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

Course Structure &Syllabus of

M. Tech. Programme in

CAD/CAM& Robotics

(Production Engineering)

Academic Year – 2019-20

VEER SURENDRA SAI UNIVERSITY OF TECHNOLOGY, ODISHA

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

M.TECH. in ROBOTICS and CAD-CAM

PEOs:

The educational objectives of M. Tech. in Robotics and CAD-CAM of VSSUT, Burla are to prepare its graduates:

PEO1: To broaden and deepen their capabilities in analytical and experimental research methods, analysis of data, and drawing relevant conclusions for scholarly writing and presentation pertaining to Robotics and CAD-CAM projects.

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 Robotics and CAD-CAM 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 CAD-CAM and Robotics.

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 Robotics and CAD-CAM 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.

SEMESTER I							
Sl.No	Core/ Elective	Subject Code	Subject Name	L	T	P	Credits
1.	Core-I	MPECC101	Advanced CAD	3	0	0	3
2.	Core-II	MPECC102	Computer Aided Manufacturing	3	0	0	3
3.	PE-I	MCCPE101	Rapid Manufacturing Processes	3	0	0	3
4.		MCCPE102	Precision Engineering				
5.		MCCPE103	Design for Manufacturing and Assembly				
6.	PE-II	MCCPE104	Finite Element Analysis in Manufacturing	3	0	0	3
7.		MCCPE105	Design Optimization				
8.		MCCPE106	Design of Hydraulic and Pneumatic Systems				
9.	Common		Research Methodology & IPR	3	0	0	3
10.	Lab-I	MPECC103	Computer Aided Design Lab	0	0	3	2
11.	Lab-II	MPECC104	CAM Lab	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	MPECC201	Robotics & Robots Application	3	0	0	3
2.	Core-IV	MPECC202	Automation in Manufacturing	3	0	0	3
3.	PE-III	MCCPE201	Computer Integrated Manufacturing	3	0	0	3
4.		MCCPE202	Concurrent Engineering				
5.		MCCPE203	Computer Aided Process Planning				
6.	PE-IV	MCCPE204	Mechanics of Advanced Materials	3	0	0	3
7.		MCCPE205	Simulation and modeling				
8.		MCCPE206	Robotic Material Handling				
9.	Common		Minor Project & Seminar	0	0	3	2
10.	Lab-III	MPECC203	Robotics Lab	0	0	3	2
11.	Lab-IV	MPECC204	Simulation Lab	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	MCCPE301	Mechatronics & MEMS	3	0	0	3
2.		MCCPE302	Computer Aided Product Design				
3.		MCCPE303	Artificial intelligence and expert systems				
4.	OE-I	MCCOE301	Quality Engineering	3	0	0	3
5.		MCCOE302	Life Cycle Engineering				
6.		MCCOE303	Advanced Maintenance Technology				
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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Subject Code:MPECC101		**Subject name** : Advanced CAD	
Pre-Requisite:	None	**Co-requisite:**	None

Module -I	**[06]**
CAD Tools:Definition of CAD Tools, Graphics standards, Graphics software: requirements of graphics software, Functional areas of CAD, Efficient use of CAD software. Basics of Geometric Modelling: Requirement of geometric modeling, Geometric models, Geometric construction methods, Modelling facilities desired.	

Module -II	**[06]**
Geometric modelling: Classification of wireframe entities, Curve representation methods, Parametric representation of analytic curves: line, circle, arc, conics, Parametric representation of synthetic curves: Hermite cubic curve, Bezier curve, B-Spleen curvewire, NURBS, Curve manipulations.	

Module -III	**[06]**
Surface Modeling: Classification of surface entities, Surface representation methods, Parametric representation of analytic surfaces: plane surface, ruled surface, surface of revolution, tabulated cylinder, Parametric representation of synthetic curves: Hermite cubic surface, Bezier surface, BSpleen surface, Blending surface, Surface manipulations.	

Module -IV	**[06]**
Solid Modelling:Geometry and topology, Boundary representation, The Euler-Poincare formula, Euler operators, Constructive solid geometry: CSG primitives, Boolean operators, CSG expressions, Interior, Exterior, closure, Sweeping: linear and non-linear, Solid manipulations.	

Module -V	**[06]**
2-D and 3-D transformations: translation, scaling, rotation, reflection, concatenation, homogeneous coordinates, Perspective projection, orthotropic projection, isometric projection, Hidden surface removal, shading, rendering. Evaluation Criteria: Evaluation criteria of CAD software, Data exchange formats: GKS, IGES, PHIGS, CGM, STEP Dimensioning and tolerances: Linear, angular, angular dimensions, maximum material condition (MMC), Least material condition (LMC), Regardless of feature size (RFS).	

TEXT BOOK(S):

1.	Mastering CAD/CAM / IbrhimZeid / McGraw Hill International.
2.	CAD/CAM Concepts and Applications/ Alavala/ PHI.

REFERENCE BOOK(S):

1.	CAD/CAM Principles and Applications/ P.N. Rao/TMH/3rd Edition
2.	CAD/CAM /Groover M.P./ Pearson education
3.	CAD / CAM / CIM, Radhakrishnan and Subramanian/ New Age
4.	Principles of Computer Aided Design and Manufacturing/ FaridAmirouche/ Pearson

COURSE OUTCOMES:

CO1	Define CAD tools and their implementations.
CO2	Demonstrate and implement geometric modeling techniques.
CO3	Implement Surface representation methodologies for surface modeling.
CO4	Develop skills to perform solid modeling.
CO5	Express to learn other software systems.

Course Articulation Matrix

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

Subject Code MPECC102		**Computer Aided Manufacturing**	
Pre-Requisite:	Basic Manufacturing Processes	**Co-requisite:**	

Module -I	**[06]**
	Introduction to Automation – Goals of Automation, levels of automation, Hard Vs Soft Automation, Computer Aided manufacturing (CAM). Numerical Control - Introduction, Problems with conventional NC, Role of NC / CNC in CAM, Applications of NC / CNC, Benefits of NC / CNC, Limitations of CNC, DNC, Combined DNC/ CNC system.
Module -II	**[06]**
	Basic Components of CNC system - Part programming, Machine control unit, Machine tool - Historical developments and their role in control of machine tools, Classification of NC / CNC systems - Based on type of Control (PTP\C\L), method of programming, type of architecture - Hardwired / Soft-wired / Open.
Module -III	**[06]**
	Machine Control Unit - Data processing Unit - elements and their functions; Interpolators - Types and Stages of Interpolation, Principles of interpolation; Sequential controllers - Concepts, Relay ladder diagrams; Programmable Logic Controllers - Elements of Hardware and Software, Methods of programming.
Module -IV	**[06]**
	Part programming - Introduction; Part Program and its elements, Methods of Programming - Manual and Computer Assisted Part programming - APT and its variations, ATP language-macro statements, programming with interactive graphics, NC part programming using CAD/CAM, Concepts of CAM - Tool path generation and control methods.
Module -V	**[06]**
	Machine Tool - Components of CNC machine tool, Drives and controls, Automatic Tool Changers, Automatic Pallet Changers, tool offsets and work offsets, high speed and precision machining concepts. Adaptive control manufacturing systems, Computer Integrated Manufacturing system, Machine Tools; Materials Handling system: AGV, Robots, Lean manufacturing.

TEXT BOOK(S):

1.	Koren Y, Computer Control of Manufacturing systems, McGraw Hill, 1986.
2.	CAD/CAM-M.P. Groover& E.W. Zimmers, PHI.
3.	Automation, Production System and CIM- M.P. Groover, PHI.

REFERENCE BOOK(S):

1.	Reinbold U, Blume C and Dilmann R, Computer Integrated Mfg. Technology & Systems, Marcel Dekker, 1985.
2.	Petruzella F D, Programmable Logic Controllers, McGraw Hill, 1989.
3.	CAD/CAM/CIM- Radhakrishnan&Subramanyan, Wiley Eastern.

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

CO1	Demonstrate the concept of automation in NC, CNC or combined systems.
CO2	Recognize to distinguish between positional control and tool path control in machining.
CO3	Describe the function of different machine control units in CNC.
CO4	Develop part programs for machining of different job geometry.
CO5	Express specific characteristics of CNC machine tool components.

Course Articulation Matrix

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

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Subject Code: MCCPE101		**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:MCCPE102		**Precision Engineering**	
Pre-Requisite:	None	**Co-requisite:**	None

Module -I	**[4]**
	Precision Engineering: Micromilling and Microdrilling, Micro Electro Mechanical Systems, Microelectronics fabrication methods, Principles of MEMS, mechanical MEMS, Thermal MEMS, Magnetic MEMS.

Module -II	**[5]**
	Nanotechnology- Carbon nanotubes and Structures, Processing system of nanometre accuracies, mechanism of material processing, Nano Physical processing of atomic bit-units, Nano-chemical and electrochemical atomic-bit processing.

Module -III	**[7]**
	Nano-Measuring Systems of Sub-Nanometre Accuracy and Resolution: In process or in situ measurement of position of processing point, Post process and on machine measurement of dimensional features and surface, Mechanical measuring systems, Optical measuring systems, Electron beam measuring systems, Pattern recognition and inspection systems

Module -IV	**[7]**
	Nano-Positioning System of Nanometre Accuracy and Repeatability: Guide systems for moving elements, Servo control systems for tool positioning, Computer aided digital ultra-precision position control, Future development of micro actuators.

Module -V	**[7]**
	Applications of Nanotechnology: Nano-grating system, Nano lithography, Photolithography, Electron beam lithography, Machining of soft metal mirrors with diamond turning, Mirror grinding of ceramics, Ultraprecision block gauges, balls for rolling bearings, Fabrication CCD's, Optical fibres.

TEXT BOOK(S):	
1	Nanotechnology- N. Taniguchi, Oxford University Press.
2	Micromanufacturing and Nanotechnology- N.P. Mahalik, Elsevier.

REFERENCE BOOK(S):	
1	Foundation of MEMS- C. Liu, Prentice Hall.
2	Introduction to Nanotechnology- C.P. Poole and F.J. Owens, Wiley Interscience

COURSE OUTCOMES:	
CO1	Express the knowledge in micro and nano manufacturing methods.
CO2	Develop MEMS system for industrial use.
CO3	Apply the quality concepts parts, accuracy requirements of machine tools and use of latest machining process such as micro machining and micro fabrication.
CO4	Demonstrate tolerance allocation and analysis for precision machine design and assessment.
CO5	Plan sensibility analysis for precision design optimization and awareness of the needs and benefits of precision engineering

Course Articulation Matrix

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

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Subject Code:MCCPE103	**Design for Manufacturing and Assembly**

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

Module -I	**[06]**
	General design principles for manufacturability: strength and mechanical factors, mechanisms selection, evaluation method, Process capability: Feature tolerances, Geometric tolerances, Assembly limits, Datum features, and Tolerance stacks.

Module -II	**[06]**
	Factors Influencing form Design: Working principle, Material, Manufacture, Design- Possible solutions, Materials choice, Influence of materials on form design, form design of Welded members, forgings and castings.

Module -III	**[06]**
	Component Design-I: Machining Consideration: Design features to facilitate machining: drills, milling cutters, keyways, Doweling procedures, counter sunk screws, Reduction of machined area, simplification by separation, simplification by amalgamation, Design for machinability, Design for economy, Design for clampability, Design for accessibility, Design for assembly.

Module -IV	**[06]**
	Component Design-II: Casting Consideration: Redesign of castings based on parting line considerations, Minimizing core requirements, machined holes, redesign of cast members to obviate cores. Identification of uneconomical design, Modifying the design, group technology, Computer Applications for DFMA.

Module -V	**[06]**
	Design for the Environment: Introduction, Environmental objectives, Global issues, Regional and local issues, Basic DFE methods, Design guide lines, Lifecycle assessment, Basic method, Environmentally responsible product assessment, Weighted sum assessment method, Techniques to reduce environmental impact, Design to minimize material usage, Design for disassembly, Design for recyclability, Design for remanufacture, Design for energy efficiency, Design to regulations and standards.

TEXT BOOK(S):

4.	Kevien Otto and Kristin Wood, Product Design. Pearson Publication
5.	K.T. Ulrich and S.D. Eppinger, Product design and development, Tata McGraw Hill

REFERENCE BOOK(S):

4.	Boothroyd, G, Design for Assembly Automation and Product Design. Marcel Dekker.
5.	Bralla, Design for Manufacture handbook, McGraw Hill.
6.	Fixel, J. Design for the Environment McGraw Hill.

COURSE OUTCOMESS:

CO1	Apply design principles for manufacturability mechanisms selection and assembly limits.
CO2	Plan form design of welded members, forgings and castings.
CO3	Design for machinability, economy, clampability, accessibility and assembly.
CO4	Implement casting consideration and concept of group technology while design.
CO5	Incorporate environment consideration, regulations and standards while designing and remanufacturing.

Course Articulation Matrix

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

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):

1.	An Introduction to the Finite Element Method- J.N. Reddy, McGraw-Hill.
2.	Finite Element Method in Engineering- S.S. Rao, Pergammon 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, John Wiley.
3.	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*

CO1	Understand the steps of finite element methods and able to solve the simple engineering problems.
CO2	Derive the shape functions of different elements for solving linear problems.
CO3	Analyze metal casting problems using FEM.
CO4	Analyze metal cutting problems using FEM.
CO5	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

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Subject Code: MCCPE105		**Design Optimization**	
Pre-requisite:	None	**Co-requisite:**	None

Module -I	**[06]**
	General Characteristics of mechanical elements, adequate and optimum design, principles of optimization, formulation of objective function, design constraints, classification of optimization problems. Single and multivariable optimization techniques.

Module -II	**[06]**
	Technique of unconstrained minimization. Golden section, Random, Pattern and Gradient search methods, interpolation methods, equality and inequality constraints.

Module -III	**[06]**
	Direct methods and indirect methods using penalty function, Lagrange multipliers, Geometric programming stochastic programming, Genetic algorithms.

Module -IV	**[06]**
	Engineering applications, structural-design application axial and transverse loaded members for minimum cost, maximum weight.

Module -V	**[06]**
	Design of shafts and torsion members, design optimization of springs. Dynamics applications for two-degree freedom system, vibration absorbers. Application in mechanisms.

TEXT BOOK(S):

1.	Engineering Optimization -Theory and Practice, S S. Rao, New Age.
2.	Optimum Design of Mechanical elements, Johnson Ray C, Wiley, John & Sons

REFERENCE BOOK(S):

1.	Genetic Algorithms in search, Optimization and Machine, Goldberg D. E., Addison Wesley.
2.	Optimization for Engineering Design Algorithms and Examples, K. Deb, PHI.
3.	Introduction to Optimum Design, Jasbir S. Arora, Academic Press.

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

CO1	Formulate optimization problems in single variable as well as multivariable.
CO2	Apply the concept of optimality for various type of constrained and unconstrained optimization problems
CO3	Apply the concept of optimality for various types of direct methods and indirect methods.
CO4	Evaluate static industrial optimization problems.
CO5	Evaluate dynamic industrial optimization problems.

Course Articulation Matrix

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

Subject Code: MCCPE106	**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*

CO1	Select proper hydraulic power generators for specific industrial uses.
CO2	Describe about hydraulic mechanisms and circuits of industrial equipment.
CO3	Handle hydraulic machines and design required circuits.
CO4	Handle pneumatic systems and design required circuits.
CO5	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

वीरसुरेंद्रसाएप्रौद्योगिकीविश्वविद्यालयबुर्ला, ओडिशा
उत्पादनअभियांत्रिकीविभाग
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.	
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Department of Production Engineering

Subject Code:MPECC103		**Subject name: CAD Lab**	
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.	Design of spur gear.
4.	To design & assembly different parts of a knuckle joint.
5.	To study the static analysis of a part using CAD software.
6.	To study the dynamic simulation of a part using CAD software.
7.	To study structural analysis using CAD software.
8.	To solve heat transfer problem using CAD software.

COURSE OUTCOMES:

CO1	Define and implement CAD software.
CO2	Implement engineering design concepts.
CO3	Analyze and Construct 3D part models.
CO4	Develop skills to perform solid modeling.
CO5	Express to learn other software systems.

Course Articulation Matrix

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

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Department of Production Engineering

Subject Code: MPECC104			**CAM Lab**
Pre-requisite:	CAM	**Co-requisite:**	None

LIST OF EXPERIMENTS	
1.	Introduction to 3D machining process in CAMWORK Software.
2.	Generate CNC code of different machining process in CAMWORK Software.
3.	To study Digital Manufacturing Platform in DELMIA Software.
4.	To study Robot simulation system in DELMIA Software.
5.	To study Manufacturing process and model simulation using DELMIA/QUEST Software
6.	To study Casting System using AutoCAST software.
7.	To Evaluate the quality of casting in virtual environments of AutoCAST software.

COURSE OUTCOMES:	
CO1	Acquire fundamental understanding of the principles of CAM.
CO2	Exposure to CAM software.
CO3	Demonstrate to apply CAM concept to product design and manufacturing
CO4	Develop geometric models using curves, surfaces and solids.
CO5	Write the program for product manufacturing.

Course Articulation Matrix

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

Subject Code: MPECC201	**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):

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

REFERENCE BOOK(S):

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

COURSE OUTCOMESS:

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

Subject Code MPECC202	**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:*

CO1	Recognize different type of manufacturing systems for specific applications.
CO2	Demonstrate the correlation between type of automation and plant layout with specific manufacturing system.
CO3	Analyze for the optimization of automated flow lines and assembly systems.
CO4	Develop various material handling systems for industrial applications.
CO5	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

Subject Code: MCCPE201	**Computer Integrated Manufacturing**

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

Module -I	**[06]**
	Introduction: The meaning and origin of CIM, The changing manufacturing and management scenario, External communication, Islands of automation and software, Dedicated and open systems, Manufacturing automation protocol, Product related activities of a company, Marketing engineering, Production planning, Plant operations, Physical distribution, Business and financial management.

Module -II	**[06]**
	Computer Aided Process planning: Role of process planning in CAD/CAM integration, Approaches to computer aided process planning- Variant approach and Generative approaches, CAPP and CMPP process planning systems.

Module -III	**[06]**
	Shop Floor Control and FMS: Shop floor control-phases, Factory data collection system, Automatic identification methods- Bar code technology, Automated data collection system, FMS-components of FMS - types -FMS workstation, Material handling and storage systems, FMS layout, Computer control systems-application and benefits.

Module -IV	**[06]**
	CIM System: Open System Open systems inter connection, Manufacturing automations protocol and technical office protocol (MAP /TOP). CIM Implementation: CIM and company strategy, System modeling tools-IDEF models, Activity cycle diagram, CIM open system architecture (CIMOSA), Manufacturing enterprise wheel, CIM architecture, Product data management, CIM implementation software.

Module -V	**[06]**
	Data Communication: Communication fundamentals, Local area networks, Topology, LAN implementations, Network management and installations. Database for CIM: Development of databases, Database terminology, Architecture of database systems, Data modeling and data associations, Relational data bases, Database operators, Advantages of data base.

TEXT BOOK(S):

2.	Automation, Production Systems and Computer Integrated Manufacturing- M.P.Groover, Pearson Education.
3.	Computer Integrated Manufacturing System- Y. Koren, McGraw-Hill.

REFERENCE BOOK(S):

3.	CAD/CAM/CIM- P. Radhakrishnan, S. Subramanyan and V. Raju- New Age International.
4.	Computer Integrated Manufacturing- Paul G. Ranky, Prentice Hall International

COURSE OUTCOMES:

CO1	Explain the concept of open system in computer integrated manufacturing.
CO2	Develop common database for integration in CIM systems.
CO3	Monitor using shop floor control in flexible manufacturing systems.
CO4	Design CIM automation protocols and its architecture for specific industries.
CO5	Develop database networks for different applications.

Course Articulation Matrix

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

Subject Code:MCCPE202		**Concurrent Engineering**	
Pre-Requisite:	Theory of Machine, Manufacturing Science, Basic Electronics, Mathematics	**Co-requisite:**	None
Module -I			**[06]**
	Introduction: Extensive definition of CE - CE design methodologies - Organizing for CE - CE tool box collaborative product development		
Module -II			**[07]**
	Use of Information Technology: IT support - Solid modeling - Product data management - Collaborative product commerce - Artificial Intelligence - Expert systems - Software hardware co-design.		
Module -III			**[08]**
	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 -IV			**[10]**
	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 -V			**[09]**
	Project Management: Life Cycle semi realization - design for economics - evaluation of design for manufacturing cost - concurrent mechanical design - decomposition in concurrent design - negotiation in concurrent engineering design studies - product realization taxonomy - plan for Project Management on new product development - bottleneck technology development		

TEXT BOOK(S):

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

REFERENCE BOOK(S):

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

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

CO1	Evaluate the elements and benefits of a concurrent engineering approach to product development
CO2	Design concurrent engineering system for product and process in manufacturing enterprises.
CO3	Describe the basic concurrent engineering concepts, approaches, tools, and computer applications in the practice of concurrent engineering.
CO4	Discuss the process models, fabrication process, assembly processes, and models of manufacturing, testing and inspection.
CO5	Plan for project management on new product development.

Course Articulation Matrix

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

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MCCPE203		Computer Aided Process Planning	
Pre-Requisite:	CAD & M	**Co-requisite:**	

Module -I	**[06]**
	Introduction: The Place of Process Planning in the Manufacturing cycle-Process planning and production Planning-Process planning and Concurrent Engineering, CAPP, Group Technology.
Module -II	**[06]**
	Part Design Representation: Design Drafting-Dimensioning-Conventional Tolerance- Geometric Tolerance-CAD-input/output devices-Topology – Geometric transformation-Perspective transformation-Data Structure-Geometric modeling for process planning–GT Coding-The OPITZ system-The MICLASS System.
Module -III	**[06]**
	Process Engineering and Process Planning: Experience based planning-Decision table and Decision trees-Process capability analysis-Process planning-Variant process planning-Generative approach-Forward and backward planning, Input format, AI.
Module -IV	**[06]**
	Computer Aided Process Planning Systems: Logical Design of process planning- Implementation considerations-Manufacturing system components, Production Volume, No. of production families – CAM-I, CAPP, MIPLAN, APPAS, AUTOPLAN and PRO, CPPP.
Module -V	**[06]**
	An Integrated Process Planning Systems: Totally integrated process planning systems-An Overview-Modulus structure-Data Structure-Operation-Report Generation, Expert process planning

TEXT BOOK(S):

10.	Gideon Halevi and Roland D. Weill, "Principle of process planning- A Logical Approach", Chapman & Hall, 1995
11.	Chang T. C. & Richard A.Wysk, "An Introduction to automated process planning systems", Prentice Hall 1985
12.	CAD/CAM-M.P. Groover& E.W. Zimmers, PHI.

REFERENCE BOOK(S):

11.	Chang, T.C., "An Expert Process Planning System", Prentice Hall, 1985
12.	Nanua Singh, "Systems Approach to Computer Integrated Design and Manufacturing", John Wiley & Sons, 1996
13.	CAD/CAM/CIM- Radhakrishnan&Subramanyan, Wiley Eastern.

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

CO1	Understand the concept of computer assisted process planning.
CO2	Represent different part configurations using GT coding systems.
CO3	Compare generative and variant process planning for specific applications.
CO4	Design feasible CAPP system to implement in specific industry.
CO5	Develop common database for process planning integration.

Course Articulation Matrix

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

Subject Code		**Mechanics of Advanced Materials**	
Pre-requisite:	Computer Aided Design & Manufacturing	**Co-requisite:**	None
Module -I			**[06]**
	Definition and characteristicscomposite materials, Overview of advantage and limitations of composite materials, Significance and objectives of composite materials, current status and future prospectus.		
Module -II			**[06]**
	Classification of composite materials, Scale of analysis; Micromechanics, Basic lamina properties, Constituent materials and properties, Properties of typical composite materials		
Module -III			**[06]**
	Stress-strain relations, Relation between mathematical and engineering constants, transformation of stress, strain and elastic parameters		
Module -IV			**[06]**
	Basic assumptions, Strain-displacement relations, Stress-strain relation of layer within a laminate, Force and moment resultant, General load–deformation relations, Analysis of different types of laminates		
Module -V			**[06]**
	Stress analysis and safety factors for first ply failure of symmetric laminates, Micromechanics of progressive failure; Design methodology for structural composite materials.		

TEXT BOOK(S):	
1.	Robert M. Jones, "Mechanics of Composite Materials", Taylor and Francis, Inc., 1999.
2.	Mathews, F. L. and Rawlings, R. D., "Composite Materials: Engineering and Science", CRC Press, Boca Raton,

REFERENCE BOOK(S):	
1.	Isaac M. Daniels, OriIshai, "Engineering Mechanics of Composite Materials", Oxford University Press, 1994.
2.	Bhagwan D. Agarwal, Lawrence J. Broutman, "Analysis and Performance of fiber composites", John Wiley and Sons, Inc. 1990.
3.	MadhujitMukhopadhyay, "Mechanics of Composite Materials and Structures", University Press,

COURSE OUTCOMES: *At the end of this course, students will demonstrate the ability to*	
CO1	Apply concepts of composite materials in manufacturing of composite materials.
CO2	Execute characteristics of composite materials.
CO3	Analyse the stress-strain relations of a lamina.
CO4	Analyse the different types of Laminate.
CO5	AnalysetheStresses, safety and Failure of laminates.

Course Articulation Matrix

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

MCCPE205		**Simulation and Modeling**	
Pre-Requisite:	None	**Co-requisite:**	None

Module -I	**[06]**
	Introduction to modelling and simulation: concept of system, model and simulation, System analysis, classification of systems. System theory basics, its relation to simulation. Simulation Terminologies. Application areas, Model Classification, Types of Simulation, Steps in a Simulation study, Concepts in Discrete Event Simulation, Simulation Examples.

Module -II	**[06]**
	Statistical models in simulation, Concepts of Discrete Distribution and Continuous Distribution, Input probability distribution function for discrete systems, continuous distribution functions and empirical distribution functions, problem solving on the statistical models in simulation, analysis of a single server queuing system.

Module -III	**[06]**
	Random numbers: Random number tables, pseudo random numbers, Generation of Random numbers, Properties of random numbers, Techniques for generating random numbers, Mid-square random number generator, Testing random number generators-uniformity, chi-square, Generating Random Variates, Inverse Transform technique, Acceptance-Rejection technique, Composition & Convolution Method.

Module -IV	**[06]**
	Input modeling: Identifying distributions with data, estimation of parameters, goodness of fit test and accessing sample dependence, multivariate input models. Output modeling: Output analysis of a single system, Obtaining a specified precision, comparison of alternative system configuration, Terminating Simulations, Steady state simulations, Validating Input–Output Transformations

Module -V	**[06]**
	Simulation of manufacturing and material handling systems, Issues in material handling system, modeling of machine randomness: system down time, Monte carlo simulation, problem solving-Inventory system problems, model validity and credibility

TEXT BOOK(S):

13.	Jerry Banks, John S Carson, II, Berry L Nelson, David M Nicol, Discrete Event system Simulation,Pearson Education, Asia, 4th Edition, 2007, ISBN: 81-203-2832-9.
14.	Geoffrey Gordon, System Simulation, Prentice Hall publication.

REFERENCE BOOK(S):

14.	Averill M Law, W David Kelton, Simulation Modelling& Analysis, McGraw Hill publication
15.	NarsinghDeo, Systems Simulation with Digital Computer, PHI Publication (EEE)
16.	Averill M. Law and W. David Kelton, "Simulation Modeling and Analysis, McGraw Hill,

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

CO1	Explain the concept of system, model, simulation and identify the application areas.
CO2	Solve problem on the statistical models in simulation.
CO3	Generate random numbers and random variates and perform their testing.
CO4	Perform input-output modeling of a single system and validate.
CO5	Implement simulation of manufacturing and material handling systems

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6

CO1	3	3	1	2	1	1
CO2	3	3	1	2	1	1
CO3	3	3	1	2	1	1
CO4	3	3	1	2	1	1
CO5	3	3	1	2	1	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	1	2	1	1

Pre-requisite:	Robotics and Robot Applications	**Co-requisite:**	None

Module -I	**[06]**
	Overview of Smart Materials: Introduction to Smart Materials, Principles of Piezoelectricty, PerovskytePiezoceramic Materials, Single Crystals vs Polycrystalline Systems, Piezoelectric Polymers, Principles of Magnetostriction, Rare earth Magnetostrictive materials, Giant Magnetostriction and Magneto-resistance Effect, Introduction to Electro-active Materials, Electronic Materials, Electro-active Polymers, Ionic Polymer Matrix Composite (IPMC), Shape Memory Effect, Shape Memory Alloys, Shape Memory Polymers, Electro-rheological Fluids, Magneto Rhelological Fluids.
Module -II	**[06]**
	High-Band Width, Low Strain Smart Sensors: Piezeoelctric Strain Sensors, In-plane and Out-of Plane Sensing, Shear Sensing, Accelerometers, Effect of Electrode Pattern, Active Fibre Sensing, Magnetostrictive Sensing, Villari Effect, Matteuci Effect and Nagoka-Honda Effect, Magnetic Delay Line Sensing, Application of Smart Sensors for Structural Health Monitoring (SHM), System Identification using Smart Sensors.
Module -III	**[06]**
	Smart Actuators: Modelling Piezoelectric Actuators, Amplified Piezo Actuation – Internal and External Amplifications, Magnetostrictive Actuation, Joule Effect, Wiedemann Effect, Magnetovolume Effect, Magnetostrictive Mini Actuators, IPMC and Polymeric Actuators, Shape Memory Actuators, Active Vibration Control, Active Shape Control, Passive Vibration Control, Hybrid Vibration Control.
Module -IV	**[06]**
	Smart Composites: Review of Composite Materials, Micro and Macro-mechanics, Modelling Laminated Composites based on Classical Laminated Plate Theory, Effect of Shear Deformation, Dynamics of Smart Composite Beam, Governing Equation of Motion, Finite Element Modelling of Smart Composite Beams.
Module -V	**[06]**
	Advances in Smart Structures & Materials: Self-Sensing Piezoelectric Transducers, Energy Harvesting Materials, Autophagous Materials, SelfHealing Polymers, Intelligent System Design, Emergent System Design.

TEXT BOOK(S):

1.	Brian Culshaw, Smart Structures and Materials, Artech House, 2000
2.	Gauenzi, P., Smart Structures, Wiley, 2009

REFERENCE BOOK(S):

1.	Cady, W. G., Piezoelectricity, Dover Publication
2.	Bhagwan D. Agarwal, Lawrence J. Broutman, "Analysis and Performance of fiber composites", John Wiley and Sons, Inc. 1990.
3.	MadhujitMukhopadhyay, "Mechanics of Composite Materials and Structures", University Press,
4.	Mazumdar S. K., "Composite Manufacturing – Materials, Product and Processing Engineering", CRC Press, Boca Raton.

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

CO1	Describe the basics of smart materials.
CO2	Apply the principle of smart sensors in industrial applications .
CO3	Apply the smart actuators in industrial applications.
CO4	Analyze the different types of laminate composites.
CO5	Design Smart Structures for industrial work.

Course Articulation Matrix

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

Subject Code: Common	**Minor Project& Seminar**

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 CAD/CAM and Robotics 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 CAD/CAM and Robotics engineering, specifically automated 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

Subject Code:MPECC203			**Robotics Lab**
Pre-requisite:	None	**Co-requisite:**	None

LIST OF EXPERIMENTS	
1.	To jog the robot using joint axis control & teach multi points in SCARA robot.
2.	To perform pick and place in SCARA robot.
3.	Draw different geometry sketch using robot command.
4.	Teach the robot palletizing operations by picking the job from pallet1 and placing it in pallet 2 using Aristo Robot.
5.	Teach the robot to load and unload a pneumatic chuck in Aristo Robot.
6.	Machining in NC lathe by writing part program.
7.	Machining in CNC Milling by writing part program.
8.	Operation of Flexible Manufacturing system.
9.	Operation of ASRS.

COURSE OUTCOMES: At the end of this course, students will demonstrate the ability to	
CO1	Develop the knowledge related to robotics and robot applications.
CO2	Perform palletizing operation by employing industrial robots.
CO3	Describe and develop NC programmes for Lathe and Milling operations.
CO4	Write offline programmes for industrial applications of robots.
CO5	Operate FMS productively.

Course Articulation Matrix

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

MPECC204	**Simulation Lab**

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

LIST OF EXPERIMENTS	
1.	Computational Fluid Dynamics analysis using ANSYS software.
2.	Finite Element analysis using ANSYS software.
3.	To study Robot simulation system in DELMIA Software.
4.	To study Manufacturing process and model simulation using DELMIA/QUEST Software
5.	To estimate industrial manufacturing analysis using SIMUL8 software
6.	To study different mathematical problem simulation using SOLIDWORK software.
7.	To study the casting simulation using AutoCAST software

COURSE OUTCOMESS:	
CO1	Design, analyse and optimize automated flow lines and assembly systems.
CO2	Develop material handling systems industry application.
CO3	Generate automated process plans for intended products.
CO4	Understand the element simulation using various software.
CO5	Understand automated material handling systems in software based.

Course Articulation Matrix

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

Subject Code: MCCPE301			**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*

CO1	Analyze the mechatronics system design and characteristics of sensors and actuators.
CO2	Write the applications of Sensors.
CO3	Express the applications of Actuation systems.
CO4	Implement the MEMS technology.
CO5	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

Subject Code:MCCPE302		**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):			
15.	Discrete event system simulation- J. Banks, J. S. Carson, B. L. Nelson, D. M. Nicol, PHI.		
16.	Simulation using GPSS- T. J. Schriber, John Wiley.		
REFERENCE BOOK(S):			
17.	Simulation Techniques for Discrete Event Systems- I. Mitrani, Cambridge University Press.		
18.	Simulation Modeling and Analysis- A. M. Law, McGraw Hill India.		
COURSE OUTCOMESS:			
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

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

Subject Code : MCCPE303	**Artificial intelligence and expert systems**

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

Module -I	**[06]**
	History-Definition of Al, Emulation of human cognitive process. The knowledge search trade off- Stored knowledge- Semantic nets - An abstract view of modeling - Elementary knowledge - Computational logic - Analysis of compound statements using simple logic connectives- Predicate logic- Knowledge organization and manipulation- Knowledge acquisition.

Module -II	**[06]**
	Problem solving agents: Problem Definition- Formulating problems- Searching for solutions- Measuring problem, Solving Performance with examples. Search Strategies- Uninformed or Blinded search- Breadth first search- Uniform cost search- Depth first search, Depth limited search- Iterative deepening- Depth first search - Bidirectional search - Comparing uniformed search strategies - Informed search strategies - Heuristic information- Hill climbing methods- Best First Search, Branch- and- Bound Search- Optimal search and A* and iterative deepening A*.

Module -III	**[06]**
	Knowledge organization and communication: Matching Techniques - Need for matching- Matching problem - Partial matching - Fuzzy matching - RETE matching algorithm - Knowledge organization- Indexing and Retrieval techniques- Integration of knowledge in memory organization systems- Perception- Communication and Expert System - Overview of linguistics - Basic semantic analysis and representation structures- Natural language generation.

Module -IV	**[06]**
	Introduction to programing language: Introduction to Programming Language of AI and its advantages- Introduction to Lisp and its syntax- Lisp syntax- Numeric function - Difference between Lisp and Pro log- Lisp syntax- Input statements- Output statements and declaration of local variables- Interaction and recursion functions - Property list and arrays.

Module -V	**[06]**
	Knowledge based systems: Expert systems, components, characteristic features of expert systems, rule based system architecture, representing & using domain knowledge, expert system shell, explaining the reasoning and knowledge acquisition, applications.

TEXT BOOK(S):

1.	Elaine Rich and Kelvin Knight, Artificial Intelligence, Tata McGraw Hill
2.	Patterson, Introduction to Artificial Intelligence and Expert systems, Prentice Hall of India, New Delhi.

REFERENCE BOOK(S):

1.	Stuart Russell and Peter Norvig, Artificial Intelligence: A modern approach. Prentice Hall, New Jersey
2.	Nilson, N. J., Principles of Artificial Intelligence, Springer Verlag Berlin.
3.	Charniak, E and Drew McDermot, Introduction to Artificial Intelligence, Addison Wesley Longman Inc.
4.	Robert J. Schalkoff, Artificial Intelligence: An Engineering Approach, McGraw-Hill international Edition.

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

CO1	Express the basic concept of AI.
CO2	Analyze the diverse problem solving agents.
CO3	Express the knowledge of organization and communication.
CO4	Apply programming language of AI and state its advantages.
CO5	Evaluate the components, characteristic features of expert systems.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	3	2
CO2	3	2	2	3	3	3
CO3	3	3	2	3	3	3
CO4	3	2	2			2
CO5	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	2.5	2	3	3	3

Subject Code: MCC0E301	**Quality Engineering**

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

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

CO1	Demonstrate the concept of quality as per quality management principles.
CO2	Compile different quality management tools.
CO3	Analyze manufacturing process control using statistical control charts.
CO4	Evaluate different sampling plans for specific product quality control.
CO5	Describe reliability for different engineering systems.

Course Articulation Matrix

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

Subject Code: MCCOE302	**Life Cycle Engineering**

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

Module -I	**[06]**
	Product life cycle – Introduction, growth, maturity & decline, Product Lifecycle Management- Definition & Overview, Background for PLM-corporate challenges, Needs of PLM, Components/Elements of PLM, Emergence of PLM, Significance of PLM - life cycle problems to be resolved, product development problems to be resolved, Customer Involvement.

Module -II	**[06]**
	PLM Life cycle model- plan, design, build, support & dispose. Threads of PLM computer aided design (CAD), engineering data management (EDM), Product data management (PDM), computer integrated manufacturing (CIM). Weaving the threads into PLM, comparison of PLM to Engineering resource planning (ERP). PLM characteristics - singularity, cohesion, traceability, reflectiveness, Information Mirroring Model. External drivers- scale, complexity, cycle times, globalization & regulation. Internal drivers - productivity, innovation, collaboration & quality. Board room drivers – income, revenues & costs.

Module -III	**[06]**
	Product life cycle management system- system architecture, Information models and product structure, Information model, the product information data model, the product model, functioning of the system. Reasons for the deployment of PLM systems

Module -IV	**[06]**
	Product Data issues – Access, applications, Archiving, Availability, Change, and Confidentiality. Product Workflow, The link between Product Data and Product Workflow, Key Management Issues around Product Data and Product Workflow, Company's PLM vision, The PLM Strategy, Principles for PLM strategy, Preparing for the PLM strategy, Developing a PLM strategy, Strategy identification and selection, Change Management for PLM.

Module -V	**[06]**
	Different phases of product lifecycle and corresponding technologies, Foundation technologies and standards e.g. visualization, collaboration and enterprise application integration, Core functions e.g., data vaults, document and content management, workflow and program management, Functional applications e.g., configuration management. Human resources in product lifecycle. PLM Case Study.

TEXT BOOK(S):

1.	Grieves Michael, Product Lifecycle Management- Driving the Next Generation of Lean Thinking, McGraw-Hill
2.	AnttiSaaksvuori, AnselmiImmonen, Product Life Cycle Management - Springer,

REFERENCE BOOK(S):

1.	Stark, John. Product Lifecycle Management: 21st Century Paradigm for Product Realization, Springer-Verlag

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

CO1	Apply the basics of PLM.
CO2	Construct product life cycle management and driving environment
CO3	Express product life cycle management system
CO4	Recognize product life cycle environment.
CO5	Analyze the components of product life cycle management.

Course Articulation Matrix

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

Subject Code:MCCOE303	**Advanced Maintenance Technology**

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):

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

REFERENCE BOOK(S):

19. Plant Equipment & Maintenance Engineering Handbook by Duncan Richardson, McGraw Hill Education.
20. Engineering Maintenance A Modern Approach by B.S. Dhillon, CRC Press
21. Plant Equipment & Maintenance Engineering Handbook by Duncan Richardson, McGraw Hill Education.

COURSE OUTCOMESS:

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		**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