming, Ladder diagram, Sequential flow chart, PLC Communication and networking, PLC selection, PLC Installation, Advantage of using PLC for Industrial automation, Application of PLC to process control industries.	04
7.	**Distributed Control System:** Overview of DCS, DCS software configuration, DCS communication, DCS Supervisory Computer Tasks, DCS integration with PLC and Computers Features of DCS, Advantages of DCS	03
8.	**Automation system functionalities and application areas** Major Functionalities like Data Acquisition, Data Supervision or Monitoring, Application Areas of Automation System	03

Lab work

No	Lab contents	Hours
1	Study of Automation strategy along with case study	04
2	Study of sensors actuators & various Pneumatic / Hydraulic elements	04
3	Development of logic circuits	04
4	Operating a simple loads using relays, switches and pushbuttons	08
5	Programming the PLC Via Ladder logic	08

Course Outcomes:

By the end of the course, the students will be able to:	
CO1	Explain the automation principles and strategies
CO2	Understand different automation levels/ methods in the industries.
CO3	Apply actuators, sensors for building hydraulic/ pneumatic circuits for low cost automation
CO4	Analyse reliability and robust features of the systems.
CO5	Evaluate basic costs in industrial automations.
CO6	Create the architecture and local control unit of Distributed Control System (DCS) of various industrial applications.

Bibliography:

Sr. No.	**Name of Book/Authors /Publishers**	**Yr. of Publication/ Edition**
1.	Programmable Logic Controllers and Industrial Automation by Madhuchhanda Mitra, Samarjt Sengupta.	**2017**
2.	IndustrialInstrumentationandControl,S.K.Singh,TheMcGrawHillCompanies	2006
3.	"Automation, Production Systems and Computer-Integrated Manufacturing", M.P. Groover, Pearson Education	2014
4.	Programmable Logic Controllers", R. Ackermann, J. Franz, T. Hartmann, A. Hopf, M. Kantel, B. Plagemann, Festo Didactic	
5.	Fluid Power with Applications" A.Esposito, Pearson Education India	2003
6.	Process Control Instrumentation Technology, C.D. Johnson,PHI	2005

Course Name	**:**	**Data Mining and Big Data**
Course Code	**:**	**PR 1210**
Credits	**:**	**3**
L T P	**:**	**2-0-2**

Course Objectives:

The main Objectives of this course:	
1	To make the students understand the fundamental concepts of data mining, big data and analytics.
2	It will help them to identify and successfully apply appropriate techniques and tools to solve big data problems.

Course Contents: **Total lectures: 28 Hours**

Practical/ Lab work: 28 Hours

Sr. No.	**Course Contents**	**No. of Lectures**
1.	Introduction to Data Mining Systems – Knowledge Discovery Process – Data Mining Techniques – Issues – applications- Data Objects and attribute types, Statistical description of data, Data Pre-processing – Cleaning, Integration, Reduction, Transformation and discretization, Data Visualization, Data similarity and dissimilarity measures.	**7**
2.	Data Mining: Association rule-mining, FP-tree, Prefix-span, Multi-support rule mining, Frequent subgraph mining (gSpan and FSG), Clustering(Agglomerative clustering, k-means, k-medoid, DBSCAN, OPTICS,CURE, BFR, MCL). Data streams (FM sketch, Reservoir sampling, topk-counting), Anomaly detection (Density based techniques, chi-square tests, p-values), Influence maximization in social networks, Sim Rank ,random walk with restarts, PageRank, HITS.	**7**
3.	Big Data Analytics: Introduction to Data Science and Data Scientists, Introduction to Big Data, Theories in Data Science, Big data technologies, Large query data sets and associated theories, Exploring the Hadoop Ecosystem, Information management in Big Data and Emerging Issues.	**6**
4.	Evolution of Big data – Best Practices for Big data Analytics – Big data characteristics – The Promotion of the Value of Big Data – Big Data Use Cases- Characteristics of Big Data Applications – Perception and Quantification of Value -Understanding Big Data Storage – A General Overview of High-Performance Architecture – HDFS – Map Reduce and YARN – Map Reduce Programming Model.	**6**
5.	Big Data Systems: Introduction; Hadoop, Map-Reduce, SQL and Data-parallel programming, Data locality. Mining Streaming Data and Realtime analytics, Querying histograms, Incremental and online query processing: online aggregation.	**02**

Lab Work:

S.No.	Lab Contents	Total Hours
1.	Design efficient algorithms for mining the data from large volumes.	14
2.	Identify appropriate AI methods to solve a given problem.	14

Course Outcomes:

By the end of the course, the students will be able to:	
1.	To know the fundamental concepts of data mining, big data and analytics
2.	To understand the various characteristics, application of data mining and big data
3.	To apply the Big Data statistics for a given data set.
4.	To analyse the Information management in Big Data, Data locality, Mining Streaming Data with Real-time analytics
5.	To evaluate the Best Practices for Big data Analytics, characteristics with Case study & Programming Model
6.	To develop the appropriate model using AI methods and efficient algorithms

Bibliography:

Sr. No.	Name of Book / Authors / Publishers	Yearof Publication/ Edition
1	Data Mining Concepts and Techniques, Jiawei Han and Micheline amber, Third Edition, Elsevier.	2012
2	"Mining of Massive Datasets", Anand Rajaraman and Jeffrey David Ullman, Cambridge University Press.	2012
3	Analytics in Practice, by Soumendra Mohanty, Tata McGraw hill Education	2011

Course Name:	**Optimization Techniques in Manufacturing**
Course Code:	**PR1211**
Credits:	**3**
L T P:	**3-0-0**

Course Objectives:

The main Objectives of this course are:	
1	Building capabilities in the students for analyzing different situations in the industrial/ business scenario involving limited resources and finding the optimal solution within constraints by using various optimization techniques.
2	To make the students able to identify and solve linear and non-linear models of optimization problems.

Lecture Hours: 42

Sr. No.	**Course contents:**	**No. of Lectures**
1	**Introduction:** Engineering Applications of Optimization, Statement of an Optimization Problem, Classification of Optimization Problems, Local and global optima; necessary and sufficient optimality conditions for unconstrained and constrained multivariate functions	6
2	**Single Variable Optimization Problems:** Optimality Criterion, Bracketing Methods, Region Elimination Methods, Interval Halving Method, Fibonacci Search Method, Golden Section Method, Successive Quadratic Estimation Method. Gradient Based Methods: Newton-Raphson Method, Bisection Method, Secant Method. Application to Root finding.	10
3	**Multivariable Optimization Algorithms:** Optimality Criteria, Unidirectional Search, Direct Search Methods: Hooke-Jeeves pattern search method, Powell's Conjugate Direction Method. Gradient Based Methods: Cauchy's Steepest Descent Method, Newton's method, Marquardt's Method	8
4	**Constrained Optimization Algorithms**: Kuhn Tucker conditions, Transformation Methods: Penalty Function Method, Method of Multipliers, Sensitivity analysis.	8
5	**Modern Methods of Optimization** - Genetic Algorithms -Simulated Annealing -Particle Swarm Optimization -Ant Colony Optimization -Optimization of Fuzzy Systems - Neural-Network, Based Optimization, Practical Aspects of Optimization, Branch and Bound Method, , Applications Design of experiments and Taguchi method – Application and problem solving;	10

COURSE OUTCOMES:

At the end of the course, the students would be able to:	
CO1.	Analyze the real-life systems with limited constraints.
CO2.	Analyzethe problems and identify the appropriate computing requirements for its solution.
CO3.	Design and conduct experiments and numerical tests of optimization methods, and to analyze and interpret their results.
CO4.	Understand variety of real industrial problems and solve these problems using software.

CO5.	Demonstrate a dedication to advance engineering research to discover new knowledge, develop new methodologies, promote innovative thinking and research output in engineering and science.
CO6.	Learn and use new techniques, skills and scientific tools for research in manufacturing and engineering.

Bibliography:

Sr. No.	Book Detail	Year of Publication
1	Kalyanmoy Deb, "Optimization for Engineering design – algorithms & examples", PHI, New Delhi, 2nd edition	**2004**
2	S. S. Rao, "Engineering Optimization: Theory and Practice", John Wiley & Sons	**1996**
3	Johnson Ray, C., "Optimum design of mechanical elements", Wiley, John & Sons,	**1990**
4	Garfinkel, R.S. and Nemhauser, G.L., "Integer programming", John Wiley & Sons.	**1972**

Course Name	**:**	**Integrated Product Design and Development**
Course Code	**:**	**PR1212**
Credits	**:**	**3**
LTP	**:**	**3-0-0**

Course Objectives:

The main objectives of this course are:	
1.	To understand the concept of product design & development.
2.	To understand the concept of product planning.

Total lectures: 42 Hours

Sr. No	Course Contents	No. of Lectures
1.	**Understanding Design** Design & its nature, Design activities: Design exploration, Design generation. Design evaluation, Design communication, Design problems: Design brief, ill-defined problems, Final design description	**05**
2.	**Product Development** Product development, Characteristics of successful product development, Challenges of product development, Phases of product development process, Research and new product development, Patents, Patent search, Patent laws, international code for patents, Intellectual property rights (IPR)	**06**
3.	**Product Planning** Product planning, Types of product development projects, Product Planning process (steps)	**05**
4.	**Product Life Cycle** Introduction and Background, Overview, Need, Benefits, Concept of Product Life Cycle, Components / Elements of Product lifecycle management (PLM), Emergence of PLM, Significance of PLM, Customer Involvement, Product Data and Product Workflow, The PLM Strategy, Principles for PLM strategy, preparing for the PLM strategy, Developing a PLM strategy, Strategy identification and selection.	**08**
5.	**Concept Development** Understanding customer needs: Kanodiagram of customer satisfaction, Prioritizing Customer needs, Establishing product function: Function analysis system technique, Function structure, Idea generation, Concept development, Concept Selection and Concept Testing	**06**
6.	**System Level Design and Detail Design** Product Architecture, Design for manufacturing, Design for robustness	**06**
7.	**Design for the environment** DFE methods, Life cycle assessment & methods to reduce environmental impact.	**06**

Course Outcomes:

At the end of the course, students will be able to:	
1.	Know the fundamental concepts of product architecture.
2.	Understand design concepts and how to develop a concept.
3.	Scrutinize product design to identify and address environmental issues related to product development process.
4.	Analyze the concepts of Product life cycle management.
5.	Evaluate concepts of product development projects.
6.	Carry out product development and planning process.

Bibliography:

Sr. No.	**Book Details**	**Yearof Publication**
1	Dieter George E., "Engineering Design – A Materials and Processing Approach", McGraw Hill, International Edition Mechanical Engg .	1991
2	K.T. Ulrich & S.D. Eppinger, Product Design & Development, TMH.	2012
3	CrossN., Engineering Design Methods-Strategies for Product Design, John Wiley & Sons.	2008
4	Kevin N. Otto, Kristin L.Wood, Product Design, Pearson Education	2004
5	Product Design: The Delft Design Approach by Annemiekvan Boeijen, Delft University, Online Resource.	2003

Course Name	**:**	**Digital Manufacturing**
Course Code	**:**	**PR 1213**
Credits	**:**	**03**
L T P	**:**	**2-0-2**

Course Objectives:

The main objectives of this course are:	
1.	To introduce the concept of digitalization &its application in manufacturing.
2.	To impart knowledge to the students in areas of Rapid Product Development, Reverse Engineering and Product Life Cycle Management.

Course Contents:

Total No. Lectures: 28, Total No. of Lab hrs. 28

S. No.	Course contents	No. of Lectures
1.	**Introduction to Digital Manufacturing** Definition of digital manufacturing, Operation Mode and Architecture of Digital Manufacturing, System Requirements and needs, applications, various methods of digitalization in the manufacturing industries, Industry 4.0, Smart Manufacturing and concept of IIOT	6
2.	**CONCEPT MODELERS:** Introduction, Principle, Thermo jet printer, Sander's model market, 3-D printer, GenisysXs printer, JP system 5, object quadra system-Rapid proto typing.	6
3.	**DIGITAL FACTORY AND VIRTUAL MANUFACTURING:** Introduction, Scope, Methods and Tools Used in Virtual Manufacturing, Benefits. Virtual factory simulation.	6
4.	**Reverse Engineering:** Need, Reverse engineering process, Reverse engineering hardware and software, Geometric model development.	6
5.	**Product Life Cycle Management:** Fundamentals, Understanding the product lifecycle, Product data, Information models and Product structures, Product lifecycle management systems.	4

Lab Work:

Sr. No.	Lab contents	Hrs
1.	To 3D scan the existing product	4
2.	To perform remodelling of the scanned product	3
3.	To carry out detailed syntactic, pragmatic and semantic analysis of an existing consumer product, suggest its improved version and repeat the analysis	3
4.	To develop product structure of a product using PLM software	4

Course Outcomes:

At the end of the course, students will be able to:	
1.	Identify different digital manufacturing techniques.
2.	Implement various steps of Reverse engineering process.
3.	Understand working of a product lifecycle management system
4.	Analyze the concept modelers, tools used in virtual manufacturing &PLM systems.
5.	Evaluate the solution for different Reverse engineering problems
6.	Develop the model product structure using PLM software & RE Techniques

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Vinesh Raja and Kiran J Fernandes, "Reverse Engineering- An Industrial Perspective", Springer-Verlag.	2008
2.	Gerard Jounghyun Kim, "Designing Virtual Systems: The Structured Approach", Springer.	2005
3.	Pham D T and Dimov S S, "Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping", Springer-Verlag.	2001
4.	Antti Saaksvuori and AnselmiImmonen, "Product Lifecycle Management", Springer.	2004
5.	Bernard Alain and Fischer A., "New Trends in Rapid Product Development", CIRP Annals, Volume 51, Issue 2, Pages 635-652, Elsevier	2002

Course Name	**:**	**Computer Integrated Manufacturing**
Course Code	**:**	**PR1214/ PR3007**
Credits	**:**	**3**
L T P	**:**	**2-0-2**

The main objectives of this course are:
1. To provide knowledge and details on the means of computer integrated manufacturing.
2.To understand various functions supporting the automated manufacturing.

Course Objectives:

Total Lectures: 28
Lab Hours: 28

Sr. No	Course contents	No. of Lectures
1.	**Introduction** Basics and need of NC/CNC/DNC, applications and advantages of CNC machines and its role in FMS, classifications of CNC machines, constructional details of CNC machines	**02**
2.	**Design of CNC** Constructional features of CNC machine tools, Designation of axis in CNC systems, feedback devices, machine control unit, Interpolators, NC/CNC controllers.	**04**
3.	**CNC Part Programming** Introduction to Part Programming, Axis identification and coordinate systems, structure of CNC part program, programming formats, Radius and Length Compensation Schemes, Advanced Programming Features & Canned Cycles, Special part programming, Advanced Programming Techniques for CNC Milling and Turning Centers. Macros and Parametric Programming Techniques, Computer aided part programming	**09**
4.	**Adaptive Control System** Adaptive control with Optimization, Adaptive control with Constraints, AC System for Turning and Grinding	**04**
5	**Co-ordinate Measuring Machines** Basic types of measuring machines, Operating modes, Programming soft-wares, Measurement and inspection capabilities, Flexible inspection systems& probes.	**04**
6	**Flexible Manufacturing System and Automated Guided Vehicle System** Types of Flexibility, FMS, FMS Components, FMS Application & Benefits, FMS Planning and Control, Quantitative analysis in FMS, Simple Problems. Automated Guided Vehicle System (AGVS), AGVS Application, Vehicle Guidance technology	**05**

Lab Work

Sr. No.	Lab Content	No. of hours: 28
1	To perform simulation operations for drilling, milling etc on Master CAM software for given job.	**2x3** **2x3**

2	To perform single and multiple point drilling operation on VMC machine using Master CAM software.	**2x2**
3	To perform milling operation on VMC machine using Master CAM Software.	**2x3**
4	To write program for inspection of cylindrical and conical threads on CMM To evaluate the accuracy of physical cams relative to design specifications on CMM.	**2x3**

Course Outcomes:

At the end of the course, students would be able to:	
1	Understand the various functions of different components and their applications used in CIM.
2	Understand the how CNC machines are different form conventional machine tools.
3	Apply their learnings for effective utilization of the CNC machines, CMMs and AGVs
4	Select and analyze the suitable adaptive control system, CMM and AGV for required applications.
5	Evaluate the performance of various components used in CIM
6	Write the Program/Coding for machining complex profile of the parts.

Bibliography:

S. No	**Book details**	**Year of Publication**
1.	Koren Y, Computer Control of Manufacturing Systems, McGraw-Hill,	1986
2.	Singh N, Systems Approach to Computer Integrated Design and Manufacturing, John Wiley & Sons.	1996
3.	Kundra T K, Rao P N, Tewari N K, Numerical Control and ComputerAidedManufacturing, Tata McGraw-Hill.	2002
4.	Mikel P. Groover, Automation, Production Systems and Computer Integrated Manufacturing, Pearson,	2015
5.	Mehta N K, Machine Tool Design and Numerical Control, McGraw Hill Education; 3rd edition.	2017

Course Name	**:**	**CAD/CAM**
Course Code	**:**	**PR1215**
Credits	**:**	**3**
L T P	**:**	**2-0-2**

Total No. of Lectures: 28, Lab Hours: 28

Course Objectives:

The main objectives of this course are:	
1.	To impart parametric fundamentals for creating and manipulating geometric models using curves, surfaces and solids
2.	To Introduce the students to standard terminologies, operational characteristics of key hardware components, programming techniques, applications, merits and demerits of Computer Numerical Controlled (CNC) machines.

Course Contents:

Sr. No.	**Course contents**	**No. of Lectures**
1.	**Introduction:** Definition and scope of CAD/CAM, Introduction to design process and role of computers in the design process.	2
2.	**Transformations:** Translation, Rotation, Scaling Symmetry and Reflection, Homogeneous Transformations, 2D and 3D transformations.	4
3.	**Curves and Surfaces:** Analytical, Synthetic curves with advantages, Disadvantages, Comparison with parametric curves, Geometric modelling curves and surfaces, Representation, Wire frame models, Parametric representations, Parametric curves and surfaces, Manipulations of curves and surfaces.	4
4.	**Solid modelling:** Solid models, Fundamentals of solid modelling, Different solid representation schemes, Half -spaces, Boundary representation (B-rep), Constructive solid geometry (CSG), Sweep representation, Hidden line removal algorithms	4
5.	**Design of CNC** Constructional features of CNC machine tools, Designation of axis in CNC systems,feedback devices, machine control unit, Interpolators, NC/CNC controllers.	5
6.	**CNC Part Programming** Introduction to Part Programming, Axis identification and coordinate systems, Radius and Length Compensation Schemes, Advanced Programming Features & Canned Cycles, Special part programming, Advanced Programming Techniques for CNC Milling and Turning Centers. Macros and Parametric Programming Techniques, Computer aided part programming, Adaptive Control System	9

Course Outcomes:

At the end of the course, students would be able to:	
1	Understand the various applications of computer aided design and manufacturing.
2	Understand the significance of CAD and CAM in competitive manufacturing industries.
3	Apply the advanced concepts of CAD/CAM for improving the overall effectiveness of the manufacturing system.
4	Analyze the performances of manufacturing systems controlled and designed by CAD systems.
5	Evaluate the various CAD/CAM techniques used for designing and manufacturing various complex profiles.
6	Find out the most optimal method for designing and manufacturing parts of complex profiles.

Lab Work

Sr. No.	Lab Content	No. of hours: 28
1		**2x3**
2	To perform 2D and 3D modelling and assembly modelling using modelling packages using AutoCAD and Solid modelling soft-wares.	**2x3**
3	To perform assignments on various aspects of geometric modelling, fabrication of prototype, programming assignments and project work.	**2x2**
4	To perform simulation operations for drilling, milling etc on Master CAM software for given job.	**2x3**
5	To perform single and multiple point drilling operation on VMC machine using Master CAM software. To perform milling operation on VMC machine using Master CAM Software.	**2x3**

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Zeid, I., CAD/CAM, McGraw Hill.	2008
2.	Rogers, D. F., Procedural Elements for Computer Graphics, McGraw Hill.	2008
3.	Koren, Y., Computer Control of Manufacturing systems, McGraw Hill.	2009
4.	Groover, M. P. and Zimmers, E. W., CAD/CAM:Computer Aided Design & Manufacturing, Pearson Education India	2006
5.	Mehta N K, Machine Tool Design and Numerical Control, McGraw Hill Education; 3rd edition.	2017

Course Name	**:**	**Computer Graphics and Product Modelling**
Course Code	**:**	**PR 3001**
Credits	**:**	**3**
L T P	**:**	**3-0-0**

Course Objectives:

The main Objectives of this course:	
1	To provide an insight into fundamentals of Computer Graphics, Curve & surface design,
2	To understand Product modelling techniques and algorithms for geometric reasoning of CAD models
3	Apply appropriate techniques and tools to solve some graphics problems.

Course contents: Total lectures: 42 Hours

Sr. No.	**Course Contents**	**No. of Lectures**
1.	Role of Computer Graphics in Product Modelling, Elements of a graphics system - Vector and Raster devices, Bresenham and ODA raster graphics algorithms Viewing Pipeline Window, Viewport and Clipping transformations	**06**
2.	Geometric and Projection Transformations Homogenous co-ordinate system, Transformations in 20 and 3D	**07**
3.	Geometric design/synthesis of Planar and Space curves- Vector valued Parametric and Rational equations, Hermite, Bez1er, B-spline and NURBS curves,	**07**
4.	Modelling of Freeform surfaces - Coons, Bezier and NURBS patches, Developable Surfaces	**07**
5.	Fundamentals of 3 D Product Modelling - Topology of Solids, Euler-Poincare equations. Geometric modelling using Boundary representation (BRep) and Set Theoretic (CSG) approaches, Regularized Boolean Operations, Constraint based modelling,	**06**
6.	Feature based modelling - Design by Features approach, Geometric reasoning of CAD models for feature extraction -Pattern recognition and graph-based approaches.	**05**
7.	Data structures for product modelling -Winged I half edge, Quad/Oct trees, STL.	**04**

Course Outcomes:

By the end of the course, the students will be able to:	
1.	To know the fundamental concepts of Computer Graphics, Curve &Surface design
2.	To understand the various characteristics, application of Product modelling techniques and algorithms for geometric reasoning of CAD models
3.	To apply appropriate techniques and tools successfully to solve graphics problems.
4.	To analyse the graphics problems & geometric reasoning of CAD models
5.	To evaluate the solution for different Geometric and Projection Transformations problems
6.	To develop the code and solution after identification and investigation of different graphics & CAD problem

Bibliography:

Sr. No.	Name of Book / Authors / Publishers	**Yearof Publication/ Edition**
1	S. S Pande, Computer Graphics and Product Modelling for CAD/CAM, Narosa Publishing	2011
2	G Farin, Curves and Surfaces for Computer Aided Geometric Design, Academic Press	1997
3	D. F. Rogers and A Adams, Mathematical elements for Computer Graphics. McGraw Hill	1989
4	M. E. Mortenson, Geometric Modelling, Wiley	1985
5	Jami J. Shah, M. Mantyala, Parametric and Feature based CAD-CAM. John Wiley	2004

Course Name	**:**	**Knowledge Based Systems in Engineering**
Course Code	**:**	**PR3004**
Credits	**:**	**3**
L T P	**:**	**3-0-0**

Total No. of Lectures: 42

Course Objectives:

The main objectives of this course are:	
1.	To provide students with knowledge-based systems in engineering.
2.	To develop a systematic approach for design and implementation of engineering systems.

Course Contents:

Sr. No.	**Course contents**	**No. of Lectures**
1.	**Knowledge Based Systems** Knowledge representation – knowledge acquisition and optimization - Knowledge based approaches to design mechanical parts and mechanisms and design for automated assembly	8
2.	**Machine Learning** Machine learning concept, artificial neural networks, types of neural networks, applications in manufacturing, use of fuzzy logic for machine thinking	10
3.	**Artificial intelligence** Basic concepts of artificial intelligence, system components, system architecture, branches in AI, human and machine intelligence.	8
4.	**Intelligent Manufacturing** Introduction, applications in engineering and manufacturing, intelligent manufacturing, Intelligent system for design and equipment selection	8
5.	**Knowledge Based Group Technology** Group technology in automated manufacturing and engineering system, structure of knowledge-based system for group technology, visual method, coding method, cluster analysis method	8

Course Outcomes:

At the end of the course, the students would be able to:	
1	Understand the various applications of knowledge based manufacturing systems.
2	Understand the concept of knowledge based manufacturing systems and its advantages over the conventional manufacturing systems.
3	Apply the concepts of AI and machine learning for improving the overall effectiveness of the manufacturing system.
4	Analyze the performances of manufacturing systems controlled by various knowledge based systems.
5	Evaluate the solutions of the problems solved by using various knowledge based techniques.
6	Find out the most optimal method for handling knowledge based manufacturing systems

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Brent M. Gordon (Editor), Artificial Intelligence: Approaches, Tools and Applications, Nova Science Publisher, New York, 2011.	2011
2.	J. Paulo Davim (Editor), Artificial Intelligence in Manufacturing Research, Nova Science Publisher, New York, 2010.	2010
3.	Andrew Kussiak, "Intelligent Manufacturing Systems", Prentice Hall, 1990.	1990
4.	Introduction to Artificial Neural Systems/Jacek M. Zurada/JAICO Publishing House Ed. 2006.	2006

Course Name	Project Management
Course Code	PR3005
Credits	3.0
L-T-P	3-0-0

Course Objectives

The main objectives of this course are:	
1.	To enhance the competence of students as "Project Managers"
2.	To equip students with the process of feasibility analysis, risk analysis and provide skills in project management.

Course Contents: -Total No. of Lectures -42

Sr. No.	Course Contents	No. of lectures
1.	**Introduction to project management:** Need of project and its management: Project Characteristics; Relationship between Project Management, Operations Management, Role of the Project Manager, Skill requirements and functional competencies of the project manager, Project Team	06
2.	**Six Variables of Project Management:** Timescales, Costs, Quality, Scope, Benefits and Risk, Project Life Cycle, Process Model and Project Timeline, Principles, Critical aspects (Themes) of Project Management – Business Case, Organization, Quality, Plan, Risk, Change, Progress	06
3.	**Stakeholder categories**, level of organization, Roles and responsibilities, change authority, communication strategies, Project Quality- Quality Planning, Quality Assurance, Quality Control Project performance control: Reporting system – Process evaluation – Auditing	06
4.	**Project risk management:** Understanding risk and uncertainty, identifying risks: planning for risk responses, strategies for positive and negative risks, techniques for controlling risks	06
5.	**Project evaluation/appraiser:** Market feasibility, Technical feasibility, Financial feasibility: Net present value (NPV), Future Value, Internal rate of return (IRR), Payback period, Cash flow, Cost Vs. Benefit analysis	06
6.	**Project Time Management** - Defining activities, sequencing, estimating time and resources for activities, tools, and techniques for preparing a project timeline, Critical Path Method (CPM), Gantt chart, using three-point estimation, Program Evaluation and Review Techniques (PERT) to determine schedule durations under uncertainty.	06
7	Introduction to Software packages and SCOR Models in Project Management. **Case Studies: -** Case studies demonstrate the applications of the following with the help of the Microsoft Project. • Project risk evaluation • Financial Evaluation • Project Time Management.	06

Course Outcomes:

After successful completion of the course, students will be able to	
1.	Students would be able to know details about Project management
2.	Define the Critical success factors of a project
3.	Do Financial feasibility of a project and help a start-up in making project report
4.	Analyse and manage stakeholders expectations and engagements for successful project outcomes.
5.	Apply the PM processes to initiate, plan, execute, monitor and control, and close projects and to coordinate all the elements of the project
6.	Use project management software's for project time management and resource allocations.

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Project Management Heerkens, Gary R.; Tata McGraw Hill, New Delhi	2003
2.	Projects, Planning, Analysis, Selection, Financing, Implementation, and Review Chandra, Prasanna; 8th Edition; Tata McGraw Hill, New Delhi	2017
3.	Managing Projects Large and Small; The Fundamental Skills for Delivering on Budget and on Time; Harvard Business School Press, Boston	2011

Course Name	**Value Engineering**
Course Code	**PR3006**
Credits	**3.0**
L T P	**3-0-0**

Course Objectives:

The main objectives of this course are:	
1.	To understand the concept of value analysis and value engineering.
2.	To understand the various techniques of solving the problems pertaining to value engineering in production, management and service industries.

Course Contents: **Total Number of Hours: 42**

Sr. No.	Course contents	No. of Lectures
1.	**Concept of Value Engineering**- Definition of Value, types of value, product life cycle, approach to value analysis techniques, Role in productivity.	10
2.	**Role of Functions and Creativity**- Types of function, functional approaches to value improvement, function analysis system techniques (FAST diagram) with case study, Importance of creativity for solving roadblocks.	11
3.	**Value Engineering Phases** – Evaluation and implementation of functions, Value analysis job plan- information step, analysis step, creativity step, judgment step, development planning step, Types of management problems, audit of savings with case study.	11
4.	**Reliability and Breakeven analysis**- Reliability estimation, system reliability in series and parallel, Concept of breakeven point with the case study.	10

Course Outcomes:

At the end of the course, students will be able to:	
1	Understand the basic concepts of value engineering.
2	Understand the advanced techniques in value engineering.
3	Know about modelling and applications in value engineering.
4	Analyse the concepts of value engineering of products.
5	Perform “functional analysis” of some products.
6	Understand VAVE philosophy by creating a quality product with enhanced capabilities.

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Miles L.D., Techniques of value engineering and analysis, McGraw Hill Book Co. 1972.	1972
2.	Kaoufman Jerry, Value Analysis's Tear Down- A New Process for product development and innovation, Yashihiko Sato Industrial Press, 2004.	2004
3.	By the way Charles W, FAST creativity and innovation: Rapidly Improving Processes, Product Development and Solving Complex Problems, J. Ross Publishing, 2007.	2007

Course Name	**:**	**Soft Computing**
Course Code	**:**	**SCR 1001**
Credits	**:**	**3**
L T P	**:**	**2 0 2**
Type of Course	**:**	**Common to all Branches**

Course Objectives:
1. To understand and analyse various soft computing techniques for a given problem.
2. To get familiar with latest trends for problem solving in soft computing domain.

Total No. of Lectures: 28

Lecture wise breakup		**No. of Lectures**
1	**Introduction to Soft Computing and MATLAB/Octave** Evolution of Soft computing, Soft and Hard Computing, Characteristics and Application of Soft Computing, Soft Computing Constituents Introduction to MATLAB/Octave, Arrays and array operations, Functions and Files	4
2	**Fuzzy Logic** Fuzzy Sets, Operations on Fuzzy Sets, Fuzzy Relations, Membership Functions: Fuzzy Rules and Fuzzy Reasoning, Fuzzy Inference Systems, Fuzzy Expert Systems, Fuzzy Decision Making, Fuzzy Logic Controller Design and Applications	6
3	**Neural Networks** Biological Neurons, Perceptron, Multi-Layer Neural Network, Machine Learning Using Artificial Neural Network (ANN), Feed forward Networks, Supervised Learning Neural Networks, Adaptive Networks, Unsupervised Learning Neural Networks, Adaptive Resonance Architectures, Advances in Neural Networks, Application of ANN in Solving Engineering Problems	5
4	**Genetic Algorithms (GA)** Introduction to GA, GA Operations, Phases of GA, Applications of GA in Machine Learning, Machine Learning Approach to Knowledge Acquisition, Hybrid System, Solving of Single Objective Problems, Solving of Multi Objective Optimization Problems	5
5	**Introduction to AI & ML** Introduction to AI and its applications, Introduction to Machine Learning, Types of Machine Learning, Machine Learning Techniques, Introduction to Deep Learning, Reinforcement Learning	8

Total no. of Lab hours: 28

List of Experiments:		**Number of Hours**
1	Setting up MATLAB/Octave	2
2	Experiments with fuzzy logic toolbox	4
3	Experiments with neural network toolbox	4
4	Implementing fuzzy logic	6
5	Implementing artificial neural network	6
6	Implementing genetic algorithms	6

Sr. No.	Name of Book/ Authors/ Publisher	Year of publication
1	Jyh-Shing Roger Jang, Chuen-Tsai Sun, Eiji Mizutani, "Neuro-Fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence", Prentice Hall of India	2009
2	S. N. Deepa, S. N. Shivanandam, "Principles of Soft Computing", Wiley India, 2nd Edition	2011
3	George J. Klir and Bo Yuan, "Fuzzy Sets and Fuzzy Logic: Theory and Applications", Prentice Hall of India	2009

Available MOOCS:

1. https://nptel.ac.in/courses/106105173
2. https://www.classcentral.com/course/swayam-introduction-to-soft-computing-10053
3. https://www.class-central.com/tag/soft%20computing
4. https://swayam.gov.in/course/4574-introduction-to-soft-computing

Course Outcomes: At the end of the course, students will be able to:	
1	Apply Fuzzy Logic and reasoning to handle uncertainty and solve various engineering problems
2	Apply different types of Neural Networks to solve problems related to recognition and prediction
3	Apply Genetic Algorithms to solve optimization problems
4	Apply various machine learning and deep learning techniques
5	Evaluate and compare solutions by various soft computing approaches for a given problem

OTHER SUBJECT CODES

PR4001	**Industrial Tour: PR4001**
PR5001	**Seminar & Report Writing: PR5001**
RPR6001	**Research & Publication Ethics: RPR6001**
PR7001	**Dissertation-I: PR7001**
PR8001	**Dissertation-II: PR8001**