वीरसुरेंद्रसाएप्रौद्योगिकीविश्वविद्यालयबुर्ला, ओडिशा
उत्पादनअभियांत्रिकीविभाग
Veer SurendraSai University of Technology Burla, Odisha
Department of Production Engineering

Course Structure &Syllabus of

M. Tech. Programme in

Manufacturing System Engineering

(Production Engineering)

Academic Year – 2019-20

VEER SURENDRA SAI UNIVERSITY OF TECHNOLOGY, ODISHA

Burla, Sambalpur-768018,
Odishawww.vssut.ac.in

M.TECH. in MANUFACTURING SYSTEM ENGINEERING (MSE)

PEOs:

The educational objectives of M. Tech. in Manufacturing System Engineering of VSSUT, Burla are to prepare its graduates:

PEO1: To acquire competency in design, control, performance and continuous improvement of manufacturing systems.
PEO2: To make them enable to excel in their professional career/entrepreneurial skill/research and higher studies so as to develop sustainable and cost-effective products according to the prevailing socio-economic context.
PEO3: To provide opportunity to work and communicate effectively in a team and to engage in the process of life-long learning.

PSOs:

PSO1: The students will be able to understand, model and solve problems related to manufacturing systems by applying engineering knowledge and management practices so as to offer techno-commercially feasible and socially acceptable solutions.
PSO2: The students will be effective communicator, aspire to learn and be able to handle problems with professional attitude while carrying out research investigations and developmental work independently as well as in group.

Program Outcomes (POs):

PO1: Ability to independently carry out research/investigation and development work to solve practical problems pertaining to Manufacturing System Engineering.
PO2: Ability to write and present a substantial technical report/document
PO3: Ability to demonstrate a degree of mastery over Production Engineering domain to further comprehend and inculcate Manufacturing System related issues.
PO4: Ability to apply techniques, skills and modern engineering tools to design, conduct, analyze and interpret experimental data for relevant engineering practices.
PO5: Ability to identify, formulate, design, demonstrate and apply engineering ideas and management principles in executing production engineering projects to meet the sustainability, societal and environmental needs.
PO6: Ability to recognize the need for self-improvement through continuing education and to engage in life-long learning.

CURRICULUM FOR M.TECH.inMANUFACTURING SYSTEM ENGINEERING

SEMESTER I							
Sl.No	Core/ Elective	Subject Code	Subject Name	L	T	P	Credits
1.	Core-I	MPEMS101	Manufacturing System Models	3	0	0	3
2.	Core-II	MPEMS102	Computer Aided Design & Manufacturing	3	0	0	3
3.	PE-I	MMSPE101	Rapid Manufacturing Processes	3	0	0	3
4.		MMSPE102	Computer Aided Product Design				
5.		MMSPE103	Manufacturing Information System				
6.	PE-II	MMSPE104	Design of Experiments	3	0	0	3
7.		MMSPE105	Advanced Maintenance Engineering				
8.		MMSPE106	Ergonomics & Work Design				
9.	Common		Research Methodology & IPR	3	0	0	3
10.	Lab-I	MPEMS103	Manufacturing Systems Lab-I	0	0	3	2
11.	Lab-II	MPEMS104	Manufacturing Systems Lab- II	0	0	3	2
12.	Audit-1						
						TOTAL CREDITS	19

SEMESTER II							
Sl.No	Core/ Elective	Subject Code	Subject Name	L	T	P	Credits
1.	Core-III	MPEMS201	Robotics & Robots Application	3	0	0	3
2.	Core-IV	MPEMS202	Modern Machining Processes	3	0	0	3
3.	PE-III	MMSPE201	Automation in Manufacturing	3	0	0	3
4.		MMSPE202	Mechatronics & MEMS				
5.		MMSPE203	Quality Engineering				
6.	PE-IV	MMSPE204	Computer Aided Engineering	3	0	0	3
7.		MMSPE205	Enterprise Resource Planning				
8.		MMSPE206	Laser Material Processing				
9.	Common		Minor Project & Seminar	0	0	3	2
10.	Lab-III	MPEMS203	Manufacturing Systems Lab- III	0	0	3	2
11.	Lab-IV	MPEMS204	Manufacturing Systems Lab- IV	0	0	3	2
12.	Audit-2						
						TOTAL CREDITS	18

SEMESTER III							
Sl.No	Core/ Elective	Subject Code	Subject Name	L	T	P	Credits
1.	PE-V	MMSPE301	Finite Element Analysis in Manufacturing	3	0	0	3
2.		MMSPE302	Design of Hydraulic & Pneumatic Systems				
3.		MMSPE303	Discrete System Simulation				
4.	OE-I	MMSOE301	World Class Manufacturing	3	0	0	3
5.		MMSOE302	Sustainable Manufacturing				
6.		MMSOE303	Micro & Nano Manufacturing				
7.	Minor Project		Dissertation (Phase-I)	0	0	20	10
TOTAL CREDITS							16

SEMESTER IV							
Sl.No	Core/ Elective	Subject Code	Subject Name	L	T	P	Credits
1.	Major Project		Dissertation (Phase-II)	0	0	32	16
TOTAL CREDITS							16

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Department of Production Engineering

Subject Code: MPEMS101	**Subject name:** Manufacturing System Models

Pre-Requisite:		**Co-requisite:**	

Module -I	**[06]**
	Fundamentals of Systems: Basic concepts of systems and chaos, Definition of systems, basic problems concerning systems, systems design, decision making Procedures. Fundamentals of Manufacturing Systems: Structural aspects of Manufacturing systems, transformational aspect of manufacturing systems, Integrated Manufacturing Systems (IMS)

Module -II	**[04]**
	Modes of Production: Types of Production, Mass Production, Multi-product, small batch production, production diversification. Integrated Manufacturing and Management systems: Basic functions and structures of management systems.

Module -III	**[06]**
	Basic framework of integrated Manufacturing Management Systems: Framework of an Integrated Manufacturing System. Material & Technological information flows in Manufacturing Systems: Logistic Systems, Material flow, Technological information flow.

Module -IV	**[04]**
	Product Planning & Design: Product Planning, Product Design. Process Planning & Design: Process Design, Operation Design, Optimum Routing Analysis, Line balancing, Layout Planning & Design: Scope & Problems of layout planning, Systematic layout Planning (SLP), Mathematical Layout Design, Production Flow Analysis, Logistic Planning & Design: Transportation Problems, Distribution Problems, Manufacturing Optimization: Evaluation criteria for Manufacturing optimization, Optimization of single stage Manufacturing, Optimization of Multi-stage Manufacturing Systems.

Module -V	**[10]**
	Managerial Information flow in Manufacturing Systems: Managerial information Flow, Decision Problems in Managerial Information Flow. Aggregate Production Planning: Production Planning Defined, Short-term Production Planning, Multiple-objective Production Planning, Product Mix Analysis, Lot-size Analysis, Material Requirements Planning (MRP) & Machine Loading, Long-term Production Planning, Production Forecasting Production Scheduling: Operations, Scheduling, Project Scheduling-PERT & CPM.

TEXT BOOK(S):

1.	Manufacturing Systems Engineering, K Hitomi, T & F.
2.	Manufacturing Systems Engineering, Bhaduri.

REFERENCE BOOK(S):

1.	Manufacturing Systems Engineering- S. Gershwin, PrenticeHall.
2.	Factory Physics- M. Spearman and W. Hopp, McGraw Hill.

COURSE OUTCOMESS: *At the end of this course, students will demonstrate the ability to*

CO1	Define the fundamentals of manufacturing systems and management of integrated manufacturing systems
CO2	Comprehend the product and process design and optimization of single and multistage manufacturing systems.
CO3	Construct various material and technological information flows in integrated manufacturing management systems.
CO4	Incorporate different managerial information flow in manufacturing systems and illustrate optimum decision making procedure.
CO5	Apply the concept of production planning, operation scheduling and project scheduling.

Course Articulation Matrix

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

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	3	2	2		

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Veer SurendraSai University of Technology Burla, Odisha

Department of Production Engineering

Subject Code: MPEMS102	**Subject name** : Computer Aided Design & Manufacturing

Pre-Requisite:		**Co-requisite:**	None

Module -I	**[06]**
Fundamentals of CAD: The design process, Application of computer for design, automated drafting, creating manufacturing data base, benefits of CAD, Design workstation- graphic terminal, operator input and output devices, Software of graphic system- graphic package, Data Base Structure, Wireframe Model and Solid Model, Graphics standards Modes of graphics operations, User interface, Software modules, Modeling and Viewing.	

Module -II	**[06]**
Geometric Modeling: Mathematical representation of curves, Surfaces and solids- Wire frame models, Entities Analytic curves, Synthetic curves, Manipulation, Surface entities, analytic, Synthetic surfaces, Solid entities, Representation, Manipulations	

Module -III	**[06]**
Geometric Transformation- Transformation of geometric models, Mapping, Inverse transformations, Projections of geometric models, Engineering applications.	

Module -IV	**[06]**
Numerical Control: Components of NC system, NC procedure, NC co-ordinate system, motion control, applications, NC part programming-manual part programming, computer assisted part programming, ATP language-macro statements, programming with interactive graphics, NC part programming using CAD/CAM.	

Module -V	**[06]**
Problems with conventional NC, NC technology: CNC, DNC, Combined DNC/ CNC system, Adaptive control manufacturing systems, Computer Integrated Manufacturing system, Machine Tools and related equipment, Materials Handling system: AGV, Robots, Lean manufacturing.	

TEXT BOOK(S):

1.	CAD/CAM Theory and Practice- I. Zeid, TMH.
2.	CAD/CAM-M.P. Groover& E.W. Zimmers, PHI.

REFERENCE BOOK(S):

1.	CAD/CAM/CIM- Radhakrishnan&Subramanyan, Wiley Eastern.
2.	Automation, Production System and CIM- M.P. Groover, PHI.

COURSE OUTCOMES:

CO1	Create and develop the concept of computer assisted design using graphic workstation.
CO2	Develop geometric models using curves, surfaces and solids.
CO3	Analyze and evaluate and write forward and inverse transformation problems of different geometric models.
CO4	Compile and construct NC with CNC systems with associated part programming.
CO5	Define between DNC with hybrid systems and adaptive controlled systems.

Course Articulation Matrix

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

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	3	3	3	3	3

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Subject Code: MMSPE101		**Rapid Manufacturing Processes**	
Pre-requisite:	None	**Co-requisite:**	None

Module -I	**[10]**
	Introduction: Definition of GMP and Rapid Prototyping, Types of prototype, Need for the compression in product development, Survey of applications, Issues related to GMP, Classification of RP systems. Stereolithography Systems: Principle, Process parameter, process details, Data preparation, data files and machine details, Physical layer Model Development, Applications.

Module -II	**[10]**
	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. Solid Ground Curing: Principle of operation, Machine details, Applications, Laminated Object Manufacturing: Principle, LOM materials, process details, application.

Module -III	**[06]**
	Concepts Modelers: Principle, Thermal jet printer, 3-D printer, GenisysXsprinter HP system 5, Object Quadra systems, Laser Engineering Net Shaping (LENS).

Module -IV	**[08]**
	Rapid Tooling: Indirect Rapid tooling -Silicon rubber tooling- Aluminum filled epoxy tooling Spray metal tooling, Cast kirksite, 3D keltool, Direct Rapid Tooling- Direct, AIM, Quick cast process, Copper polyamide, Rapid Tool, DMILS, ProMetal, Sand casting tooling, Laminate tooling, Soft Tooling vs. Hard tooling.

Module -V	**[06]**
	Software for RP: STL files, Overview of Solid view, magics, mimics, magic communicator, etc. Internet based software, Collaboration tools, 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- Kai and Fai, World Scientific.
2.	Rapid Prototyping & Manufacturing- Paul F. Jacobs, McGraw-Hill.
3.	Enter Text Here

COURSE OUTCOMES: *At the end of this course, students will demonstrate the ability to*

CO1	Develop the fundamentals of rapid prototype and their classifications.
CO2	Implement the Selective Laser Sintering techniques.
CO3	Analyze the Modelers printer techniques.
CO4	Express the Rapid tooling and implement in rapid manufacturing.
CO5	Write the software aspects of rapid manufacturing and product modeling.

Course Articulation Matrix

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

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	2	3	3	2	2

Subject Code: MMSPE102		**Computer Aided Product Design**	
Pre-Requisite:	Automation and NC Machine	**Co-requisite:**	
Module -I			**[06]**
	Systems, modeling, general systems theory, concept of simulation, simulation as a decision-making tool, types of simulation. Pseudo random numbers, methods of generating random variates, discrete and continuous distributions, testing of random numbers.		
Module -II			**[06]**
	Problem formulation, data collection and reduction, time flow mechanism, key variables, logic flow chart, starting condition, run size, experimental design consideration, output analysis and interpretation validation.		
Module -III			**[06]**
	Comparison and selection of simulation languages, study along with practice of any one simulation language.		
Module -IV			**[06]**
	Development of simulation models using the simulation language studied for systems like, queuing systems, production systems.		
Module -V			**[06]**
	Simulation models for systems like Inventory systems, maintenance and replacement systems, investment analysis and network.		
TEXT BOOK(S):			
3.	Discrete event system simulation- J. Banks, J. S. Carson, B. L. Nelson, D. M. Nicol, PHI.		
4.	Simulation using GPSS- T. J. Schriber, John Wiley.		
REFERENCE BOOK(S):			
3.	Simulation Techniques for Discrete Event Systems- I. Mitrani, Cambridge University Press.		
4.	Simulation Modeling and Analysis- A. M. Law, McGraw Hill India.		
COURSE OUTCOMESS: *At the end of this course, students will demonstrate the ability to*			
CO1	Apply functional modeling method to model the activities of a system.		
CO2	Formulate a system problem besides analyzing and interpreting of output.		
CO3	Select and use any particular simulation language.		
CO4	Develop models using a simulation language for queuing and production systems.		
CO5	Organize and implement models for inventory, maintenance and replacement systems besides analysis.		

Course Articulation Matrix

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

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

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

Subject Code:MMSPE103	**Manufacturing Information System**

Pre-Requisite:		**Co-requisite:**	

Module -I	[06]
Introduction: The evolution of order policies, from MRP to MRP II, Role of Production Organization, Operations Control. Database: Terminologies, Entities and attributes.	

Module -II	[06]
Data models, schema and subschema, Data Independence, ER Diagram, Trends in database; Designing Database: Hierarchical model, Network approach.	

Module -III	[06]
Relational Data model -concepts, principles, keys, relational operations - functional dependence - Normalization, types - Query languages.	

Module -IV	[09]
Manufacturing Considerations: The product and its structure, Inventory and process flow, Shop floor control - Data structure and procedure - various model - the order scheduling module, input/output analysis module the stock status database, the complete IOM database.	

Module -V	[09]
Information System for Manufacturing: Parts oriented production information system - concepts and structure -computerized production scheduling, online production control systems, Computer based production management system, computerized manufacturing information system - case study.	

TEXT BOOK(S):

5.	Manufacturing Information Systems- L.G. Sartori, Addison-Wesley PublishingCompany.
6.	An Introduction to Database Systems- C.J. Date.C.J., Narosa Publishing House.

REFERENCE BOOK(S):

5.	Material Requirements Planning- G. Orlicky, McGraw-Hill.
6.	Knowledge based Manufacturing Management- R. Kerr.Addison-Wesley.

COURSE OUTCOMESS: *At the end of this course, students will demonstrate the ability to*

CO1	Design product centered database system.
CO2	Compile and illustrate diverse data base models and the procedures employed.
CO3	Express relational data models and operations.
CO4	Develop information system for shop-floor manufacturing and control.
CO5	Apply the concept of computer-based production management and manufacturing information system.

Course Articulation Matrix

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

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

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

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Subject Code: MMSPE104	**Design of Experiments**

Pre-requisite:	None	**Co-requisite:**	None

Module -I **[06]**

Introduction: Strategy of Experimentation, Typical applications of Experimental design, Basic Principles, Guidelines for Designing Experiments. Basic Statistical Concepts: Concepts of random variable, probability, density function cumulative distribution function. Sample and population, Measure of Central tendency; Mean median and mode, Measures of Variability, Concept of confidence level. Statistical Distributions: Normal, Log Normal &Weibull distributions. Hypothesis testing, Probability plots, choice of sample size. Illustration through Numerical examples.

Module -II **[06]**

Experimental Design: Classical Experiments, Factorial Experiments, Terminology: factors, levels, interactions, treatment combination, randomization, Two-level experimental designs for two factors and three factors. Three-level experimental designs for two factors and three factors, Factor effects, Factor interactions, Fractional factorial design, Saturated Designs, Central composite designs. Illustration through Numerical examples.

Analysis and Interpretation Methods: Measures of variability, Ranking method, Column effect method & Plotting method, Analysis of variance (ANOVA) in Factorial Experiments: YATE's algorithm for ANOVA, Regression analysis, Mathematical models from experimental data. Illustration through Numerical examples.

Module -III **[06]**

Quality by Experimental Design: Quality, Western and Taguchi's quality philosophy, elements of cost, Noise factors causes of variation. Quadratic loss function & variations of quadratic loss function. Robust Design: Steps in Robust Design: Parameter design and Tolerance Design. Reliability Improvement through experiments, Illustration through Numerical examples.

Module -IV **[06]**

Experiment Design Using Taguchi's Orthogonal Arrays: Types of Orthogonal Arrays, selection of standard orthogonal arrays, Linear graphs and Interaction assignment, Dummy level Technique, Compound factor method, Modification of linear graphs. Illustration through Numerical examples.

Module -V **[06]**

Signal to Noise Ratio: Evaluation of sensitivity to noise. Signal to Noise ratios for static problems: Smaller-the-better type, Nominal-the-better type, Larger-the-better type. Signal to Noise ratios for Dynamic problems. Illustration through Numerical examples.

Parameter and Tolerance Design: Concepts, Taguchi's inner and outer arrays, parameter design strategy, tolerance design strategy. Illustration through Numerical examples.

TEXT BOOK(S):

1. Montgomery, D. C., Design and Analysis of Experiments, John Wiley & Sons.
2. Dean, A. M. and Voss, D. T., Design and Analysis of Experiments, Springer Science & Business Media.

REFERENCE BOOK(S):

1. Box, G. E. P., Hunter, W. G., and Hunter, J. S., Statistics for Experimenters: An Introduction to Design, Data Analysis, and Model Building, John Wiley & Sons.
2. Diamond, W. J., Practical Experiment Designs for Engineers and Scientists, John Wiley & Sons.
3. Jeff Wu, C. E. and Hamada, M. I., Experiments: Planning, Analysis, and Parameter Design Optimization, John Wiley & Sons.

COURSE OUTCOMES: *At the end of this course, students will demonstrate the ability to*

CO1	Apply guidelines for designing experiments and elucidate basic statistical concepts.
CO2	Illustrate experimental design besides explaining various analysis and interpretation methods.
CO3	Demonstrate quality by experimental design and through various Numerical examples.
CO4	Describe about details of experimental design using Taguchi's orthogonal arrays.
CO5	Explain signal to noise ratios of various dynamic problems through numerical examples.

Course Articulation Matrix

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

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	3		2	2	2

Subject Code:MMSPE105	**Advanced Maintenance Engineering**

Pre-Requisite:	Maintenance Engineering & Management	**Co-requisite:**	

Module -I		**[06]**
	Defect generation-types of failures, Defects reporting and recording, Defect analysis, Failure analysis, Equipment downtime analysis, Breakdown analysis-Failure tree analysis (FTA), Root cause analysis (RCA), failure modes and effective analysis (FMEA).	
Module -II		**[06]**
	Planned and unplanned maintenance-Breakdown maintenance, Corrective maintenance, Opportunistic maintenance, Routine maintenance, Preventive maintenance, Predictive maintenance.	
Module -III		**[06]**
	Condition Monitoring: online and off line monitoring, C.M. techniques, temperature monitoring, leakage monitoring, vibration monitoring, vibration analysis, oil analysis techniques, crack monitoring, benefits of CM.	
Module -IV		**[06]**
	Selection and scope of computerization-Equipment classification, Codification of break down, material and facilities, Job sequencing, Material management module, Captive Engineering module.	
Module -V		**[06]**
	Total productivity maintenance (TPM), features and principles, Pillars of TPM, Autonomous maintenance, equipment and process improvement using Kaizen, TPM verses TQM, TPM verses RCM. TPM benefits.	

TEXT BOOK(S):

7.	Industrial Maintenance Management- S. K. SRIVASTAVA, S. Chand & Company Ltd.
8.	Handbook of Machine Tools- Vol. 3- M. Weck and H. Bibring, John Wiley &Sons.

REFERENCE BOOK(S):

7.	Plant Equipment & Maintenance Engineering Handbook by Duncan Richardson, McGraw Hill Education.
8.	Engineering Maintenance A Modern Approach by B.S. Dhillon, CRC Press
9.	Plant Equipment & Maintenance Engineering Handbook by Duncan Richardson, McGraw Hill Education.

COURSE OUTCOMESS: *At the end of this course, students will demonstrate the ability to*

CO1	Analyze failure/equipment down time/breakdown by applying the concept of FTA, RCA and FMEA.
CO2	Demonstrate breakdown maintenance, corrective, routine, preventive and predictive maintenance applied to diverse industries.
CO3	Write about condition monitoring techniques, vibration analysis, vibration monitoring and oil analysis.
CO4	Express about computerization of maintenance system, job sequencing, codification and cataloguing.
CO5	Implement total productivity maintenance (TPM), TQM and RCM for equipment and process improvement.

Course Articulation Matrix

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

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

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

Subject Code: MMSPE106		**Ergonomics & Work Design**	
Pre-requisite:	None	**Co-requisite:**	None

Module -I	**[06]**
	Human factors in a production system: characteristics features of man-machine system: quantitative and qualitative visual displays; Human factors associated with speech communication.
Module -II	**[06]**
	Introduction to kinesiology; Biomechanics and bioengineering aspects of human motor activity; performance analysis of body members in making specific types of movements; and conceptual relationships of stimuli and responses.
Module -III	**[06]**
	Design of control function. Tools and related control devices and control systems. Design of work place and work-components.
Module -IV	**[06]**
	Applied anthropometry, activity analysis: concepts of productivity and its improvement strategies; Design of individual work place. Human performance under heat, cold, illumination, vibration, noise, pollution. Static and dynamic conditions.
Module -V	**[06]**
	Application of results from human factors data and analysis in work study; work design; Method study and work measurement techniques; performance rating and time standards.

TEXT BOOK(S):

1.	Ergonomics for Beginners: A Quick Reference Guide, Third Edition, Jan Dul ,BernardWeerdmeester, CRC Press.
2.	Introduction to Ergonomics, Third Edition, R.S. Bridger, CRC Press.

REFERENCE BOOK(S):

1.	Human Factors in Engineering and Design, Ernest J. McCormick, Mark S. Sanders (Editor) McGraw-Hill Inc., US; 6th Revised edition (1 March 1987).
2.	

COURSE OUTCOMES: *At the end of this course, students will demonstrate the ability to*

1.	Understand and analyze the human factors in a production system.
2.	Analyze and implement biomechanics and bioengineering aspects of human motor activity.
3.	Design the individual work place with control devices.
4.	Implement design by considering anthropometry and activity analysis.
5.	Analyze the results from human factors data in work study

Course Articulation Matrix

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

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	2	3	2	3	2	3

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Veer SurendraSai University of Technology Burla, Odisha
Department of Production Engineering

Subject Code		**Research Methodology & IPR**	
Pre-requisite:	None	**Co-requisite:**	None

COURSE OBJECTIVES: *After successful completion of this course, students will able:*

1.	
2.	
3.	
4.	
5.	

Module -I	**[06]**

Module -II	**[06]**

Module -III	**[06]**

Module -IV	**[06]**

Module -V	**[06]**

TEXT BOOK(S):

1.	
2.	

REFERENCE BOOK(S):

1.	
2.	
3.	
4.	

COURSE OUTCOMES: *At the end of this course, students will demonstrate the ability to*

1.	
2.	
3.	
4.	
5.	

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Subject Code: MPEMS103		**Manufacturing Systems Lab-I**	
Pre-requisite:	None	**Co-requisite:**	None

LIST OF EXPERIMENTS

1.	Study of tool maker's microscope and measurement of thread profiles of various threaded specimens.
2.	Measurement of geometric features of metric thread using Optical Profile Projector.
3.	Study of features and working of Co-ordinate Measuring Machine (CMM).
4.	Calibration of Co-ordinate Measuring Machine (CMM).
5.	Measurement of geometrical feature concentricity and flatness using CMM.
6.	Study of features and working of 3D Scanner.
7.	Calibration and Measurement of specimen using 3D Scanner.
8.	Study of features and working of 3D Printer.
9.	To Generate a simple parts using 3D Printers.

COURSE OUTCOMES: *At the end of this course, students will demonstrate the ability to*

1	To comprehend the working and handling of industrial measuring equipment to measure dimension of parts, surface roughness and forces during machining.
2	Analyze the components of coordinate measuring machine and measuring techniques.
3	Analyze the components of 3D Scanner machine and calibration techniques.
4	Create the geometrical features of gears and their measurement with profile projector.
5	Organize team based assignments

Course Articulation Matrix

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

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

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

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Department of Production Engineering

Subject Code: MPEMS103		**Manufacturing Systems Lab-II**	
Pre-requisite:	None	**Co-requisite:**	None

LIST OF EXPERIMENTS

1.	An introduction to CAD software.
2.	To study all the basic features of a CAD software.
3.	To study the static analysis of a part using CAD software.
4.	To study the dynamic simulation of a part using CAD software.
5.	To study structural analysis using CAD software.
6.	To solve heat transfer problem using CAD software.
7.	To design an experiment using a software.
8.	To study Taguchi's design

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

1 Develop & understands the concept of CAD commands & software.
2. Develop computational analysis, simulation & solve problem using CAD software.
3. Develop Design database knowledge for product and process.
4. Demonstrate heat transfer problems using CAD software
5. Apply Taguchi Design for conducting experiments.

Course Articulation Matrix

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

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	3	2	3	2	2

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Department of Production Engineering

Subject Code:MPEMS201	**Robotics & Robots Application**

Pre-Requisite:		**Co-requisite:**	

Module -I	[06]
Robot Fundamentals: Definitions, History of robots, Laws of Robotics, Robot Specification, Anatomy of a Robot, Robot classifications, Function line diagram representation of robot arms, common types of arms, Robot end effectors- Types, Tools as end effectors, Considerations in gripper selection and design.	
Module -II	[06]
Manipulator Kinematics: Homogeneous coordinate transformation, matrix representations of coordinate transformation, D-H representation of kinematics linkages, Forward and Inverse Kinematics of manipulators, Euler's angle and fixed rotation for specifying position and orientation.	
Module -III	[06]
Robotics Dynamics: Velocity Kinematics, Acceleration of rigid body, Lagrange-Euler Formulation, Newton–Euler's formulation. Trajectory Planning: General considerations in path description and generation, Joint space schemes, Cartesian space schemes, 4-3-4 & trapezoidal velocity strategy for robots.	
Module -IV	[06]
Robot Actuators and Sensors: Internal and external sensors, Position- potentiometric, Optical sensors, Encoders - absolute, incremental, Touch and slip sensors, Velocity and acceleration sensors, Proximity sensors, Force and torque sensors. Actuators- Hydraulic, Pneumatic and Electrical, Comparison of actuating systems and their relative merits and demerits.	
Module -V	[06]
Robot Programming: Methods of robot programming- Textual and Leadthrough, WAIT, SIGNAL and DELAY commands, Capabilities and limitations of leadthrough programming, Robot language structure, Motion, sensor and end effectors commands, Programming examples. Robot application in Manufacturing- Material Transfer- Material handling, loading and unloading, Processing - spot and continuous arc welding and spray painting, Assembly and Inspection.	

TEXT BOOK(S):

9.	Industrial Robotics- Groover M P et al, Pearson Education.
10.	Robotics and Control- Mittal R K &Nagrath I J, TMH.

REFERENCE BOOK(S):

10.	Robotics Technology and Flexible Automation- S.R.Deb, TMH.
11.	Robotic Engineering- Richard D. Klafter, PHI.

COURSE OUTCOMES: *At the end of this course, students will demonstrate the ability to*

CO1	Express the components of a robotic system and their working principles.
CO2	Construct transformation of coordinate frames and plan direct and inverse kinematic model of robotic manipulator.
CO3	Write diverse formulations for robotics dynamics and generate trajectory profiles for robots.
CO4	Prescribe suitable sensors and actuators for diverse robotic functions.
CO5	Inscribe robot programming for different robot applications.

Course Articulation Matrix

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

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

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

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Department of Production Engineering

Subject Code: MMSPE202	**Modern Machining Processes**

Pre-Requisite:	Non-Traditional Machining	**Co-Requisite:**	None

Module -I **[04]**

Introduction – Need for non-traditional machining methods-Classification of modern machining processes – Classification Based on Energy, Mechanism, source of energy, transfer media and process – Process selection Based on Physical Parameters, shapes to be machined, process capability and economics – Overview of all processes.

Module -II **[10]**

Abrasive jet machining (AJM), Water jet cutting (WJC), Abrasive water jet machining (AWJM), Magnetic abrasive finishing (MAF): Principle, Mechanism of material removal, applications, process parameters, and modelling of all processes.
Ultrasonic machining: Principle, elements of the process, mechanics of metal removal process parameters, economic considerations, effect of process parameters, application.

Module -III **[10]**

Electrochemical Machining: Principle, Faraday's law, Material Removal Rate, Dynamics of ECM process, Tool design, Advantages, Application, Limitations.
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, Application limitation. Wire Electric Discharge Machining (W-EDM).

Module -IV **[08]**

Laser Beam Machining: Lasing process and principle, population inversion, Principle of Ruby laser, Nd:YAG Laser and CO_2 Laser, Power control of laser output, Applications.
Electron Beam Machining: Basic principle, Controlling parameters and focal distance, Application. Ion Beam Machining: Principle and Mechanism, Applications.
Plasma Arc Machining: generation of Plasma, metal removing mechanism, Equipments, Torch, Classification, Direct and indirect torches, process parameters, accuracy and surface finish and other applications.
Ion Beam Machining (IBM): Operating principles, Mechanism and parameters influencing metal removal, Applications, Advantages and Limitations

Module -V **[08]**

Thermal Spray Coating: Vapor Deposition Chemical Vapor Deposition,
Hybrid Machining Processes: Electro Chemical Discharge Machining (ECDM), Electrochemical Micromaching with Laser Assistance (ECML), Electrochemical assistance of Ultrasonic Machining (USMEC), Magnetorheological finishing (MRF), Electro –chemical grinding, Deburring and Honing, Fundamentals of EMM, advantages and applications

TEXT BOOK(S):

11. Modern machines process- P.C. Pandey and H.S. Shan. TMH
12. Advance Machining Processes V.K. Jain New Age
13. Non-Conventional Machining- P.K. Mishra, Narosa Publishing House
14. Introduction to Advanced Machining and Finishing Processes- Kibria and Rathod. Narosa Publishing House

REFERENCE BOOK(S):

12. Manufacturing Processes- Amstead, Ostwald &Begeman, John Wiley & Sons.
13. Manufacturing Engg. & Technology, Kalpakjian , Pearson Education
14. Processes and Materials of Manufacturing- Lindberg, PHI.

COURSE OUTCOMESS: *At the end of this course, students will demonstrate the ability to*

1. Express the contribution of non-traditional machining process in micro and precision manufacturing field.
2. Define suitable machining process for suitable materials.
3. Evaluate the process parameters, their effect and applications of different processes.
4. Incorporate the merits and demerits of the non-traditional manufacturing process
5. Demonstrate the principle of working, mechanism of metal removal in the various unconventional machining process.

Course Articulation Matrix

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

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	3	2	3	3	3

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Department of Production Engineering

Subject Code: MMSPE201	**Automation in Manufacturing**

Pre-requisite:		**Co-requisite:**	

Module -I	**[06]**
	Manufacturing Systems- Components & classifications, Automation in manufacturing systems, principles and strategies, mathematical models, costs. Single-station manufacturing cells.

Module -II	**[06]**
	Automated flow lines: Methods or work part transport transfer Mechanical buffer storage control function, design and fabrication consideration.

Module -III	**[06]**
	Analysis of Automated flow lines: General terminology and analysis of transfer lines without and with buffer storage, partial automation, implementation of automated flow lines. Assembly system and line balancing: Assembly process and systems assembly line, line balancing methods, ways of improving line balance, flexible assembly lines.

Module -IV	**[06]**
	Automated material handling: Types of equipment, functions, analysis and design of material handling systems conveyor systems, automated guided vehicle systems. Automated storage systems, automated storage and retrieval systems; work in process storage, interfacing handling and storage with manufacturing.

Module -V	**[06]**
	Group Technology- Part classification & coding, Computer Aided Process Planning (CAPP) - Retrieval & Generative type process planning system.

TEXT BOOK(S):

1.	Automation, Production Systems and Computer Integrated Manufacturing- M.P. Groover, PHI.

REFERENCE BOOK(S):

1.	Computer Control of Manufacturing Systems- Y. Coren, McGraw Hill.
2.	CAD/CAM/CIM- Radhakrishnan& Subramanian, Wiley Eastern.

COURSE OUTCOMES: *Upon completion of this course students will be able to:*

1.	Recognize different type of manufacturing systems for specific applications.
2.	Demonstrate the correlation between type of automation and plant layout with specific manufacturing system.
3.	Analyze for the optimization of automated flow lines and assembly systems.
4.	Develop various material handling systems for industrial applications.
5.	Describe automated material handling and storage / retrieval system for different manufacturing applications.

Course Articulation Matrix

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

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	2	2	3	3	3	2

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Department of Production Engineering

Subject Code: MMSPE202			**Mechatronics& MEMS**
Pre-requisite:	Theory of Machine, Manufacturing Science, Basic Electronics, Mathematics	**Co-requisite:**	None

Module -I	**[06]**
	Introduction: Introduction to Mechatronics: Mechatronic system, measurement systems, Introduction to Mechanical, Electrical, Fluid and Thermal systems, Rotational and Transnational systems, Electro-Mechanical, Hydraulic- Mechanical systems.

Module -II	**[06]**
	Sensors: Desirable features, Displacement, position and proximity sensors, Velocity, motion and Force sensors, Time of flight sensors, Binary force sensor, temperature and Pressure measurement, Sensor selection.

Module -III	**[06]**
	Actuation Systems: Actuation Systems, Pneumatic and Hydraulic systems, Directional control valves, Rotary actuator, Mechanical actuation systems- Mechanical Systems, Electrical Actuation Systems- Electrical Systems, Relays and Solenoids, DC brushed motors, DC brushless motors, DC servo motors, Stepper Motors. Drive selection.

Module -IV	**[06]**
	Introduction to MEMS technology: Basic definitions, MEMS Materials: Mechanical and other properties of materials used in MEMS Microfabrication / Micromachining: Overview of microfabrication, Review of microelectronics fabrication processes like photolithography, deposition, doping, etching, structural and sacrificial materials, other lithography methods,

Module -V	**[06]**
	MEMS Modeling: Basic modeling elements in electrical, mechanical, thermal and fluid systems, analogy between 2nd order mechanical and electrical systems. Modeling elastic, electrostatic, electromagnetic systems.

TEXT BOOK(S):

1.	Mechatronics- W Bolton, Pearson Education.
2.	MEMS and Microsystems Design and Manufacture- Tai, Ran Hsu, TMH.

REFERENCE BOOK(S):

1.	Mechatronics Principles and Applications- G.C.Onwubolu, Butterworth-Heinemann
2.	Foundations of MEMS- Chang Liu, Pearson International Edition.
3.	Fundamentals of Microfabrication- Madou, CRC Press.

COURSE OUTCOMES: *At the end of this course, students will demonstrate the ability to*

1.	Analyze the mechatronics system design and characteristics of sensors and actuators.
2.	Write the applications of Sensors.
3.	Express the applications of Actuation systems.
4.	Implement the MEMS technology.
5.	Apply MEMS for various industrial applications.

Course Articulation Matrix

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

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	2.4	2.4	3	2.6	2

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Subject Code: MMSPE203		**Quality Engineering**	
Pre-requisite:	None	**Co-requisite:**	None

Module -I	**[06]**
	Attributes of quality, Evolution of philosophy of Quality Management, Economics of quality and measurement of cost of quality, Data presentation techniques for quality analysis Principles of Quality Management- Pioneers of TQM, Quality costs, Quality system Customer Orientation, Benchmarking, Re-engineering, Concurrent Engineering.

Module -II	**[06]**
	Single Vendor Concept- JIT, Quality Function deployment, Quality Circles, KAIZEN, SGA, POKA-YOKE, Taguchi Methods. Leadership- Organizational Structure, Team Building, Information Systems and Documentation, Quality Auditing- ISO 9000- QS 9000.

Module -III	**[06]**
	Methods and Philosophy of Statistical Process Control, Control Charts for Variables and Attributes, Cumulative sum and exponentially weighted moving average control charts, Others SPC Techniques- Process Capability Analysis- Six sigma accuracy.

Module -IV	**[06]**
	Acceptance Sampling Problem, Single Sampling Plans for attributes, Double, multiple and sequential sampling, Military standards, The Dodge-Roming sampling plans.

Module -V	**[06]**
	Reliability analysis and predictions, Bath-Tub Curve, Exponential and Weibull distribution in modelling reliability, System reliability

TEXT BOOK(S):

1.	Total Quality Management for Engineers- M. Zairi, Woodhead Publishing.
2.	Introduction to Statistical Quality Control- D.C. Montgomery, John Wiley and Sons.

REFERENCE BOOK(S):

1.	ISO 9000- A Manual for Total Quality Management- S. Dalela and Saurabh, S.Chand and Company Ltd.
2.	Statistical Quality Control- E.L. Grant and Leavensworth, McGraw-Hill.

COURSE OUTCOMES: *At the end of this course, students will demonstrate the ability to*

1.	Apply quality as per quality management principles.
2.	Evaluate between quality management tools.
3.	Analyze process control using statistical control charts.
4.	Plan the best sampling plan for specific product quality control.
5.	Analyze reliability for specific engineering systems.

Course Articulation Matrix

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

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	2		2	2	3	3

Subject Code MMSPE204		**Computer Aided Engineering**	
Pre-Requisite:	Computer Aided Design & Manufacturing	**Co-requisite:**	

Module -I	**[06]**
	Introduction to solid modelling, Concepts of 3-D modelling, Model structure. Engineering drawing, Fundamentals of assembly and sub-assembly, Parametric modelling, Advanced feature-based design. CAD Applications: Engineering Products, analogy: documentation, Design Representation, FEM, Optimization, Software/AutoCAD/Mechanical Desktop/I-DEAS.
Module -II	**[06]**
	Solid Modeling: Representation of Solids, Topology, wireframe modeling. Boundary Representation.CSG, Operations: extrude, revolve, examples
Module -III	**[06]**
	Design of Curves: Representation, piecewise continuous, differential geometry of curves. Ferguson segments, Béziersegments.B-Splines.Rational Curves/NURBS. Design of Surfaces: Piecewise continuous, differential geometry, Fersugon,16 point form, Bézier, B-spline.Composite Surfaces: Ferguson and Bézier surfaces.
Module -IV	**[06]**
	Fundamentals of modeling for finite element analysis, Analysis methods, Design creativity. Computational geometry. Mesh generation. FEM: An introduction. Optimization: Single variable methods. KKT conditions. Stochastic Methods.
Module -V	**[06]**
	Design for manufacturability – Machining, Casting and metal forming, Optimum design, Design for assembly and disassembly, Probabilistic design concepts - FMEA - QFD - Taguchi Method for design of experiments - Design for product life cycle. Real-world problems: critiques, analysis, and improvements.

TEXT BOOK(S):

15.	Computer Aided Engineering Design by Saxena, Anupam, Sahay, Birendra
16.	Fundamentals of Computer-Aided Engineering- by Benny Raphael, Ian F. C. Smith

REFERENCE BOOK(S):

15.	Computer Aided Analysis and Design by SrinivasaPrakashRegalla

COURSE OUTCOMESS:*Upon completion of this course students will be able to:*

6.	Apply the knowledge of mathematical skills in the design and analysis of model generations and analysis.
7.	Demonstrate the Industry standard software packages and analytical tools for solid modeling in design projects.
8.	Create various component design consists of curves and surfaces.
9.	Incorporate analytical skills in model verifications and interpretations of FEA results.
10.	Recognize social and environmental impacts using developed designs or engineering decisions.

Course Articulation Matrix

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

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

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

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Subject Code:MMSPE205		**Enterprise Resource Planning**	
Pre-requisite:	None	**Co-requisite:**	None

Module -I	**[06]**
	Fundamentals of ERP Introduction to ERP - Principles of ERP – ERP An Overview – ERP Framework – Benefits of ERP – ERP Related Technology - Business Blue Print – ERP vs Business Process Re-Engineering - Data Warehousing - Data Mining - On-line Analytical Processing (OLAP).

Module -II	**[06]**
	ERP Implementation - ERP Tools - ERP Implementation Lifecycle - Implementation Methodology - Hidden Cost Issues – Analysis of cases from five Indian Companies - Vendors, Consultants and Users - Contracts with Vendors, Consultants and Employees - Project Management and Monitoring.

Module -III	**[06]**
	ERP Architecture and Technologies Languages - Client & Server Architecture – Technology Choices – Internet Direction – Evaluation Framework – Management Information Systems – Decision Support Systems - CRM – CRM Pricing – Chain Safety – Evaluation Framework – Dynamic Models – Process Models.

Module -IV	**[06]**
	ERP Systems and Applications: Basic concepts of Oracle, SAP, Baan and MAXIMO – Comparison – Integration of Different ERP Applications – ERP as Sales Force Automation – Integration of ERP and Internet – ERP Implementation strategies – Organizational and social issues.

Module -V	**[06]**
	ERP Modules and Packages Business modules in an ERP Package - Training on various modules of IBCS - ERP Package-Oracle ERP and MAXIMO, including ERP on the NET - Enterprise Integration Applications (EIA) - ERP and E-Commerce – Web Enabling ERP.

TEXT BOOK(S):

1.	N.K.Venkitakrishnan , Enterprise Resource Planning – Concepts and Practice, Prentice Hall of India
2.	Alexis Leon, ERP Demystified, Tata McGraw–Hill Publishing Company limited

REFERENCE BOOK(S):

1.	Brady, Enterprise Resource Planning, Thomson Learning.
2.	S.Sadagopan, ERP: A managerial Perspective, Tata McGraw-Hill.
3.	Vollmann, Bery&Whybark , Manufacturing and Control Systems, Galgotia.

COURSE OUTCOMES: *At the end of this course, students will demonstrate the ability to*

1.	Describe the basicsof ERP and its framework.
2.	Illustrate ERP tools and implementation methodologies.
3.	Enumerate ERP Architecture and Technologies.
4.	Apply the concept of different ERP systems and suggest ERP Implementation strategies.
5.	Elucidate divers ERP Modules and Packages.

Course Articulation Matrix

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

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	2	2	3	3	2

Subject Code: MMSPE206		**Laser Material Processing**	
Pre-requisite:	None	**Co-requisite:**	None

Module -I	**[06]**
	Laser Systems- Laser beam characteristics, laser principles, High power lasers for materials applications, Principles and working of CO2, Nd:YAG and Excimer laser, Optics for irradiation.

Module -II	**[06]**
	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	**[06]**
	Laser Metallurgy- Laser surface treatment, Transformation hardening, Rapid quenching, Methods to obtain desired penetration depths, Laser surface alloying, Laser surface cladding, Shock hardening, Advantages of laser surface treatment.

Module -IV	**[06]**
	Laser Beam Machining- Cutting, 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	**[06]**
	Introduction to PAM, non-thermal generation of plasma, equipment and mechanism of metal removal, Component Parts of a Plasma Arc Torch, selection of gas, PAM parameters, PAM process characteristics. Safety precautions, applications, advantages and limitations.

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
3.	Manufacturing Engg. & Technology, Kalpakjian , Pearson Education

REFERENCE BOOK(S):

1.	Modern machining process, Pandey and Shan, Tata McGraw Hill
2.	Laser Materials Processing- W.M. Steen, Springer-Verlag.
3.	High power laser applications- J.F. Reddy, Academic Press.
4.	Metals Handbook: Machining Volume 16, Joseph R. Davis (Editor), American Society of Metals.

COURSE OUTCOMES: *At the end of this course, students will demonstrate the ability to*

CO1	Express the fundamentals of laser and plasma generation technology, types and application
CO2	Comprehend thermal and metallurgical aspects of laser processing and PAM.
CO3	Incorporate Development of analytical model for laser application.
CO4	Organize the processes that use laser and PAM in a variety of industries.
CO5	Implement the techniques, skills, and modern engineering tools necessary for engineering practice.

Course Articulation Matrix

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

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	2	3	3	3	2

Pre-Requisite:		Co-requisite:	

For the Minor Project and Seminar, the students are encouraged either to carry out minor projects (simulation or experimental) or collect the information on a specialized current topic pertaining to the domain of manufacturing process engineering and prepare a technical report, showing his understanding of the project work/topic of interest, and submit it to the department. It shall be evaluated by the departmental committee consisting of head of the department, seminar supervisor and senior faculty members. The assessment is based on the quality of presentation, report and viva voce. Further, the allocation of supervisors for the minor and major project work will be done based on the exhibition of student's work in the seminar.

COURSE OUTCOMESS: *After successful completion of this course, students will be able to:*

CO1	Review the literature both at national and international levels and define a specific problem through gap analysis.
CO2	Identify and focus on an emerging area of research in the field of manufacturing process engineering, specifically advanced manufacturing processes.
CO3	Perform research analysis to interpret the simulation/experimental data generated.
CO4	Draw conclusions and also suggest scope for further work.
CO5	Demonstrate satisfactorily the scientific principles and engineering ideas behind the research project undertaken and communicate effectively through oral or written or pictorial means.

Course Articulation Matrix

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

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	3	3	3	3	3

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Veer SurendraSai University of Technology Burla, Odisha
Department of Production Engineering

Subject Code			**Manufacturing Systems Lab-III**
Pre-requisite:	None	**Co-requisite:**	None

LIST OF EXPERIMENTS

1.	Study the experimental behaviour of similar metal using Friction Stir Welding machine.
2.	Study the experimental behaviour of dissimilar metal using Friction Stir Welding machine.
3.	To demonstrate the relationship between material removal rate (MRR) and duty cycle in case of EDM for a constant current and voltage.
4.	To demonstrate the relationship between material removal rate (MRR) and current in case of EDM for a constant voltage and duty cycle.
5.	To study the working principle of Laser Beam Machining (LBM).
6.	To study the Experimental investigation of metal removal rate by keeping voltage constant in Electro chemical machining.
7.	To study the Experimental investigation of metal removal rate by keeping current constant in Electro chemical machining.
8.	To study the working principle of Abrasive Jet Machining (AJM)
9.	Experimentation on Abrasive Jet Machining (AJM)
10.	Experimental study on Ultra Sonic Machining (USM)

COURSE OUTCOMES: *At the end of this course, students will demonstrate the ability to*

1. Organize machining on non-conventional machines.
2. Organize control parameter settings for process optimization.
3. Perform machining on non-conventional machines.
4. Perform control parameter settings for process optimization.
5. Evaluate and analyse non-conventional machining processes.

Course Articulation Matrix

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

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	H	H	M	H	M	M

Subject Code: MPEMS204		**Manufacturing Systems Lab-IV**	
Pre-requisite:	None	**Co-requisite:**	None

LIST OF EXPERIMENTS

1.	Finite Element analysis (static analysis) using ANSYS software
2.	Dynamics analysis using ANSYS software.
3.	Introduction to 3D machining process in CAMWORK Software.
4.	Generate CNC code of different machining process in CAMWORK Software.
5.	To study Digital Manufacturing Platform in DELMIA Software.
6.	To study Robot simulation system in DELMIA Software.
7.	To study Manufacturing process and model simulation using DELMIA/QUEST Software
8.	To study Casting System using AutoCAST software.
9.	Pick and place operation in Robot.
10.	Study the part programming of various Robots.
11.	Operation of Flexible Manufacturing system.

COURSE OUTCOMES: *At the end of this course, students will:*

1.	Apply the basic concepts of FEM to solve the problems using ANSYS
2.	Analyze the machining process using CAMWORK, DELMIA ,
3.	Express the Casting System using AutoCAST.
4.	Demonstrate pick and place operation in Robot.
5.	Implement the Operation of Flexible Manufacturing system.

Course Articulation Matrix

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

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	3	3	3	3	3

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Department of Production Engineering

Subject Code: MMSPE301	**Finite Element Analysis in Manufacturing**

Pre-requisite:	None	**Co-requisite:**	None

Module -I	**[08]**
Basics of FEM-Initial value and boundary value problems- Galerkin and Raleigh Ritz methods- Steps in FEA-Discretization, Interpolation, derivation of element characteristic matrix, shape function, assembly and imposition of boundary conditions- Solution and post processing for solving One dimensional solid mechanics, plane truss problems.	

Module -II	**[07]**
Global and Natural co-ordinates- Shape functions for one and two dimensional elements- Three noded triangular and four noded quadrilateral element, Isoparametric elements-Jacobian matrices and transformations- Basics of two dimensional axisymmetric analysis.	

Module -III	**[05]**
FE analysis of metal casting- Special considerations, latent heat incorporation, Gap element-Time stepping procedures-Crank-Nicholson algorithm.	

Module -IV	**[05]**
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	**[06]**
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- for one dimensional analysis and validation.	

TEXT BOOK(S):

3.	An Introduction to the Finite Element Method- J.N. Reddy, McGraw-Hill.
4.	Finite Element Method in Engineering- S.S. Rao, Pergammon Press.

REFERENCE BOOK(S):

4.	Metal Forming and the Finite Element Methods- S. Kobayashi, Soo-Ik-Oh and T. Altan, Oxford University Press.
5.	The Finite Element Method in Heat Transfer Analysis- R.W. Lewis, K. Morgan, H.R. Thomas and K.N. Seetharaman, John Wiley.
6.	Fundamentals of Finite Element Analysis by David V. Hutton, TMH Publications, Edition 2005.

COURSE OUTCOMES: *At the end of this course, students will demonstrate the ability to*

1.	Understand the steps of finite element methods and able to solve the simple engineering problems.
2.	Derive the shape functions of different elements for solving linear problems.
3.	Analyze metal casting problems using FEM.
4.	Analyze metal cutting problems using FEM.
5.	Utilize up-to-date interactive modeling and simulation techniques, and commercial software packages for solution of manufacturing problems.

Course Articulation Matrix

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

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	3	2	3	2	2

Subject Code: MMSPE302	**Design of Hydraulic & Pneumatic Systems**

Pre-requisite:	None	**Co-requisite:**	None

Module -I	**[06]**
	Hydraulic Power Generators- Selection and specification of pumps, pump characteristics. Linear and Rotary Actuators- selection, specification and characteristics. Pressure - direction and flow control valves- relief valves, non-return and safety valves - actuation systems.

Module -II	**[06]**
	Reciprocation, quick return, sequencing, synchronizing circuits- accumulator circuits- industrial circuits- press circuits.

Module -III	**[06]**
	Hydraulic milling machine- grinding, planning, copying, forklift, earth mover circuits- design and selection of components- safety and emergency mandrels.

Module -IV	**[06]**
	Pneumatic fundamentals- control elements, position and pressure sensing-logic circuits- switching circuits-fringe conditions modules and integration- sequential circuits- cascade methods- mapping methods- step counter method- compound circuit design- combination circuit design.

Module -V	**[06]**
	Pneumatic equipments - selection of components - design calculations-application- fault finding- hydro-pneumatic circuits - use of microprocessors for sequencing - PLC, Low cost automation- Robotic circuits.

TEXT BOOK(S):

1.	Fluid power with Applications- Antony Espossito, Prentice Hall.
2.	Basic Fluid Power- D. A. Pease and J.J. Pippenger, Prentice Hall.

REFERENCE BOOK(S):

1.	Hydraulic and Pneumatics- A. Parr, Jaico Publishing House.
2.	Pneumatic and Hydraulic Systems- W. Bolton, Butterworth - Heineman.

COURSE OUTCOMES: *At the end of this course, students will demonstrate the ability to*

1.	Select proper hydraulic power generators for specific industrial uses.
2.	Describe about hydraulic mechanisms and circuits of industrial equipment.
3.	Handle hydraulic machines and design required circuits.
4.	Handle pneumatic systems and design required circuits.
5.	Automate system using microprocessor for industrial application.

Course Articulation Matrix

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

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	2		2	3	2

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Subject Code: MMSPE303		**Discrete System Simulation**	
Pre-requisite:	None	**Co-requisite:**	None

Module -I	**[06]**
	Systems, modeling, general systems theory, concept of simulation, simulation as a decision-making tool, types of simulation. Pseudo random numbers, methods of generating random variates, discrete and continuous distributions, testing of random numbers.
Module -II	**[06]**
	Problem formulation, data collection and reduction, time flow mechanism, key variables, logic flow chart, starting condition, run size, experimental design consideration, output analysis and interpretation validation.
Module -III	**[06]**
	Comparison and selection of simulation languages, study along with practice of any one simulation language.
Module -IV	**[06]**
	Development of simulation models using the simulation language studied for systems like, queuing systems, production systems.
Module -V	**[06]**
	Simulation models for systems like Inventory systems, maintenance and replacement systems, investment analysis and network.

TEXT BOOK(S):

1.	Discrete event system simulation- J. Banks, J. S. Carson, B. L. Nelson, D. M. Nicol, PHI.
2.	Simulation using GPSS- T. J. Schriber, John Wiley.

REFERENCE BOOK(S):

1.	Simulation Techniques for Discrete Event Systems- I. Mitrani, Cambridge University Press.
2.	Simulation Modeling and Analysis- A. M. Law, McGraw Hill India.

COURSE OUTCOMES: *At the end of this course, students will demonstrate the ability to*

1.	Apply functional modeling method to model the activities of a system.
2.	Formulate a system problem besides analyzing and interpreting of output.
3.	Select and use any particular simulation language.
4.	Develop models using a simulation language for queuing and production systems.
5.	Use models for inventory, maintenance and replacement systems besides analysis.

Course Articulation Matrix

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

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	3	2		2	2

Subject Code: MMSOE301	**World Class Manufacturing**

Pre-Requisite:	None	**Co-requisite:**	None

Module -I	[06]
	World-Class Manufacturing (WCM): Manufacturing Excellence and Competitiveness, Meaning of World-class, Competing in World markets, WCM Techniques, Review of frameworks for WCM, Justification of WCM. An overview of Manufacturing Strategy: Manufacturing strategy concepts and domains. Incorporating manufacturing perspective in corporate Strategy, Trade-offs in manufacturing objectives. Creating competitive advantages through manufacturing strategy. Competitiveness models. The process of manufacturing strategy formulation and implementation, Manufacturing strategy – examples from the industry.

Module -II	[06]
	Introduction to Lean Manufacturing: Elements of Lean manufacturing: Stability, Standardized work, Just in time, Jidoka, Hoshin Planning, The culture of lean, Implementation of Lean manufacturing: Implementation framework for the Lean manufacturing.

Module -III	[06]
	An overview of various maintenance systems, Evolution of TPM, Productivity and TPM, OEE, TPM and TQC, Small Group Activities, Pillars of TQM, Kobetsu-Kaizen (Continuous Improvement), Jishu-Hozen (Autonomous maintenance), Planned Maintenance System, Skill upgrade training, Initial control (Equipment Life cycle management), Hinshitsu-Hozen (Quality Maintenance), Office TPM, Total safety management, Implementation, 5s.

Module -IV	[06]
	Total Quality Management (TQM): Definition, Understanding quality, Evolution of TQM, Framework for TQM, Commitment and leadership, Customer satisfaction, Employee involvement, Continuous process improvement, Supplier partnership, Performance measures, Formulation and implementation of TQM.

Module -V	[06]
	Other features of WCM: Supply Chain Management & key issues in SCM, Role of Information system in WCM, Knowledge management - Introduction, Benefits, Tools and techniques, Study of various performance measures in world class organization, Human Resource Dimensions in WCM.

TEXT BOOK(S):

17. Jim Todd, World-class Manufacturing, McGraw Hill, London.
18. Schonberger R.J., World Class Manufacturing - The Lesson of Simplicity, Free Press.

REFERENCE BOOK(S):

16. Voss C.A., Manufacturing Strategy: Process and Content, Chapman & Hall, London.
17. Pascal, D., Lean production simplified, 2nd Edition, Productivity Press.
18. Nakajima, S., Introduction to Total Productive Maintenance, Productivity Press.
19. Besterfield D. H., et al., Total Quality Management, Pearson Education.
20. Mohanty R.P. and Deshmukh S.G., Advanced Operations Management, Pearson.

COURSE OUTCOMESS: *At the end of this course, students will demonstrate the ability to*	
CO1	Express WCM framework and techniques to formulate and implement.
CO2	Organize the elements and implementation of lean manufacturing.
CO3	Incorporate diverse maintenance and management systems for productivity and quality improvement.
CO4	Demonstrate the evolution, framework, formulation and implementation of TQM.
CO5	Plan the role of SCM, information system in WCM.

Course Articulation Matrix

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

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

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

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Department of Production Engineering

Subject Code: MMSOE302		**Sustainable Manufacturing**	
Pre-requisite:	None	**Co-requisite:**	None

Module -I	**[06]**
	Introduction to Sustainability – Basic concepts, material conservation, recovery and reuse, Resources in manufacturing. Drivers for sustainable development and sustainable manufacturing, Fundamentals of sustainable manufacturing, Energy consideration in micro-manufacturing.

Module -II	**[06]**
	Life Cycle Analysis: Role of LCA, remanufacture and disposal , tools for LCA, Principles of Life Cycle Assessment (Goal, Scope and Life Cycle Inventory), Product Life Cycle Management: Energy and Mass, Work-pool and Throughput. Manufacturing process modeling for sustainability.

Module -III	**[06]**
	Sustainable design: Sustainable design's impact on sustainable manufacturing, Modern approaches for Sustainable Manufacturing, Toxic substances in industry, and need of renewable sources. Optimization for achieving sustainability in unit manufacturing: multi criteria decision making tools.

Module -IV	**[06]**
	Green manufacturing. Green manufacturing techniques: dry and near-dry machining, edible oil based cutting fluids, cryogenic machining for eco-efficiency.Implementation of lean methods: validating requirements, Green Supply chain: Carbon footprints in transportation. Bio-oil based advanced machining.

Module -V	**[06]**
	Reverse-engineering and design changes to improve products sustainability, remanufacturing, recycling, reuse, scrap, simulation models for manufacturing, validation, verification, output analysis, Concepts of optimization, numerical optimization through simulation.

TEXT BOOK(S):

3.	Sustainable Manufacturing, J. P. Davim, WILEY
4.	Sustainable Manufacturing: Challenges, Solutions and Implementation Perspectives, Springer

REFERENCE BOOK(S):

3.	Advances in Sustainable Manufacturing, Springer
4.	Sustainable Manufacturing and Remanufacturing Management, Springer

COURSE OUTCOMES: *At the end of this course, students will demonstrate the ability to*

6.	Express the concept of sustainability and identify the drivers for sustainable manufacturing.
7.	Elucidate the principles of LCA.
8.	Suggest suitable design for sustainable manufacturing.
9.	Explain the concepts and implementation of green manufacturing methods.
10.	Perform remanufacturing to improve product sustainability.

Course Articulation Matrix

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

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	M		M	M	H	H

Subject Code: MMSOE303		**Micro and Nano manufacturing**	
Pre-Requisite:	Enter Text Here	**Co-requisite:**	Enter Text Here
Module -I			**[10]**
	Nano-technology Fundamentals and Principles, Survey of Nano-structure, Carbon nanotubes and Structures, Processing system of nanometer accuracies,.mechanism of material processing, Nano Physical processing of atomic bit-units, Nano-chemical and electrochemical atomic-bit processing.		
Module -II			**[10]**
	Nano-Measuring Systems of Sub-Nanometre Accuracy and Resolution: In process or in situ measurement of position of processing point, Post process, example of different measuring systems. Application of ultra precision motion controls for Micro Machining, Magnetostrictive actuators, piezoelectric systems. ultra-precision position control, Future development of micro actuators.		
Module -III			**[06]**
	Conventional Methods of Micro machining: Mirror machining of soft materials, ultra-precision Mirror polishing of hard and brittle materials, finish turning, Boring, Grinding &Honning techniques		
Module -IV			**[12]**
	Non-conventional methods of micro machining: Chemical and Electrochemical techniques for Micro machining: Chemical Micro machining (CMM), Chemical Etching Plasma Etching, laser Micro machining, Electrochemical Micro machining (EMM) : Pu EMM, EMM through photo resist musk, Electron Beam Lithography (EBL), Plasma Arc Micro machining. Focused Ion Beam(FIB) micro machining, Slim Micro machining.		
Module -V			**[04]**
	Coating technology and surface engineering, PVD, CVD etc.		
TEXT BOOK(S):			
19.	Strength of Materials- G.H.Ryder, Macmillan India.		
20.	Mechanics of Materials- R.C. Hibbeler, Pearson		
3.	Strength of Materials- S.S. Rattan, TMH Publications		
REFERENCE BOOK(S):			
21.	Mechanics of Materials-I- E.J. Hern; Paragaman.		
22.	Introduction to Mechanics of Solids- Crandell, Dahl and Lardner, McGraw Hill		
COURSE OUTCOMESS: *At the end of this course, students will demonstrate the ability to*			
11.	Develop to solve composite bars in tension and compression, temperature stresses, 2D stress system, principal stresses, Mohr's circle, principal strains, measurement of strains.		
12.	Demonstrate to draw shear force and bending moment diagrams for statically determinate beams.		
13.	Express to solve problems of simple bending in initially straight beams and composite beams.		
14.	Incorporate to solve problems of torsion in solid and hollow shafts and to calculate slope and deflection of beams by integration and Macaulay's method.		
15.	Evaluate buckling load in columns and to evaluate dimensions of component using Theories of failure.		

Course Articulation Matrix

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

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	3	2	2	3	2

Subject Code			**Dissertation (Phase-I)**
Pre-requisite:	None	**Co-requisite:**	None

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

1. Identify and focus on an emerging area of research in the field of production engineering
2. Review the literature both at national and international levels
3. Define a specific program through gap analysis.
4. Communicate effectively through oral or written or pictorial means.
5. Demonstrate satisfactorily the scientific principles behind the research project undertaken.

Course Articulation Matrix

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

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	H	H	M	H	M	H

Subject Code			**Dissertation(Phase-II)**
Pre-requisite:	None	**Co-requisite:**	None

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

1. Design research project work related constituents.
2. Develop research project work related constituents.
3. Perform experiments and/or simulations pertaining to research project objectives.
4. Produce research project related control settings for parameter/process optimization.
5. Evaluate and analyse parameters and processes concerning the research project.

Course Articulation Matrix

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

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	H	H	M	H	M	H