

**DEPARTMENT OF MECHANICAL ENGINEERING**

**COURSE STRUCTURE**

**For**

**M.TECH**

**SPECIALIZATION**

**IN**

**PRODUCTION ENGINEERING**

(Effective from 2019-20)



**VEER SURENDRA SAI UNIVESITY OF TECHNOLOGY**

**BURLA, SAMBALPUR**

**PIN-768018**

## Vision

To be recognised as a centre of excellence in education and research in the field of mechanical engineering by producing innovative, creative and ethical mechanical engineering professionals for socio-economic upliftment of society in order to meet the global challenges.

## Mission

Mechanical Engineering Department of VSSUT Burla strives to impart quality education to the students with enhancement of their skills to make them globally competitive through:

- M1:** Maintaining state of the art research facilities to provide conducive environment to create, analyze, apply and disseminate knowledge.
- M2:** Fortifying collaboration with world class R&D organizations, educational institutions, industry and alumni for excellence in teaching, research and consultancy practices to fulfil 'Make In India' policy of the Government.
- M3:** Providing the students with academic environment of excellence, leadership, ethical guidelines and lifelong learning needed for a long productive career.

## Programme Educational Objectives (PEO)

<b>PEO1</b>	Apply management principles to manage projects of inter-disciplinary nature adhering to professional ethics.
<b>PEO2</b>	Analyze, design and evaluate engineering products and processes using the knowledge of mathematics, science, engineering and IT tools.
<b>PEO3</b>	Engage in lifelong learning to adapt to changing needs for professional advancement

## PEO-Mission Matrix

	<b>M1</b>	<b>M2</b>	<b>M3</b>
<b>PEO1</b>	<b>1</b>	<b>1</b>	<b>3</b>
<b>PEO2</b>	<b>3</b>	<b>3</b>	<b>2</b>
<b>PEO3</b>	<b>1</b>	<b>2</b>	<b>3</b>

## Programme Outcomes (PO)

<b>PO1</b>	An ability to independently carry out research /investigation and development work to solve practical problems pertaining to production engineering.
<b>PO2</b>	An ability to write and present a substantial technical report/document.

<b>PO3</b>	An ability to demonstrate a degree of mastery over production engineering, a level higher than the requirements in the undergraduate program of mechanical engineering.
<b>PO4</b>	An ability to identify, critically analyze, formulate and solve manufacturing technology and automation problems to obtain optimal feasible solution considering safety, environment and other realistic constraints.
<b>PO5</b>	An ability to demonstrate skills in latest engineering tools, software and equipments to analyze and solve complex production engineering problems.
<b>PO6</b>	An ability to work as an individual and in a team with an understanding of the profession in ethical manner.

### **Programme Specific Outcomes (PSO)**

On completion of M. Tech in Production Engineering the students will be able to:

<b>PSO1</b>	Develop process plan, simulate manufacturing processes and set up production systems for the physical realisation of components and products.
<b>PSO2</b>	Carry out independent research work and disseminate the knowledge in industry / research organizations to provide solutions to complex real life industrial problems for improving production processes.

### Semester I

Sl. No.	Core/ Elective	Subject Code	Subject Name	L	T	P	Credits
1	Core-1	MMEPE101	Advanced Casting and Welding	3	0	0	3
2	Core-2	MMEPE102	Theory of Machining and Grinding	3	0	0	3
3	PE-1 (any one)	MPEPE101	Theory of Plasticity and Metal Forming Processes	3	0	0	3
		MPEPE102	Robotics and Flexible Manufacturing	3	0	0	3
		MPEPE103	Machine Tool Technology	3	0	0	3
4	PE-2 (any one)	MPEPE104	Inspection and Quality Assurance	3	0	0	3
		MPEPE105	Operation Management	3	0	0	3
		MPEPE106	Mathematical Methods in Manufacturing	3	0	0	3
5	Common	MMEPE103	Research Methodology & IPR	3	0	0	3
6	Lab-1	MMEPE104	Manufacturing Engg. Lab.-I	0	0	3	2
7	Lab-2	MMEPE105	Manufacturing Engg. Lab.-II	0	0	3	2
8	Audit -1			0	0	0	0
<b>Total Credits</b>							<b>19</b>

### Semester II

Sl. No.	Core/ Elective	Subject Code	Subject Name	L	T	P	Credits
1	Core-3	MMEPE201	Non-Traditional Manufacturing Process	3	0	0	3
2	Core-4	MMEPE202	Computer Aided Design and Manufacturing	3	0	0	3
3	PE-3 (any one)	MPEPE201	Tools and Dies Design	3	0	0	3
		MPEPE202	Composite Materials and Processing	3	0	0	3
		MPEPE203	Micro and Nano Manufacturing (MNM)	3	0	0	3
4	PE-4 (any one)	MPEPE204	Concurrent Engineering	3	0	0	3
		MPEPE205	Surface Engineering	3	0	0	3
		MPEPE206	Finite Element Analysis in	3	0	0	3

			Manufacturing				
5	Common	MMEPE203	Minor project & Seminar	0	0	3	2
6	Lab-3	MMEPE204	Manufacturing Engg. Lab.-III	0	0	3	2
7	Lab-4	MMEPE205	Manufacturing Engg. Lab.-IV	0	0	3	2
8	Audit -2			0	0	0	0
<b>Total Credits</b>							18

### Semester III

Sl. No.	Core/ Elective	Subject Code	Subject Name	L	T	P	Credits
1	PE-5 (any one)	MPEPE501	Tribology in Design and Manufacturing	3	0	0	3
		MPEPE502	Inventory System	3	0	0	3
		MPEPE503	Rapid Prototyping	3	0	0	3
2	OE-1 (any one)	MPEOE501	Reliability Engineering	3	0	0	3
		MPEOE502	Maintenance Engineering & Management	3	0	0	3
		MPEOE503	Laser Materials Processing	3	0	0	3
3	Project	MMEPE301	Dissertation (Phase-I)	0	0	20	10
<b>Total Credits</b>							16

### Semester IV

Sl. No.	Core/ Elective	Subject Code	Subject Name	L	T	P	Credits
1	Project	MMEPE401	Dissertation (Phase-II)	0	0	32	16
<b>Total Credits</b>							16

**GRAND TOTAL CREDITS: 19+18+16+16= 69**

### Audit course 1 & 2

Sl.No.	Course Code	Subject Name
1.	BCAC1001	English for Research Paper Writing
2.	BCAC1002	Disaster Management
3.	BCAC1003	Sanskrit for Technical Knowledge

4.	BCAC1004	Value Education
5.	BCAC2001	Constitution of India
6.	BCAC2002	Pedagogy Studies
7.	BCAC2003	Stress Management by Yoga
8.	BCAC2004	Personality Development through Life Enlightenment Skills.

## FIRST SEMESTER

### ADVANCED CASTING AND WELDING

#### **Course Contents**

##### **Module-I (8 Hours)**

Gating system for casting, Elements of a gating system, Sprue, Sprue base well, Gates, Gating System Design, Pouring time, Choke area, Gating Ratios, Ingate design, Slag Trap Systems, Risering Design, Caine's Method, Modulus Method, Naval Research Lab Method, Chills, Feeding aids

##### **Module-II (8 Hours)**

Solidification of Metals, Freezing of a pure Metal, Nucleation and Growth, Shrinkage, freezing of alloys, Thermal characteristics of the mould, casting defects, gas defects, pouring metal defects, Metallurgical defects

##### **Module-III (8 Hours)**

Basic Metallurgy of fusion welds, general theory of solidification of metals and alloys, homogeneous and heterogeneous nucleation, Effect of welding speed on grain structure, properties of weld metals, fusion boundary zone, heat affected zone, properties of heat affected zone

**Module-IV (8 Hours)**

Welding stress and distortion, residual stress, causes of residual stress, effect of weld thermal cycle and shrinkage on residual stresses, Reaction stresses, stresses generated by phase transformation, Measurement and calculation of residual stresses in weld metals.

**Module-V (8 Hours)**

Pre-heat and post weld heat treatment, Methods of Pre-heating, Advantages and limitations of pre-heating, weld defects, classification, arc welding defects and other than arc welding defects, Weld inspection, residual inspection, NDT testing.

**Text Books**

1. Manufacturing Technology, Vol.1 P.N.Rao, TATA Mc Graw Hill
2. Welding Engineering and Technology by R.S.Parmar, Khanna Publication

**Course Outcomes**

Upon completion of the course, students will be able to:

<b>CO1</b>	Discriminate the knowledge of principles, operations and applications of different casting and welding processes.
<b>CO2</b>	Analyze the effects of process parameters on the quality of cast and weld products.
<b>CO3</b>	Identify the NDT techniques for the evaluation of cast and weld components.
<b>CO4</b>	Apply the knowledge of welding in Heavy Engineering and nuclear industries.
<b>CO5</b>	Identify heat treatment processes for various applications and relate to casting processes in industries.

**Course Articulation Matrix**

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	2	2	1

CO2	3	2	3	2	2	1
CO3	3	2	3	2	2	1
CO4	3	2	3	2	2	1
CO5	3	2	3	2	2	1

**Program Articulation Matrix row for this course**

	PO1	PO2	PO3	PO4	PO5	PO6
<b>CO</b>	<b>3</b>	<b>2</b>	<b>3</b>	<b>2</b>	<b>2</b>	<b>1</b>

**THEORY OF MACHINING AND GRINDING**

**Course Contents**

**Module-I (8 Hours)**

Function of different angles of cutting tools, Tool geometry and nomenclatures-ASA, ORS, NRS systems, Conversion of angles, Geometry of twist drill and slab milling cutters, Tool materials. Mechanism of chip formation, mode of failure under stress, fracture and yielding mechanism, Type of chips, Factors involved in chip formation, shear plane, Effect of cutting variable on chip reduction coefficient, Chip formation in drilling and milling.

**Module-II (8 Hours)**

Force system in turning, Merchant circle diagram, velocity relationship and Kronenberg relationship, Stress in conventional shear plane, Energy of cutting process, restricted cutting, force analysis during oblique cutting, Earnstand Merchant angle relationship, Lee-shafer relationship, Forces in drilling and plane slab milling, Measurement of forces-dynamometer for measuring turning and drilling forces.

**Module-III (8 Hours)**

Thermo dynamic of chip formation-The shear plane temperature-Interface temperature from dimensional analysis-Experimental determination of chip tool interface temperature, Coolant-Theory of cutting action at the chip tool interface, Techniques for application of cutting fluids.

#### **Module-IV (8 Hours)**

Tool Wear: Criteria of wear, Machinability and tool life, Flank wear-Taylor's tool life equation, crater wear, causes and mechanism of tool failure, Vibration and chatter in machining, Economics of metal machining, On-line control in metal machining.

#### **Module-V (8 Hours)**

High speed grinding: Tool Geometry, High performance super-abrasive grinding wheels, Metal-ceramic joining, Ultra high speed grinding with monolayer CBN grinding wheel. Machining and grinding under cryogenic environment. Micro and nanogrinding of glasses and ceramics in ductile regime using diamond grinding wheel.

#### **Text Books**

1. Metal cutting theory and Practice: A. Bhattachary, New Central Book Agency (P) Ltd.
2. Machining and Machine Tools: A. B. Chattopadhyay, Wiley-India Publication.
3. Grinding Technology, Stephen Malkin, ChangshengGuo, Industrial Press.

#### **Reference Books**

1. Metal Cutting Principles: M. C. Shaw, Oxford University Press.
2. Metal Cutting: Edward M. Trent, Paul K. Wright, Butterworth Heinemann Publication.
3. Metal Machining Theory and Practices: T. H. C. Childs, K. Maekawa, T. Obikawa, Y. Yamane, Butterworth Heinemann Publication.
4. Fundamentals of metal machining and machine tools: G. Boothroyd, International Student Edition

#### **Course Outcomes**

Upon completion of the course, students will be able to:

<b>CO1</b>	Analyze the geometry of single point cutting tool in different systems and explain the mechanisms of metal cutting and chip formation.
<b>CO2</b>	Evaluate the mechanism of orthogonal and oblique cutting and analyse the cutting forces developed.
<b>CO3</b>	Explain the heat generation during metal cutting and its effect and use of cutting fluids in metal cutting.

<b>CO4</b>	Apply fundamental relations and theories like Merchant Circle theory, Talyor's Tool life equation etc. to estimate/calculate the various forces and power requirements in metal cutting operation.
<b>CO5</b>	Understand the importance of milling, grinding and super finishing in metal cutting process.

	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>
<b>CO1</b>	3	2	-	2	-	-	-	-	-	3	-	-
<b>CO2</b>	3	-	1	-	-	1	-	-	-	1	-	3
<b>CO3</b>	2	-	-	3	-	1	1	-	-	-	-	2
<b>CO4</b>	2	2	-	-	1	2	-	-	1	-	-	-
<b>CO5</b>	-	-	2	2	-	-	-	-	2	-	2	3

	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>
<b>CO</b>	2	1	-	2	-	-	1	3	-	3	-	2

## PROFESSIONAL ELECTIVE-I

### THEORY OF PLASTICITY AND METAL FORMING PROCESS

#### Course Contents

##### Module-I (8 Hours)

Fundamentals plasticity: True stress-strain curve. Bauschinger effect. Empirical equations to stress-strain curves. Three-dimensional stress and strain, 3D stress invariants

##### Module-II (8 Hours)

Yield criteria of materials: Tresca and Von-Mises theory, Prandtl-Reuss and Levy Mises stress strain relations, work hardening.

##### Module-III (8 Hours)

Equilibrium approach: Concepts of friction in metal forming, Coulumb friction and constant shear friction factor ( $m$ ). Application of stress equilibrium approach to extrusion, drawing, rolling and forging.

### Module-IV (8 Hours)

Slip line field theory: Applications to frictionless punch and wedge indentation. Simple solution for frictionless extrusion, drawing.

### Module-V (8 Hours)

Upper and lower bound theorems: Application to plane strain problems, Simple indentation and extrusion using hodographs.

### Text Book(s)

1. Engineering Plasticity – W. Johnson (Von Nostrand)
2. Mechanical Metallurgy – Dieter (Mc Graw Hill)

### Reference Book(s)

1. An Introduction to Principles of Metal Working – G.W.Rowe
2. Metal Forming: Processes and Analysis – Avitzur (TMH)

### Course Outcomes

Upon completion of the course, the students will demonstrate the ability to:

CO1	Apply the theory of plasticity and its application for analyzing various metal forming processes
CO2	Describe the advancement in forming technologies
CO3	To apply the theory of metal forming to extrusion, drawing, rolling and forging
CO4	To analyze the extrusion, drawing, rolling and forging process.
CO5	To analyze the process if frictionless punch and wedge indentation

### Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	1	1
CO2	2	1	3	1	1	1
CO3	3	1	3	3	1	1
CO4	3	1	3	3	1	1
CO5	3	1	3	3	1	1

### Program Articulation Matrix row for this course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	3	1	3	3	1	1

# ROBOTICS AND FLEXIBLE MANUFACTURING

## Course Contents

### Module-I (8 Hours)

Robotics: Historical background, Definitions, Laws of Robotics, Robotic system and robot anatomy, common robot configurations. Coordinate system, work envelop.

### Module-II (8 Hours)

Robot Kinematics: Forward and reverse Kinematics of 3-DOF and 4-DOF Robot arms. Homogeneous Transformations, Kinematic Equations using homogeneous transformations.

### Module-III (8 Hours)

Elements of robotic system – end effector, actuators, controller, teach pendant, sensors, Specification of robots. Applications, safety measures Actuators: Hydraulic actuators, Pneumatic actuators, Electrical actuators. Directional control, servo control, Flow control valves.

### Module-IV (8 Hours)

End effectors: Classification, Drive systems, Magnetic, Mechanical, Vacuum and Adhesive grippers, Force analysis in a gripper. Sensors: Need for sensing systems, sensory devices, Types of sensors.

### Module-V (8 Hours)

Robot vision system, Robot Languages and Programming: Types of programming, Motion programming, Robot language – VAL systems. Flexible Automation: Technology, FMS, Function of Robot in FMS, Flexible manufacturing cell.

### Text book(S):

1. Robotics Technology and Flexible Automation- S.R.Deb, TMH.
2. Industrial Robotics- Groover M P et al, Pearson Edu.
3. Robotics and Control- Mittal R K &Nagrath I J, TMH.

### Reference(S):

1. Robotic Engineering- Richard D. Klaffer, PHI.
2. Robotics- Fu K S et al., McGraw Hill.

## Course Outcomes

Upon completion of the course, the students will demonstrate the ability:

CO1	To explain the basic principles of Robotic technology, configurations, control and programming of Robots.
-----	---

CO2	To design an industrial robot which can meet kinematic and dynamic constraints and describe the concept of Robot kinematics and dynamics
CO3	To choose the appropriate Sensor and Machine vision system for a given application.
CO4	To explain the basic principles of programming and apply it for typical Pick & place, loading & unloading and palletizing applications.
CO5	To identify how automation can be used in production system and give exposure flexible manufacturing concepts.

### Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	1	1	2	1	2
CO2	1	2	3	1	2	-
CO3	2	-	2	3	2	-
CO4	-	-	3	3	2	2
CO5	1	-	2	3	3	1

### Program Articulation Matrix row for this course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	2	1	3	3	3	2

## MACHINE TOOL TECHNOLOGY

### Course Contents

#### Module-I (8 Hours)

General classification of machine tools, working and auxiliary motions, Mechanical transmission and its elements, General requirement of machine tools. Kinematics of Machine Tools – Stepped and step less drive, Basic considerations in the design of drives, Variable speed range in machine tools, Graphical representation of speed, structure diagram, selection of optimum ray diagram, Design of speed and feed gear boxes, step-less regulation of speed and feed rates.

#### Module-II (8 Hours)

Machine tool Structures: Design criteria, materials, static and dynamic stiffness, Basic dynamic stiffness, Basic design procedure, design of beds and columns, Model technique in design of machine tool structures.

#### Module-III (8 Hours)

Guideways and Power Screws: Classification of guideways, material and Lubrication, design criteria and calculations for guideways, designs of guides under hydrostatic lubrication, Aerostatic slideways, Antifriction guideways, Combination guideways, Classification of power screws, Design principles of power screws, Elimination of backlash. Machine Tool spindles and its Bearings: Materials of spindles, Effect of machine tool compliance on machining accuracy, Design principles of spindles, Antifriction and sliding bearings.

#### **Module-IV (8 Hours)**

Controlling systems in Machine Tools, Classification, Control systems for changing speeds and feeds, Ergonomic considerations applied to design of control members, principles of automatic and adaptive control.

#### **Module-V (8 Hours)**

Vibration in Machine Tools-Forced Vibration, self-excited vibration, stick-slip vibration and its minimization, vibration isolation.

#### **Text Books**

1. Machine Tools Design, N.K. Meheta, TMH.
2. Design of Machine Tools, S.K. Basu, D.K.Pal, OIBH.
3. Principles of Machine Tools, G.C.Sen, Bhattacharya, New Central Book Agency.
4. Metal Cutting Theory and Practice, A. Bhattacharya, New Central Book Agency (P) Ltd.
5. Machining and Machine Tools, A. B. Chattopadhyay, Wiley-India Publication.

#### **Course Outcomes**

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

CO1	Ability to identify various parts of machine tools
CO2	Ability in controlling size of the machines by Machine elements
CO3	Ability to apply various design aspects of spindles and bearings
CO4	Knowledge in steps of automation and its various features
CO5	Ability to reduce vibration and chatter developing on machine tools

#### **Course Articulation Matrix**

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	2	1	1
CO2	2	1	3	3	1	1
CO3	3	1	3	3	1	1

<b>CO4</b>	2	1	3	3	1	1
<b>CO5</b>	2	1	3	1	1	1

**Program Articulation Matrix row for this course**

	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>
<b>CO</b>	2	1	3	2	1	1

**PROFESSIONAL ELECTIVE-II**

**INSPECTION AND QUALITY ASSURANCE**

**Course Contents**

**Module-I (8 Hours)**

Inspection: Need for inspection, Precision & Accuracy, Interchangeability, selective assembly, Taylor's Principle of limit gauge design.

**Module-II (8 Hours)**

Use of slip gauge, Use of sine bar, Measurement of surface roughness by Talysurf, Inspection of V-thread by Tool Makers Microscope. Inspection of gear, 2-wire and 3-wire method of measurement, Gear tooth calliper.

**Module-III (8 Hours)**

Reliability: Failure data analysis, hazard models, constant hazard, linearly increasing hazard, system reliability.

**Module-IV (8 Hours)**

Quality Assurance – Statistical quality control, control chart, process control chart for attributes & variables, Acceptance sampling, OC curve, sampling plan, AOQL, AQL.

**Module-V (8 Hours)**

Quality circle, Total quality control, Taguchi method, Kaizen system, Kanban, ISO 9000, Quality documentation, Quality audit.

**Text Book(s)**

1. Engineering Metrology, R. K. Jain, Khanna Publish
2. Reliability Engineering, L. S. Srinath, East West Press.

## Reference Book(s)

1. Statistical Quality Control – E. C. Grant, Leavenworth Mc.Graw Hill Books Co.
2. Quality Assurance through ISO 9000 – H. D. Gupta, South Asia Pub.
3. Quality Circle in India- S. R. Udpa, TMH

## Course Outcomes

At the end of the syllabus students will be able to:

<b>CO1</b>	Apply the principle of measurement and limit gauges for practical usage.
<b>CO2</b>	Evaluate the various elements of surface texture and gain the ability to measure the diverse elements of surface texture, screw threads and gears.
<b>CO3</b>	Express the different forms of failure in Reliability system and apply system reliability concept in real life problems.
<b>CO4</b>	Implement the concept of different types of sampling plans, O-C Curve and calculation of AOQL.
<b>CO5</b>	Execute the major probability distributions in the engineering field and compute the control limits, tolerance limits/ specifications limits and the errors involved.

## Course Articulation Matrix

	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>
<b>CO1</b>	2	2	2	1	-	1
<b>CO2</b>	2	2	2	1	-	1
<b>CO3</b>	2	2	2	1	-	1
<b>CO4</b>	2	2	2	1	-	1
<b>CO5</b>	2	2	2	1	-	1

## Program Articulation Matrix row for this course

	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>
<b>CO</b>	2	2	2	1	-	1

## Course Contents

### Module-I (8 Hours)

**Introduction:** Functional subsystem of an Organization, Definition of Operation Management, System Concept of Production, Strategic Management- Corporate Strategies, Generic Competitive Strategies, Functional Strategies, Gross Domestic Product (GDP) and its impact, World Class Manufacturing

### Module-II (8 Hours)

Product design and analysis: what is product design and analysis, concept of new product development, steps of product design

### Module-III (8 Hours)

Line Balancing, Concept of mass Production system, Objective of Assembly Line Balancing, Rank Positional Weight Method, Stochastic Assembly Line Balancing

### Module-IV (8 Hours)

Maintenance, Planning & Control: Objectives of Maintenance, Types of maintenance, basic reasons for replacement, Replacement problems, Determination of maintenance crew size using Analytical Queuing Model, Total Productive Maintenance: Objectives, Waste elimination, Benefits, Pillars of TPM

### Module-V (8 Hours)

Modern Production Management Tools: Just In Time Manufacturing, Computer Integrated Manufacturing, Total quality management, Poke a Yoke, Kaizen, Lean Manufacturing

## Text Books

1. Production and Operation Management, E E Adam, R J Ebert, Prentice Hall of India, 2004
2. Production and Operation Management, R Paneerselvam, Prentice Hall of India, 2005

## Course Outcomes

At the end of the syllabus students will be able to:

<b>CO1</b>	Apply the principle of Different strategies of operation management
<b>CO2</b>	Designing of a new product
<b>CO3</b>	Acquire the knowledge of Line balancing
<b>CO4</b>	Acquire the knowledge of Maintenance management

<b>CO5</b>	Acquire the knowledge of techniques of Modern production management

### Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
<b>CO1</b>	-	1	1	2	1	2
<b>CO2</b>	1	2	3	1	2	-
<b>CO3</b>	2	-	2	3	2	-
<b>CO4</b>	-	-	3	3	2	2
<b>CO5</b>	1	-	2	3	3	1

### Program Articulation Matrix row for this course

	PO1	PO2	PO3	PO4	PO5	PO6
<b>CO</b>	2	1	3	3	3	2

## MATHEMATICAL METHODS IN MANUFACTURING

### Course Contents

#### Module-I (8 Hours)

Frequency distributions, Central tendency, AM, GM, Weighted mean, mode median, Dispersion, Coefficient of variation, Probability distribution, Binomial, Poisson, Normal distribution. Sampling distribution, types: Random sampling, sample size & standard error, point estimate, interval estimate, Hypothesis testing. Hypothesis Testing of mean with different conditions. Differences in mean, Chi squares as test of independence, as test of goodness fit.

#### Module-II (8 Hours)

Experiments with single factor, Analysis of variance, Fixed effect model Estimation of model parameters, Comparison of individual treatment means, Orthogonal contrasts, Scheffes method of comparing contrasts, Comparing pairs of treatment means, Model adequacy checking, plot of residuals, choice of sample size, OC curves, Method of CI estimation, Fitting response curves, Regression Approach Orthogonal Polynomials.

### Module-III (8 Hours)

Factorial Designs, Two factor factorial design, statistical analysis of fixed effect model, Estimation, choice of sample size, Random & Mixed model

### Module-IV (8 Hours)

Fitting response curves and surfaces, General Factorial design.  $2^k$  Factorial Design, Single replicate, Addition of center points to the  $2^k$  design Yates Algorithm for  $2^k$  design,  $3^k$  design, Yates of Algorithm for  $3^k$  design.

### Module-V (8 Hours)

Response surface methods & designs, Methods of steepest Ascent, Analysis of  $2^{\text{nd}}$  order model, Fitting response surface, Evolutionary operation. Taguchi contribution to experimental Design: Quantity engg., Philosophy, Taguchi approach to parameter design.

### Text Book(s)

1. Statistics for Management – Richard I. Leviz, PHI
2. Design and Analysis of Experiments – D.C.Montgomery, John Wiley & Sons.

### Course Outcomes

Upon completion of the course, the students will demonstrate the ability to:

CO1	Arrange the application of numerical method for non-linear problems
CO2	Apply numerical methods for manufacturing processes
CO3	Evaluate the numerical results of manufacturing processes
CO4	Analysis of algorithms for fitting response curves and surfaces
CO5	In depth study of modeling by Taguchi contribution to experimental Design

### Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	3	3	1
CO2	3	1	2	3	3	1
CO3	3	1	2	3	3	1
CO4	3	1	2	3	3	1
CO5	3	1	2	3	3	1

### Program Articulation Matrix row for this course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	3	2	2	3	3	1

## SESSIONALS

### Manufacturing Engg. Lab.-I

#### Content

1. Study of the sand rammer and preparation of standard AFS Sand Specimen.
2. Determination of grain fineness number of moulding sand.
3. Study of moisture tester and determination of moisture content of moulding sand.
4. Determination of clay content of moulding sand.
5. Study of permeability number and determination of permeability number of green sand.
6. Study of universal sand strength testing machine and determination of green compression strength of moulding sand.
7. To extrude a cylindrical shaped part by forward and backward extrusion.
8. To determine the deep drawing ratio of the material.

To study about the spinning machine

#### Course Outcomes

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

CO1	Analysis in casting moulding sands, clays, moisture contents by various processes
CO2	Measurement of compressive, shear and failure stress of moulding sands
CO3	Experimental verification of metal formed products by compression, extrusion, deep drawing processes
CO4	Study critical assessment of products prepared by spinning
CO5	Failure analysis of materials by forming methods

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	2	2	1	-	-	-	-	-	3
CO2	2	2	2	3	3	3	-	-	-	-	-	2
CO3	2	1	3	2	2	2	-	-	-	-	-	2
CO4	2	3	1	3	3	1	-	-	-	-	-	2
CO5	3	3	2	1	1	2	-	-	-	-	-	3

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO	3	3	3	3	3	3	-	-	-	-	-	3

## Manufacturing Engg. Lab.-II

### Content

1. Tensile test of a Low Carbon Specimens using a Universal Testing Machine (UTM).
2. Compression test of cast iron specimens on Universal Testing Machine (UTM).
3. Izod impact tests on Low Carbon Steel Specimen.
4. Determination of Rockwell Hardness number of Low Carbon Steel, Copper and Brass Specimen.
5. Study the Erichsen sheet metal testing machine and Determination cupping number of Aluminum, copper and Brass Specimen by Erichsen cupping testing machine.
6. To determine the friction factor 'm' during plastic deformation of metals by Ring Compression test.
7. Calculation of friction factor 'm' and analysis of 'height/diameter 'ratio during the axis-symmetric compression of a cylinder.

### Course Outcomes

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

CO1	Determine failure analysis of materials by Universal Testing Machine
CO2	Ability to understand stress limits by Impact test
CO3	Know deformation study of sheet metals during loading
CO4	Understand the importance of cyclic loading of work-piece
CO5	Know overall failure analysis of materials from static to dynamic loads

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	2	2	1	-	-	-	-	-	3

CO2	2	2	2	3	3	3	-	-	-	-	-	2
CO3	2	1	3	2	2	2	-	-	-	-	-	2
CO4	2	3	1	3	3	1	-	-	-	-	-	2
CO5	3	3	2	2	1	1	-	-	-	-	-	3

	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>
<b>CO</b>	3	3	3	3	3	3	-	-	-	-	-	3

## SECOND SEMESTER

### NON-TRADITIONAL MANUFACTURING PROCESS

#### Course Contents

##### Module-I (8 Hours)

Need for Non-traditional Machining: Classification, Ultrasonic machining principle, Transducer, Magnetostrictive material, Analysis for Material Removal Rate by Shaw, Effect of process parameters, Application.

##### Module-II (8 Hours)

Abrasive Jet Machining: Principle, Application, Advantages and disadvantages Variables in AJM. Water Jet Machining: Jet Cutting equipment, Principle, advantages, Practical Applications.

##### Module-III (8 Hours)

Electrochemical Machining: Principle. Determination Material Removal Rate, evaluation of metal removal rate, Dynamics of ECM process, Tool design, Advantages, Application, Limitation, Electro-chemical grinding, Electro Discharge Machining: mechanism of material removal, Basic EDM circuitry and principles of operation, Analysis of relaxation circuits,

Concepts of critical resistance, Machining accuracy and surface finish. Tool Material, Dielectric fluid, Applications and limitations,

#### **Module-IV (8 Hours)**

Laser Beam Machining: Lasing process and principle, population inversion, Principle of Ruby laser, Nd: YAG Laser and CO<sub>2</sub> Laser, Electron Beam Machining: Basic principle, Controlling parameters and focal distance, Plasma Arc Machining: Generation of Plasma, Equipments, Torch, Classification, Direct and indirect torches and applications, parameters effecting cutting, Advantages.

#### **Module-V (8 Hours)**

Principle of Coating Technology: Mechanism, Chemical and Physical vapour deposition, Application, Metal Spraying, Metallic coating, Plasma flame spraying.

#### **Text Books**

1. Non-Conventional Machining, P. K. Mishra, Narosa Publication
2. Manufacturing Science, A. Ghosh, A. K. Mallick, East West Publication
3. Modern Machines Process, P. C.Pandey, H. S. Shan, Tata McGraw Hill

#### **Course Outcomes**

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

CO1	Select suitable machining process for suitable materials
CO2	know the basic principle of mechanical non-traditional machining processes
CO3	know the basic principle of electrical non-traditional machining processes
CO4	know the basic principle of non-traditional machining processes using laser and allied sources
CO5	Familiar with the use of advanced coating for surface engineering

#### **Course Articulation Matrix**

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	-	2	1	-	-
CO2	1	-	2	1	1	-
CO3	1	-	2	1	1	-
CO4	1	-	1	1	2	-
CO5	-	-	3	1	-	-1

## Program Articulation Matrix row for this course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	1	-	3	1	2	-

## COMPUTER AIDED DESIGN AND MANUFACTURING

### Course Contents:

#### Module-I (8 Hours)

Fundamentals of CAD: The design process, applications of computer for design, creating the Manufacturing, Database, The design workstation, Graphical Terminal, Operator input Devices, Plotters and other devices, the CPU secondary storage.

#### Module-II (8 Hours)

Computer graphics Software and Database: Configuration, Graphics Packages, Constructing the Geometry, transformations, Database structure and content, wire frame versus solid modelling.

#### Module-III (8 Hours)

CAM – Introduction, Numerical Control and NC Part Programming: NC Coordinate system, NC motion control system, Economics of NC, Manual and Computer Aid Programming, the APT language, NC programming with interactive graphics.

#### Module-IV (8 Hours)

Problems with conventional NC, NC technology: CNC, DNC combined DNC/CNC system, Adopter control manufacturing systems.

#### Module-V (8 Hours)

Computer Integrated manufacturing system, Machine Tools and related Equipment, Materials Handling and Storage system, computer system.

### Text Book(s):

1. Computer Aided design and Manufacture, Grover M.P.Simmers, E.W. Prentice Hall
2. CAD/CAM/CIM,P.Radhakrishnan&Subramanyam, Willey Eastern Limited.
3. Principles of Computer Aided Design and Manufacturing / FaridAmirouche / Pearson.

## Course outcomes

Upon completion of the subject the students will be able to:

CO1	Describe and identify the parts, to choose the functions and operations of a CAD / CAM system and draw up specifications.
CO2	Describe the mathematical basis in the technique of representation of geometric entities including points, lines, and parametric curves, surfaces and solid, and the technique of transformation of geometric entities using transformation matrix.
CO3	Generate NC part programs to run the system for machining works
CO4	Explain the operation of a CAD / CAM system to assess its performance and describe the use of GT and CAPP for the product development.
CO5	Identify the various elements and their activities in the Computer Integrated Manufacturing Systems.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	1	1	-	1	-	-	-	1	1	3	1
CO2	3	2	-	-	2	-	1	-	1	1	2	1
CO3	2	3	2	1	3	-	-	-	-	-	2	2
CO4	3	3	2	3	-	-	-	-	-	-	2	1
CO5	3	3	2	1	3	-	-	-	-	-	2	1

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO	3	3	2	3	3	-	1	-	1	1	3	2

## PROFESSIONAL ELECTIVE-III

### TOOLS AND DIE DESIGN

#### Course Contents:

#### Module-I (8 Hours)

System approach to production design, Elements of a product manufacturing facility, materials selection, interchangeability & standardization, use of new technology, value engineering and analysis, cost analysis.

### **Module-II (8 Hours)**

Design of single-point cutting tools, Tool strength and rigidity calculation, selection of tool angles, chip breakers, carbide, tipped tools, High production cutting tools. Form Tools: Types of form tools, method of determining the profile of circular and flat form of tool, analytical and graphical method. Cutting process in broaching, geometric elements of broach teeth, Design of Internal & external surface broach, calculation of no. of teeth, Rigidity, cutting force, power.

### **Module-III (8 Hours)**

Forging Design-Allowances, Forging process, Forging die design, Drop forging Dies and auxiliary tools, Upset forging.

### **Module-IV (8 Hours)**

Design for sheet metal works: Press working-shearing action, center of pressure, clearance, cutting force, Die block design, punch design, punch support, stop, pilot, stripper, knockout, blanking & piercing die design, progressive & compound die design, Drawing dies, metal flow, Blank diameter, Drawing force.

### **Module-V (8 Hours)**

Jigs & Fixture design: Locating & clamping, principles of location, clamping, devices, materials for locating & clamping elements, Design principles, Design of Drilling Jig & Milling fixtures.

### **Text Books:**

1. Machine Tool design Handbook, CMTI, Bangaluru.
2. Machine Tool Design, N.K. Mehta, Tata McGraw Hill.

### **Reference Books:**

1. Cyril Donaldson, George H.LeCain, V.C. Goold, "Tool Design", Tata McGraw Hill Publishing Company Ltd., 2000.
2. E.G.Hoffman," Jig and Fixture Design", Thomson Asia Pvt Ltd, Singapore, 2004

3. Prakash Hiralal Joshi, "Tooling data", Wheeler Publishing, 2000
4. Venkataraman K., "Design of Jigs, Fixtures and Presstools", TMH, 2005
5. Haslehurst M., "Manufacturing Technology", The ELBS, 1978

### Course Outcome

Upon completion of the course, students will be able to

CO1	Apply the concept of system design in various engineering fields.
CO2	Explain the basic rules for tool and die design.
CO3	Implement the appropriate metal forming process for a given application.
CO4	Explain the principles for locating and clamping of devices.
CO5	Identify newly emerging technologies in the field of Tool & Die making.

### Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	2	3	-
CO2	3	1	3	2	3	-
CO3	3	1	3	2	3	-
CO4	3	1	3	2	3	-
CO5	3	1	3	2	3	-

### Program Articulation Matrix row for this course

	PO1	PO2	PO3	PO4	PO5	PO6
<b>CO</b>	<b>3</b>	<b>1</b>	<b>3</b>	<b>2</b>	<b>3</b>	<b>-</b>

## COMPOSITE MATERIALS AND PROCESSING

### Course Contents:

#### Module-I (8 Hours)

Introduction of Composites and their classifications: Based on reinforcement and Matrix with advantages, limitations and applications. Laminae and laminates. Interface in composites: Types of interface in composites, wettability and bonding. Test for measuring interfacial strength. Basic terminologies; volume fraction, weight fraction and Rule of mixtures, Density & void content.

#### Module-II (8 Hours)

Fabrication techniques: pultrusion, filament winding, prepreg technology, injection and compression moulding, bag moulding, resin transfer moulding, reaction injection moulding. Diffusion bonding and powder metallurgy methods, joining of composites. Other manufacturing processes; Processing of MMC- Diffusion bonding; Stir casting; Squeeze casting. Basic properties of GRP, CFRP, Al-B, Casting and Particulate composites.

#### Module-III (8 Hours)

Stress-strain relations for anisotropic materials; Generalized Hook's law; Stiffnesses, Compliances & engineering constants for orthotropic materials. Mechanical properties of unidirectional composite lamina. Longitudinal and transverse Young modulus, shear modulus, Poisson ratio. Empirical relationship of Halpin-Tsai. Longitudinal and transverse Strength. Composites under compressive loading. Properties of angle ply lamina. Transformation of Young moduli, shear modulus. Concept of coupling coefficients.

#### Module-IV (8 Hours)

General and special orthotropic materials. Tsai Pagano invariants Strength of orthotropic lamina. Biaxial strength theories. Maximum strength, maximum strain theory. Tsai-Hill maximum work theory. Tsai Wu tensor theory.

#### Module-V (8 Hours)

Codes and engineering representation of Laminates. Macro mechanical behavior of a laminate. Laminate stiffness for different types; symmetric, anti-symmetric, cross ply laminates. Stresses in different laminae in a laminate. Configurations and design of laminates for special properties Strength and mechanism of failure in a composite laminate. Concept of FPF(First Ply Failure and total failure). Hygroscopic and thermal stresses.

**Text Books:**

1. Composite Materials: Science and Engineering Paperback – by Krishan K. Chawla
2. Mechanics Of Composite Materials (Materials Science & Engineering Series) - by Robert M. Jones
3. Fiber-reinforced Composites –by P.K. Mallick

**Reference Books:**

1. Structural Analysis of Polymeric Composite Materials (Chapman & Hall/CRC Applied Environmental Statistics) - by Mark E. Tuttle
2. Definitive Composite Materials and Processing - by M. Balasubramanian

**Course Outcomes:**

Upon completion of the course, students will be able to

<b>CO1</b>	Explain concept of the composite materials and its terminologies used.
<b>CO2</b>	Understand and analyze the fabrication techniques of composite materials.
<b>CO3</b>	Understand the behavior and specialties of orthotropic materials.
<b>CO4</b>	Comprehend the usage of theory of elasticity and theories of failure in mechanics of anisotropic materials.
<b>CO5</b>	Understand the composite laminates and analyze the properties of laminates.

	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>
<b>CO1</b>	1	2	-	2	-	-	-	-	-	-	-	-
<b>CO2</b>	2	3	3	-	-		-	-		1	-	1
<b>CO3</b>	2	-	-	3	-	-	1	2	-	-	-	-
<b>CO4</b>	3	2	-	-	1	-		-	1	-	-	-
<b>CO5</b>	1	-	-	2	-	-	-	-	2	-	2	3

	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>
<b>CO</b>	3	2	1	-	1	-	1	2	-	1	-	1

## **Micro and Nano Manufacturing (MNM)**

### **Syllabus:**

#### **Module I:**

Introduction: Importance of Nano-technology, Emergence of Nanotechnology, Bottom-up and Top-down approaches, Challenges in Nanotechnology.

Nanomaterial Synthesis and Processing: Methods for creating nanostructures, Processes for producing ultrafine powders-Mechanical grinding, Wet Chemical synthesis of nanomaterials-sol-gel process, Liquid solid reactions, Gas phase synthesis of nano materials: Furnace, Chemical Vapour Condensation (CVC), Cold Plasma Method, Laser Ablation, Vapour-liquid-solid growth, particle precipitation aided CVD, Summary of Gas Condensation Processing (GPC)

#### **Module II:**

Structural Characterization: X-ray diffraction, Small angle X-ray scattering, Optical Microscope and their description, Scanning Electron Microscopy (SEM), Scanning Probe Microscopy (SPM), Transmission Electron Microscopy (TEM), Scanning Tunneling Microscopy (STM), Atomic Force Microscopy (AFM)

#### **Module III:**

Spectroscopic Characterization: Basic concept of spectroscopy, Operational principle and application for analysis of nanomaterials, UV-VIS-IR Spectrophotometers, Principle of operation and application for band gap measurement, Raman spectroscopy

Surface Characterization: X-ray Photoelectron Spectroscopy (XPS), Auger Electron Spectroscopy (AES), Low Energy Ion Scattering Spectroscopy (LEIS), Rutherford Backscattering Spectroscopy (RBS)

Thermal Characterization of Nanomaterials: DTA, TGA, DSC Principle and applications

#### **Module IV:**

Micro fabrication Techniques: Lithography, Thin Film Deposition and Doping, Etching and Substrate Removal, Substrate Bonding, MEMS Fabrication Techniques, Bulk Micromachining, Surface Micromachining, High Aspect Ratio Micromachining

#### **Module V:**

Nanofabrication Techniques: E-Beam and Nano-Imprint Fabrication, Epitaxy and Strain Engineering, Scanned Probe Techniques, Self-Assembly and Template Manufacturing

MEMS devices and applications: Pressure sensor, Optical MEMS and RF-MEMS, Micro-actuators for dual-stage servo systems

**Reference Books:**

1. Micro fabrication and Nano manufacturing, Mark James Jackson, CRC Press, 2005.
2. Introduction to Nanoscience and Nanotechnology, G. L. Hornyak, H. F. Tibbals, J. Dutta, J. J. Moore, CRC Press 2009.
3. Physical principles of Electron Microscopy, An Introduction to TEM, SEM and AEM, Springer, 2005.
4. Thermal Analysis of Materials, R. F. Speyer, Marcel Dekker Inc. New York, 1994.
5. Elements of X-Ray Diffraction, B. D. Cullity, 3<sup>rd</sup> Edition, Prentice Hall, 2002.
6. MEMS and Microsystems: Design and Manufacture, Tai-Ran Hsu, Mc Graw Hill, 2008.
7. Springer Handbook of Nanotechnology by Bharat Bhushan, Springer, 3<sup>rd</sup>edn, 2010.
8. Nanoscale Materials in Chemistry edited by Kenneth J. Klabunde and Ryan M. Richards, 2<sup>nd</sup>edn, John Wiley and Sons, 2009.
9. Nanocrystalline Materials by A I Gusev and A ARempel, Cambridge International Science Publishing, 1<sup>st</sup>Indian Edition, Viva Books Pvt. Ltd. 2008.

**Course Outcomes**

Upon completion of the course, students will be able to

<b>CO1</b>	Understanding manufacturing considerations at the micro and nano scale
<b>CO2</b>	Understanding design and analysis and tools used for micro and nano manufacturing
<b>CO3</b>	Select manufacturing methods, techniques and process parameters for material processing quality
<b>CO4</b>	Design and select industrially-viable processes, equipment and manufacturing tools for specific industrial products
<b>CO5</b>	Understanding the various characterization of nano materials and their applications in industrial products

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	2	2	1	-	-	2	-	-	1
CO2	1	2	2	3	3	3	-	-	1	-	1	1
CO3	2	1	3	2	2	-	2	3	1	-	-	-
CO4	2	3	1	3	3	-	2	3	2	-	-	1
CO5	3	3	2	1	1	-	1	1	2	-	-	1

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
<b>CO</b>	3	3	3	3	3	3	2	3	2	-	1	1

## **PROFESSIONAL ELECTIVE - IV**

### **CONCURRENT ENGINEERING**

#### **Course Contents:**

#### **Module-I (8 Hours)**

Introduction: Extensive definition of CE - CE design methodologies, Organizing for CE, CE tool box collaborative product development. Use of Information Technology: IT support, Solid modeling, Product data management, Collaborative product commerce.

#### **Module-II (8 Hours)**

Design Stage: Life-cycle design of products, Opportunity for manufacturing enterprises, Modality of Concurrent Engineering Design, Automated analysis idealization control, Concurrent engineering in optimal structural design - Real time constraints.

#### **Module-III (8 Hours)**

Manufacturing Concepts and Analysis: Manufacturing competitiveness, Checking the design process, Conceptual design mechanism- Qualitative Physical approach, An intelligent design for manufacturing system, JIT system, Low inventory, Modular, Modeling and reasoning for computer based assembly planning, Design of Automated manufacturing.

#### **Module-IV (8 Hours)**

Project Management: Life Cycle semi realization, Design for economics, Evaluation of design for manufacturing cost, Concurrent mechanical design, Decomposition in concurrent design

#### **Module-V (8 Hours)**

Negotiation in concurrent engineering design studies, Product realization taxonomy, Plan for Project Management on new product development, Bottleneck technology development

**Text Book(s):**

1. Concurrent Engineering Fundamentals: Integrated Product Development- Prasad, Prentice Hall.
2. Concurrent Engineering: Automation Tools and Technology- Andrew Kusaik, Wiley.

**Reference Book(s):**

1. Integrated Product Development- Anderson MM and Hein, L. Berlin, Springer Verlag.
2. Successful Implementation of Concurrent Product and Process- Sammy G Sinha, Wiley.

**Course Outcomes**

Upon completion of the course, students will be able to

<b>CO1</b>	Knowledge of Concurrent Engineering and its applications in industries
<b>CO2</b>	Knowledge of Concurrent Engineering Design and constraints
<b>CO3</b>	Knowledge on various manufacturing concepts and automation methods
<b>CO4</b>	In depth study of Project Management and cost evaluation
<b>CO5</b>	Knowledge of new product development procedures like removal of Bottleneck

**Course Articulation Matrix**

	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>
<b>CO1</b>	1	-	2	2	-	1
<b>CO2</b>	2	-	2	3	2	-
<b>CO3</b>	-	-	3	2	3	-
<b>CO4</b>	1	-	2	-	2	-
<b>CO5</b>	1	2	3	2	1	1

**Program Articulation Matrix row for this course**

	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>
<b>CO</b>	2	2	3	3	3	1

# **SURFACE ENGINEERING**

## **Course Contents:**

### **Module-I (8 Hours)**

Surface dependent engineering properties, viz., wear, friction, corrosion, fatigue, reflectivity, emissivity, etc.; common surface initiated engineering failures; mechanism of surface degradation; importance and necessity of surface engineering

### **Module-II (8 Hours)**

Classification and scope of surface engineering in metals, ceramics, polymers and composites, tailoring of surfaces of advanced materials. Surface protection (Physical); surface modification (Chemical) techniques: classification, principles, methods, and technology; conventional surface engineering methods: carburising, nitriding, cyaniding, diffusion coating, hot dipping, galvanizing etc.; electrochemistry and electro-deposition; scope and application of conventional surface engineering techniques in engineering materials; advantages and limitations of conventional processes.

### **Module-III (8 Hours)**

Recent trend in surface engineering: chemical vapour deposition (CVD); physical vapour deposition (PVD), types of PVD, balanced and unbalanced magnetron sputtering, arc evaporation, plasma spray coating; plasma assisted ion implantation; surface modification by directed energy beams like ion, electron and laser beams; energy transfer, beam configuration and modes, surface integration.

### **Module-IV(6 Hours)**

Heat and mass transfer (composition and temperature profile) during directed energy beam irradiation; novelty of composition and microstructure; post irradiation characterization (microstructural & compositional) and testing/evaluation of surface-properties; structure-property correlation.

### **Module-V (8 Hours)**

Physical and mechanical characterization of coatings. Various methods for evaluating the performance of the coating.

## **Text Books:**

1. Surface Engineering of Metals, Principles, Equipment, Technologies, Tadeusz Burakowski, Tadeusz Wierzchon, CRC Press
2. Handbook of Hard Coatings Deposition Technologies, Properties and Applications, Rointan F. Bunshah, Noyes Publication
3. Handbook of Thin-Film Deposition Processes and Techniques, Principles, Methods, Equipment and Applications, Krishna Seshan, Noyes Publications
4. Material Science of Thin Films, Milton Ohring, Academic Press

**Reference Books:**

1. Handbook of Physical Vapor Deposition (PVD) Processing, Film Formation, Adhesion, Surface Preparation and Contamination Control, Donald M. Mattox, Noyes Publications
2. Introduction to Surface and Thin Film Processes, John A. Venables, Cambridge University Press
3. Physics and Chemistry of Interfaces, Hans-Jürgen Butt, Karlheinz Graf, Michael Kappl, WILEY-VCH GmbH & Co. KGaA
4. ASM Handbook, Volume-18, Friction, Lubrication, and Wear Technology

**Course Outcomes**

Upon completion of the course, the students will demonstrate the ability to:

CO1	Demonstrate knowledge of basics of surface engineering
CO2	Demonstrate an understanding of plasma, electron emission, ionization, and different types of discharges.
CO3	Demonstrate an understanding of advanced different methods of coating depositions
CO4	Demonstrate an awareness of different types of surface protection against wear, oxidation, and corrosion
CO5	Demonstrate an understanding of various mechanical and tribological properties of coatings and coating characterization using modern analytical techniques

**Course Articulation Matrix**

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	2	1	-
CO2	2	2	1	1	1	1
CO3	3	3	2	3	2	1

<b>CO4</b>	<b>3</b>	<b>3</b>	<b>3</b>	<b>3</b>	<b>1</b>	<b>1</b>
<b>CO5</b>	<b>3</b>	<b>3</b>	<b>3</b>	<b>3</b>	<b>1</b>	<b>1</b>

Program Articulation Matrix row for this course

	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>
<b>CO</b>	<b>3</b>	<b>3</b>	<b>2</b>	<b>3</b>	<b>1</b>	<b>1</b>

## **FINITE ELEMENT ANALYSIS IN MANUFACTURING**

### **Course Contents:**

#### **Module-I (8 Hours)**

Basics of FEM- Initial value and boundary value problems- weighted residual, Galerkin and Raleigh Ritz methods- Review of Variational calculus- Integration by parts- Basics of variational formulation. Steps in FEA- Discretization, Interpolation, derivation of element characteristic matrix, shape function, assembly.

#### **Module-II (8 Hours)**

Imposition of boundary conditions- Solution and post processing- One dimensional analysis in solid mechanics and heat transfer.

#### **Module-III (8 Hours)**

Global and Natural co-ordinates- Shape functions for one and two dimensional elements- Three noded triangular and four noded quadrilateral element- Nonlinear analysis- Isoparametric elements- Jacobian matrices and transformations- Basics of two dimensional axi-symmetric analysis.

#### **Module-IV (8 Hours)**

FE analysis of metal casting- Special considerations, latent heat incorporation, gap element- Time stepping procedures- Prediction of grain structure- Basic concepts of plasticity- Solid and flow formulation- Small incremental deformation formulation- FE analysis of metal cutting, chip separation criteria, incorporation of strain rate dependency.

#### **Module-V (8 Hours)**

Pre Processing, Mesh generation, element connecting, boundary conditions, input of material and processing characteristics- Solution and post processing- Overview of application packages such as ANSYS and DEFORM- Development of code for one dimensional analysis and validation.

**Text Book(s):**

1. An Introduction to the Finite Element Method- J.N. Reddy, McGraw-Hill.
2. Finite Element Method in Engineering- S.S. Rao, Pergamon Press.

**Reference Book(s):**

1. Metal Forming and the Finite Element Methods- S. Kobayashi, Soo-Ik-Oh and T. Altan, Oxford University Press.
2. The Finite Element Method in Heat Transfer Analysis- R.W. Lewis, K. Morgan, H.R. Thomas and K.N. Seetharaman, JohnWiley.

**Course Outcomes**

Upon completion of the course, the students will demonstrate the ability to:

<b>CO1</b>	Apply the types of approximation methods and use of finite element method
<b>CO2</b>	Evaluate the heat problems
<b>CO3</b>	Develop isoparametric formulations
<b>CO4</b>	Apply the FEM in metal casting
<b>CO5</b>	Write computer program of finite element method

**Course Articulation Matrix**

	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>
<b>CO1</b>	3	2	3	3	3	1
<b>CO2</b>	3	2	3	3	3	1
<b>CO3</b>	3	2	3	3	3	1
<b>CO4</b>	3	2	3	3	3	1
<b>CO5</b>	3	2	3	3	3	1

**Program Articulation Matrix row for this course**

	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>
<b>CO</b>	3	2	3	3	3	1

## SESSIONALS

### Mini Project

#### Manufacturing Engg. Lab.-III

#### Content

1. Study of the Process and Principle of Wire Electric Discharge Machining (Wire EDM).
2. Study of the relation between MRR & Supply Current in Electric Discharge Machining (EDM).
3. Determination of Tensile Strength of Low Carbon Steel and Aluminum specimen by Computerized Universal Testing Machine (Instron-3382).
4. Study of the effect of power and counter weight on MRR in Ultrasonic machining (USM).
5. Characterization of Surface Morphology of a specimen by Optical Microscope (OM) and Scanning Electron Microscope (SEM).
6. Study of the Process and Principle of Abrasive Jet Machining (AJM).
7. Understanding failure of the coated work-piece by using Ducom scratch tester.

#### Course Outcomes

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

CO1	Know the EDM process and its analysis of material removal rate (MRR)
CO2	Use of computerised tensile testing of work-piece and failure analysis
CO3	Calculate material removal rate (MRR) by USM and AJM process and their effectiveness
CO4	Recognize metallurgical properties of material by OM and SEM
CO5	Understand failure analysis of coating by using scratch tester

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	2	2	1	-	-	-	-	-	3
CO2	2	2	2	3	3	3	-	-	-	-	-	2
CO3	2	1	3	2	2	2	-	-	-	-	-	2

CO4	2	3	1	3	3	1	-	-	-	-	-	2
CO5	3	3	2	1	2	2	-	-	-	-	-	3

	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>
<b>CO</b>	3	3	3	3	3	3	-	-	-	-	-	3

## Manufacturing Engg. Lab.-IV

### Content

1. Measurement of the surface roughness using Talysurf Instrument.
2. Measurement of cutting forces on while turning a work-piece using KISTLER piezoelectric force dynamometer.
3. Study of CNC lathe and part programming.
4. Study and Preparation of lap joint using spot welding.
5. Study of the Cutting process of stainless steel material by Laser Beam Machining (LBM).
6. Measurement of grinding forces on a work-piece using Surface Grinder by KISTLER piezoelectric force dynamometer.

### Course Outcomes

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

CO1	Calculate the surface texture of different specimens
CO2	Measurement of cutting forces in turning and grinding
CO3	Know programming skills to make an object by CNC lathe
CO4	Join two sheet metals by resistance spot welding process
CO5	Perform laser machining of sheet metal and its metallurgical characterization

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	2	2	1	-	-	-	-	-	3
CO2	2	2	2	3	3	2	-	-	-	-	-	2
CO3	2	1	3	2	2	2	-	-	-	-	-	2
CO4	2	3	1	3	3	1	-	-	-	-	-	2

CO5	3	3	2	1	1	1	-	-	-	-	-	3
-----	---	---	---	---	---	---	---	---	---	---	---	---

	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>
<b>CO</b>	3	3	3	3	3	2	-	-	-	-	-	3

### THIRD SEMESTER

#### PROFESSIONAL ELECTIVE - V

#### TRIBOLOGY IN DESIGN AND MANUFACTURING

##### Course Contents:

##### Module-I (8 Hours)

Surfaces, Friction and Wear- Topography of the surfaces, Surface features, Surface interaction, Theory of Friction, Sliding and Rolling Friction, Friction properties of metallic and non-metallic materials, friction in extreme conditions, Wear, types of wear, Mechanism of wear, Wear resistance materials, Surface treatment, Surface modifications, Surface Coatings

##### Module-II (8 Hours)

Lubricants and their physical properties lubricants standards, Lubrication Regimes Hydrodynamic lubrication, Reynolds Equation, Thermal, inertia and turbulent effects, Elasto hydrodynamic and plastohydrodynamic and magneto hydrodynamic lubrication, Hydro static lubrication, Gas lubrication, Design and performance analysis of thrust and journal bearings

##### Module-III (8 Hours)

Full, partial, fixed and pivoted journal bearings design, Lubricant flow and delivery, power loss, Heat and temperature rotating loads and dynamic loads in journal bearings, special bearings, Hydrostatic Bearing design.

##### Module-IV (8 Hours)

Geometry and Kinematics, Materials and manufacturing processes, Contact stresses, Hertzian stress equation, Load divisions, Stress and deflection, Axial loads and rotational effects, Bearing life capacity and variable loads, ISO Standards, Oil films and their effects, Rolling Bearings Failures.

### Module-V (8 Hours)

Surface topography measurements, Electron microscope and friction and wear measurements, Laser method, Instrumentation, International standards, Bearings performance measurements, Bearing vibration measurement.

### Text Books:

1. Basic Lubrication Theory: A Cameron, Ellis Herward Ltd.
2. Introduction to Tribology of Bearings, B C Majumdar, A H Wheeler

### Reference Books:

1. Engineering Tribology, J A Williams, Oxford University Press
2. Tribology Hand Book, M J Neale, Butterworth Heinemann

### Course Outcomes

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

CO1	Will demonstrate basic understanding of friction, lubrication, and wear processes.
CO2	Enhance students' awareness of tribological issues in the design of machine components, such as journal bearings, thrust bearings, hydrostatic bearing, gas bearing, seals, and gasket systems.
CO3	Design and conduct experiments, as well as analyze and interpret data.
CO4	Design a tribological system for optimal performance.
CO5	Develop skill for communicating research results and technical presentations.

### Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	1			
CO2	2	3	3	3	2	1
CO3	1	1	1	2	2	
CO4	1	2	1	2		
CO5	2	2	3	3	3	

## Program Articulation Matrix row for this course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	2	2	3	2	2	1

## INVENTORY SYSTEM

### Course Contents:

#### Module-I (8 Hours)

Material System, Importance of Inventory in production distribution system. Purchasing – Functions, Procedures – Value Analysis in Purchasing – Vendor Selection, Rating and Development – Buying Seasonal Commodities, Purchasing under Uncertainty, Purchasing capital equipments, Public buying.

Stores Management – Location & layout, Stores System, Storing practice, Quality of incoming material, Stores accounting & stock verifications, obsolete & surplus, Scrap disposal.

#### Module-II (8 Hours)

Raw Materials Inventory System: Concept, Function, Inventory cost, Inventory models assuming certainty & risk, Quantity discount. Economical order quantity, Economical manufacturing batch size, Safety stock, Joint ordering policy – Probabilistic Inventory system: (Q,r) and (R,S) policies.

Inventory Management: ABC analysis, VED analysis, Perpetual inventory system. Periodic inventory system, Japanese inventory system.

#### Module-III (8 Hours)

Material Requirement Planning: Bill of material, level coding, Master Production scheduling, Gross requirement determination, Net requirements, Lot size determination techniques (Wasner-werifin, Silver-meal heuristic, part-period Balancing), Offsetting Safety stock in MRP.

#### Module-IV (8 Hours)

Manufacturing Resource Planning: MRP under capacity constraints, Capacity requirement planning, Just-in-time concept: Pull & Push system, Essential conditions of JIT application, practical implementation of JIT through Kanban & other systems.

### **Module-V (8 Hours)**

Physical distribution of Materials: Finished product – Classification, Product features, Branch decisions, packaging decisions, Labelling decisions, product line decision, Distribution channel-nature, Function, Channel behaviour, Physical distribution-warehousing. Transportation, Placing-Products-Retailing. Advertising media selection, sales promotion personal selling.

### **Text Books:**

1. Introduction to Materials Management | Eighth Edition | By Pearson - by N. Chapman Stephen , Arnold J. R. Tony , Gatewood Ann K. , M. Clive Lloyd
2. Supply Chain & Logistics Management - by Mr.IshankaSaikiaMr.V.Anandaraj,Dr.S.Ramachandran,S.Kumaran
3. Essentials of Inventory Management Kindle Edition - by Max Muller

### **Reference Books:**

1. Handbook of Materials Management – by Gopalkrishnan P
2. Materials Management: An Integrated Approach Paperback – by Gopalakrishnan
3. Definitive Guide to Inventory Management, The: Principles and Strategies for the Efficient Flow of Inventory across the Supply Chain - by CSCMP, Matthew A. Waller , Terry L. Esper

### **Course Outcomes**

Upon completion of the course, the students will demonstrate the ability to:

CO1	Cite the types of inventory
CO2	Note the manner in which inventory can be incorporated into a company's competitive strategy
CO3	Identify the policies that should be used to control inventory
CO4	State the types of forecasting variations that can be used
CO5	Identify the components of the major production management systems

## Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	2	3	1	2
CO2	2	2	1	3	2	2
CO3	3	2	1	1	3	3
CO4	3	1	1	3	2	2
CO5	1	1	1	1	1	2

## Program Articulation Matrix row for this course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	3	2	1	3	2	2

## PROFESSIONAL ELECTIVE - V

### RAPID PROTOTYPING

#### Course Contents

##### Module-I (8 Hours)

Introduction: Definition of Prototype, Types of prototype, Need for the compression in product development, Survey of applications, Growth of RP industry, Classification of RP systems.

##### Module-II (8 Hours)

Stereolithography Systems: Principle, Process parameter, process details, Data preparation, data files and machine details, Application.

##### Module-III (8 Hours)

Selective Laser Sintering: Type of machine, Principle of operation, process parameters, Data preparation for SLS, Applications, Fusion Deposition Modeling: Principle, Process parameter, Path generation, Applications.

##### Module-IV (8 Hours)

Rapid Tooling: Indirect Rapid tooling -Silicon rubber tooling- Aluminum filled epoxy tooling  
 Spray metal tooling, Direct Rapid Tooling- Sand casting tooling, Laminate tooling, Soft  
 Tooling vs. Hard tooling.

**Module-V (8 Hours)**

Rapid Manufacturing Process Optimization: factors influencing accuracy, data preparation errors, Part building errors, Error in finishing, influence of build orientation. Surface digitizing, surface generation from point cloud, surface modification- data transfer to solid models.

**Text Book(s):**

1. Stereolithography and other RP& M Technologies- Paul F. Jacobs, Society of Manufacturing Engineers, NY.
2. Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling- D.T. Flham and S.S.Dimov, Springer Verlag.

**Reference Book(s):**

1. Rapid Prototyping: Principles and Applications in Manufacturing- C.C. Kai and L.K.Fai, World Scientific Co.
2. Rapid Prototyping & Manufacturing- Paul F. Jacobs, McGraw-Hill.

**Course Outcomes**

Upon completion of the course, the students will demonstrate the ability to:

CO1	Acquire the knowledge on prototyping
CO2	Acquire the skill of developing a prototyping using Stereo lithography Processes
CO3	Acquire the skill of developing prototyping using selective Laser sintering
CO4	Acquire the knowledge on Rapid Tooling
CO5	Acquire the knowledge on Rapid Manufacturing Process optimization

**Course Articulation Matrix**

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	-	3	2	2	-
CO2	1	-	1	1	2	-
CO3	1	-	1	1	2	-

<b>CO4</b>	1	-	3	1	2	-
<b>CO5</b>	2	-	3	2	3	-

**Program Articulation Matrix row for this course**

	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>
<b>CO</b>	2	-	3	2	3	-

## **RELIABILITY ENGINEERING**

**Course Contents:**

**Module-I (8 Hours)**

Reliability; basic concepts, Uncertainty in engineering systems; Modeling, Multiple random variables, product failure theories, Failure models, Limit state function, Probability distribution, PDF & CDF,

**Module-II (8 Hours)**

Evaluation of joint probability distribution, Markov Process, Stochastic Finite Element Analysis, Randomness in response variables, First and higher order methods for reliability assessment,

**Module-III (8 Hours)**

Deterministic & probabilistic approach, Risk based design, Central limit theorem, load and resistance approach

**Module-IV (8 Hours)**

Fault tree approach, system reliability, stress strength interference method, Monte-Carlo and other simulation techniques, Regression analysis

**Module-V (8 Hours)**

Software based reliability analysis, Sensitivity analysis and reliability based design optimization, international standards, Applications & case studies.

**Text Books:**

1. Reliability Engineering, E. Balagurusamy, McGraw Hill
2. Reliability Engineering, Theory and Practices, Iliia Vonta, Mangey Ram, CRC Press

**Course Outcomes**

Upon completion of the course, the students will demonstrate the ability to:

CO1	Acquire the knowledge on prototyping
CO2	Acquire the skill of developing a prototyping using Stereo lithography Processes
CO3	Acquire the skill of developing prototyping using selective Laser sintering
CO4	Acquire the knowledge on Rapid Tooling
CO5	Acquire the knowledge on Rapid Manufacturing Process optimization

**Course Articulation Matrix**

	PO1	PO2	PO3	PO4	PO5	PO6
<b>CO1</b>	2	-	2	2	2	-
<b>CO2</b>	3	-	1	2	3	-
<b>CO3</b>	3	-	1	2	1	-
<b>CO4</b>	2	-	3	2	3	-
<b>CO5</b>	1	-	2	2	3	-

**Program Articulation Matrix row for this course**

	PO1	PO2	PO3	PO4	PO5	PO6
<b>CO</b>	3	-	3	2	3	-

**MAINTENANCE ENGINEERING & MANAGEMENT****Course Contents:****Module-I (8 Hours)**

Importance of maintenance, Objectives of maintenance, Types of maintenance, Maintenance systems, Planned and unplanned maintenance, Breakdown maintenance,

Corrective maintenance, Opportunistic maintenance, Routine maintenance, Preventive maintenance, Predictive maintenance, Condition based maintenance systems, Design-out maintenance, Selection of maintenancesystems.

**Module-II (8 Hours)**

Maintenance planning and scheduling, establishing a maintenance plan, Safety precautions – Characteristics of items to be maintained, Classification of items, Maintenance procedure, Guidelines for matching procedures to items, Maintenance organization, Resource characteristics, Resources structure, Maintenance control, Administrative structure, Training of maintenancepersonnel.

**Module-III (8 Hours)**

System operations and documentation, Documenting maintenance operations, Record keeping, Data collection and analysis, Failure statistics,

**Module-IV (8 Hours)**

Planning and scheduling plant shutdowns, Depreciation and Machine Life, Replacement policies, Spares and types of spares, sparesplanning.

**Module-V (8 Hours)**

Network techniques in maintenance activities, Evaluation of maintenance performance. Total productive maintenance – development and scope, Basic systems of TPM, Procedures and steps. Productivity circles, TPM as a part of TQM, benefits of TPM.

**Text Book(s):**

1. Maintenance Planning and Control, A. Kelly, EastWestPress.
2. Mechanical Fault Diagnosis, R.A.Collacott, Chapman andHall.

**Reference Book(s):**

1. Managing Maintenance Resources, A.Kelly,Butterworth-Heinemann.
2. Handbook of Maintenance Management, Levitt Joel, IndustrialPress.

**Course Outcomes**

Upon completion of the course, the students will demonstrate the ability to:

CO1	Understanding various types of maintenance and their applications
CO2	In depth study of maintenance planning, control and applications

CO3	Analysis of various maintenance operations and statistics
CO4	Understanding planning and scheduling and their impact on plant
CO5	In depth analysis of various productive maintenance and benefits

### Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	-	-	1
CO2	2	1	1	2	2	1
CO3	2	1	2	3	3	1
CO4	2	1	2	3	3	2
CO5	1	1	1	-	-	1

### Program Articulation Matrix row for this course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	2	1	2	3	3	2

## LASER MATERIALS PROCESSING

### Course Contents

#### Module-I (8 Hours)

Laser Systems- Laser beam characteristics, laser principles, High power lasers for materials applications, Principles and working of CO<sub>2</sub>, Nd:YAG and Excimer laser, Optics for irradiation.

#### Module-II (8 Hours)

Thermal process in Interaction zones- Laser Materials processing parameters, Conduction and convection, Analytical models in one dimensional heat flow, Depth of irradiation with respect to energy density, Reflectivity of material with respect to wave length, Rate of heating, cooling and temperature gradient.

#### Module-III (8 Hours)

Laser Metallurgy- Laser surface treatment, Transformation hardening, Rapid quenching, Methods to obtain desired penetration depths, Laser surface alloying, Laser surface cladding, Shockhardening, Advantages of laser surface treatment.

#### Module-IV (8 Hours)

Laser Cutting and Drilling- Laser instrumentation for cutting and drilling, cut quality and process characteristics, methods of cutting. Laser Welding- Process mechanisms (Key hole and Plasmas), operating characteristics, process variations, imperfections.

**Module-V(8 Hours)**

Laser drilling and welding: Laser instrumentation for laser drilling, hole quality control, laser welding process mechanism, operating characteristics, defect in laser drilling and welding.

**Text Book(s):**

1. Opto electronics – An introduction- W. J. Hawkes, Prentice Hall of India.
2. Laser Processing of Engineering Materials- J.C. Ion, Butter Worth-Heinemann.

**Reference Book(s):**

1. Laser Materials Processing- W.M. Steen, Springer Verlag.
2. High power laser applications- J.F.Reddy, Academic Press.

**Course Outcomes**

Upon completion of the course, the students will demonstrate the ability to:

CO1	Acquire the knowledge of working principles of common industrial lasers
CO2	Acquire the knowledge on thermal behavior of materials due to laser interaction
CO3	Acquire the knowledge of surface modifications of materials using laser
CO4	Acquire the knowledge of laser cutting
CO5	Acquire the knowledge of laser drilling and welding

**Course Articulation Matrix**

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	-	2	-	1	-
CO2	3	-	2	3	2	-
CO3	2	-	2	2	1	-
CO4	1	-	2	1	2	-
CO5	1	-	2	1	2	-

**Program Articulation Matrix row for this course**

	PO1	PO2	PO3	PO4	PO5	PO6
CO	3	-	2	3	2	-

## **SESSIONALS**

**Dissertation (Phase-I)**

## **FOURTH SEMESTER**

**Dissertation (Phase-II)**