CURRICULUM STRUCTURE

PG: M.TECH.

MECHANICAL ENGINEERING

CAD/CAM AND ROBOTICS

REVISION: FRCRCE-1-24

Effective from Academic Year 2024-25
Board of Studies Approval: 9/03/2024
Academic Council Approval: 16/03/2024

Dr. DEEPAK BHOIR
Dean Academics

Dr. BHUSHAN T. PATIL
Head of Department

DR. SURENDRA RATHOD
Principal

Preamble:

Greetings and congratulations to all the education partners Fr Conceicao Rodrigues College of Engineering for getting autonomous status to the college from the year 2024-25. University Grant Commission vide letter No. F. 2-10/2023(AC-Policy) dated 23rd Nov 2023 conferred the autonomous status to Fr. Conceicao Rodrigues College of Engineering, Fr. Agnel Ashram, Bandstand, Bandra (West), Mumbai 400050 affiliated to University of Mumbai for a period of 10 years from the academic year 2024-2025 to 2033-2034 as per clause 7.5 of the UGC (Conferment of Autonomous Status Upon Colleges and Measures for Maintenance of Standards in Autonomous Colleges) Regulations,2023. We look towards autonomy as a great opportunity to design and implement curriculum sensitive to needs of Learner, Indian Society and Industries.
Government of Maharashtra has also directed Autonomous Colleges to revise their curriculum in line with National Education Policy (NEP) 2020 through Government Resolution dated 4th July 2023. We commit to ourselves to the effective implementation of UGC Regulations and NEP 2020 in its spirit.

Based on recent recommendations of the GR, we are pleased to offer our holistic curriculum for 2024-26, a "**H-Tree Model"** of Engineering Education. A unique **"H-Tree Model"** of Engineering Education Curriculum is carefully designed to systematically develop IQ (Intelligence Quotient), PQ (Physical Quotient), EQ (Emotional Quotient) and SQ (Spiritual Quotient) of a learner.
In alignment with the National Higher Education Qualifications Framework (NHEQF) guidelines set forth by the University Grants Commission, this Master of Technology (M. Tech.) program in Mechanical Engineering with specialization in CAD/CAM and Robotics is meticulously crafted. This syllabus is designed to cultivate graduates who demonstrate a deep commitment to ethical practices, critical thinking, and holistic problem-solving.

The postgraduate programmes help students to extend their knowledge of their chosen subject and prepare them for higher research studies. The advanced knowledge and specialized skills they gain in the PG programme are crucial to sustaining the journey of a student from the acquirer of knowledge to the creator of knowledge.

Drawing inspiration from the NHEQF level descriptors, this two-year postgraduate program aims to equip students with the knowledge and skills necessary to address complex challenges in the field of Mechanical Engineering especially in CAD/CAM and Robotics. PG framework is in sync with National Credit Framework (NCrF) for the creditization of all learning and assignment, accumulation, storage, transfer & redemption

of credits, subject to assessment. By emphasizing the application of theoretical principles to practical scenarios, the curriculum fosters a deep understanding of physical principles, methodologies, and interdisciplinary approaches essential for solving real-world problems. The PG programme also includes vocational courses relevant to the chosen discipline.

Furthermore, the program places a strong emphasis on self-directed learning, encouraging students to continuously upgrade their knowledge and skills to adapt to the evolving demands of the industry. Through a blend of theoretical coursework, hands-on projects, and research opportunities, students will develop the ability to gather and interpret data, critically evaluate theories, and make informed decisions based on evidence.

Central to the ethos of this program is the cultivation of a strong sense of personal responsibility and accountability. Graduates of this M.Tech. program will be equipped to navigate the dynamic landscape of technological advancements, exhibit full ownership of their work outputs, and demonstrate leadership qualities essential for driving innovation and sustainable development.

Various steps are taken to transform teaching learning process to make learning a joyful experience for students. We believe that this curriculum will raise the bar of academic standards with the active involvement and cooperation from students, academic and administrative units.

Graduate Attributes of Master's Programme:

NHEQF has outlined the statement of learning achievements at a particular level on the basis of the following elements of descriptors:

- Knowledge and understanding
- General, technical, and professional skills required to perform and accomplish tasks
- Application of knowledge and skills
- Generic learning outcomes
- Constitutional, humanistic, ethical, and moral values
- Employability and job-ready skills, and entrepreneurship skills and capabilities/qualities and mindset

Credit requirement and Eligibility for the Master's Programme:

A 4-year Bachelor's degree (e.g. B.E., B.Tech. etc.) with a minimum of 160 credits for a 2-year/4-semester Master's programme (e.g. M.E., M. Tech. etc.) at level 7 of NHEQF.

Curriculum and Credit Distribution for M.Tech Mechanical (CAD/CAM and Robotics):

	Two-Year PG Programme (Generic and Professional) Minimum Credits		
	Course Work	Research (Dissertation)	Total
1st Semester	20	-	40
2nd Semester	20	-	
3rd Semester	-	20	40
4th Semester	-	20	

Main features of the master's curriculum framework:

- ✓ Opportunity for learners to choose the courses of their interest.
- ✓ Flexibility to switch to alternative modes of learning (offline, ODL, Online learning, and hybrid modes of learning).
- ✓ Mobility and flexibility as per the UGC (Establishment and Operation of Academic Bank of Credits in Higher Education) Regulations, 2021, and UGC Guidelines for Multiple Entry and Exit in Academic Programmes offered in Higher Education Institutions. These documents are to facilitate the implementation of the proposed "Curriculum and Credit Framework for Postgraduate Programmes."
- ✓ As emphasized by NEP 2020, the curriculum includes formative and continuous assessment rather than summative assessment.
- ✓ Another opportunity for students is the facility to pursue two academic programmes simultaneously. Fr. CRCE has no objection if a student wish to pursue two academic programmes simultaneously, one in full-time physical mode at Fr. CRCE and another in Open and Distance Learning (ODL)/Online mode with any HEI which is recognised by UGC/Statutory council/ Government of India for running such programs.
- ✓ The candidates having relevant experience / proficiency of atleast 4 years in experience in a trade or profession, will be exempted from the related ONE course in the curriculum. To complete the credit requirements in lieu of this, the candidate need to complete the project given by the department for the equivalent credit.
- ✓ The candidates having relevant experience / proficiency of more than 4 years in a trade or profession will be exempted from the related TWO courses in the curriculum. To complete the credit requirements in lieu of this, the candidate need to complete the project given by the department for the equivalent credit.
- ✓ The candidate has to prove the relevant experience / proficiency through documents endorsed by the concerned authorities.

- ✓ Exit Point: For the PG programme, there shall only be one exit point for those who join two year PG programme. Students who exit at the end of 1st year shall be awarded a Postgraduate Diploma.

Curriculum Structure for PG Programs at Fr CRCE w.e.f. A.Y. 2024-25

Nomenclature of the courses in the curriculum	
Abbreviation	**Title**
PCC	Program Core Courses
PEC	Program Elective Courses
OE	Open Elective
CCL	Core Course Lab
SBL	Skill Based Lab
MP	Major Project

Credit Specification:

- ❖ Theory: 1 credit = 13 to 15 hrs of teaching
- ❖ Lab: 1 Credit = 26 to 30 hrs of lab work
- ❖ Seminar/Group Discussion: 1 Credit=13 to 15 hrs of participation

Society of St. Francis Xavier, Pilar's
Fr. Conceicao Rodrigues College of Engineering
Fr. Agnel Ashram, Bandstand, Bandra (W), Mumbai – 400 050
(Autonomous College affiliated to University of Mumbai)

SEMESTERWISE CURRICULUM STRUCTURE

FIRST YEAR M.TECH. Mechanical Engineering (CAD/CAM and Robotics) Program:

SEM-I												
Course Code	Course Vertical	Sub-Vertical	Course Name		Contact Hours	Examination Marks					Credits	
						ISE1	MSE	ISE2	ESE	Total	Points	Total
PCC21ME01	PCPEC	PCC	Computer Aided Design	TH	3	20	30	20	30	100	3	4
				TU	1	20	--	30	-	50	1	
PCC21ME02	PCPEC	PCC	Mechatronics and Automation	TH	3	20	30	20	30	100	3	4
				TU	1	20	--	30	-	50	1	
PEC21ME01X	PCPEC	PEC	Program Elective 1	TH	2	20	30	20	30	100	2	3
				TU	1	20	--	30	-	50	1	
PEC21ME02X	PCPEC	PEC	Program Elective 2	TH	2	20	30	20	30	100	2	3
				TU	1	20	--	30	-	50	1	
OE211X	OE	OE	Open Elective 1	TH	2	20	30	20	30	100	2	3
				TU	1	20	--	30	-	50	1	
CCL21ME01	CCLSBL	CCL	Program Lab-I **CAD and Computer Aided Engineering**	PR	2	20	--	30	--	50	1	1
SBL21ME01	CCLSBL	SBL	Skill Based Lab-I **Simulation Based Optimization and Data Analytics**	TH	4$	20	--	30	50	100	2	2
				Total	**TH:TU:PR 10:5:6=21**	**240**	**150**	**310**	**150**	**850**	**20**	**20**

Course Code	Program Elective 1 (PEC21ME01X)	Course Code	Program Elective 2 (PEC21ME02X)
PEC21ME011	Artificial Intelligence and Expert System	PEC21ME021	MEMS
PEC21ME012	Smart Materials	PEC21ME022	Optimization
PEC21ME013	Simulation and Modelling	PEC21ME023	Advanced Manufacturing Technology

Course Code	Open Elective 1 (OE211X)
OE2111	Constitution of India and Professional Ethics
OE2112	Digital Business Management
OE2113	Design of Experiments

SEM-II												
Course Code	Course Vertical	Sub-Vertical	Course Name		Contact Hours	Examination Marks					Credits	
						ISE1	MSE	ISE2	ESE	Total	Points	Total
PCC21ME03	PCPEC	PCC	Industrial Robotics	TH	3	20	30	20	30	100	3	4
				TU	1	20	--	30	-	50	1	
PCC21ME04	PCPEC	PCC	Computer Aided Machining (CAM)	TH	3	20	30	20	30	100	3	4
				TU	1	20	--	30	-	50	1	
PEC21ME03X	PCPEC	PEC	Program Elective 3	TH	2	20	30	20	30	100	2	3
				TU	1	20	--	30	-	50	1	
PEC21ME04X	PCPEC	PEC	Program Elective 4	TH	2	20	30	20	30	100	2	3
				TU	1	20	--	30	-	50	1	
OE212X	OE	OE	Open Elective 2	TH	2	20	30	20	30	100	2	3
				TU	1	20	--	30	-	50	1	
CCL21ME02	CCLSBL	CCL	Program Lab-II **CAM and Additive Manufacturing**	PR	2	20	--	30	--	50	2	1
SBL21ME02	CCLSBL	SBL	Skill Based Lab-II **Mechatronics and Robotics**	TH	4$	20	--	30	50	100	2	2
				Total	**TH:TU:PR 10:5:6=21**	**240**	**150**	**310**	**150**	**850**	**20**	**20**

Course Code	Program Elective 3 (PEC21ME03X)	Course Code	Program Elective 4 (PEC21ME04X)
PEC21ME031	Product Design	PEC21ME041	Rapid Manufacturing
PEC21ME032	Advanced Finite Element Analysis	PEC21ME042	Sustainable Manufacturing
PEC21ME033	Control Engineering	PEC21ME043	Internet of Things (IOT)

Course Code	Institute Level Optional Course II (OE212X)
OE2121	Project Management
OE2122	Finance Management
OE2123	Environmental Management

Note 1: Skill Based Lab- I and II are focused on the learning through experience. SBL shall facilitate the learner to acquire the fundamentals of practical engineering in his or her specialization in a project-oriented environment. The learning through skill based labs can be useful in facilitating their research work and hence useful in early completion of their dissertation work.

SEMESTERWISE CURRICULUM STRUCTURE

SECOND YEAR M.TECH. Mechanical Engineering (CAD/CAM and Robotics) Program:

Course Code	Course Name		Contact Hours	Examination Marks					Credits	
				ISE1	MSE	ISE2	ESE	Total	Points	Total
MP22ME01	Major Project: Dissertation -I	PR	40	20	--	30	50	100	20	20
TH:TU:PR 0:0:28=28			40	20	--	30	50	100	**20**	**20**

Note 1: It is mandatory to complete the Online Credit Courses (OCC) available on NPTEL / Swayam /MOOC or similar platform approved by UoM. These two courses shall be completed in any semester I or II or III, but not later end of the Semester III. Institute shall make a provision that credits earned with OCC- I and OCC-II shall be accounted in the third semester grade-sheet with actual names of courses. The learner shall be allowed to take up these courses from his or her institute or organisation/ industry where his / her major project is carried out. The students shall complete the courses and shall qualify the exam conducted by the respective authorities/ instructor from the platform. The fees for any such courses and the corresponding examination shall be borne by the learner.

Online Credit Course – I
The learner shall opt for the course in the domain of Research Methodology. The opted course shall be of 3 credits of equivalent number of weeks.

Online Credit Course –II
The learner shall opt for the course recommended by Faculty Advisor/ Project Supervisor related to the area of M. Tech dissertation. The opted course shall be of 3 credits of equivalent number of weeks.

Course Code	Course Name		Contact Hours	Examination Marks					Credits	
				ISE1	MSE	ISE2	ESE	Total	Points	Total
MP22ME02	Major Project : Dissertation -II	PR	40	50	--	50	100	200	20	20
TH:TU:PR 0:0:40=40			40	50	--	50	100	**200**	20	**20**

Note 2: The Dissertation -II submission shall not be permitted till the learner completes all the requirements ME course.

Note 3: The contact hours for the calculation of load of the teacher for Major Project are as follows:
Major Project Dissertation I and II - 02 Hour / week / student

Note 4: Students are also allowed to combine internship with dissertation project.

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
PCC21ME01	Computer Aided Design	L	T	P	L	T	P	Total
		3	1	0	3	1	0	4
		Examination Scheme						
			ISE1	MSE	ISE2	ESE		Total
		Theory	20	30	20	100 (30% weightage)		100
		Tutorial	20	--	30	--		50

Pre-requisite Course Codes	Linear Algebra – Basics of Matrix Multiplication and Coordinate Geometry	
Course Outcomes	CO1	Integrate the role of graphic communication in the engineering design process.
	CO2	Use algorithmic foundation for solving problems by writing computer programs.
	CO3	Implement 2D and 3D transformations for positioning/shaping objects, or to change viewing positions, or even to change how something is viewed (e.g. perspective projections)
	CO4	Formulate the parametric representation of standard conic shapes, 2D and 3D freeform curves and surfaces in the most efficient manner— required for creating complex profiles and geometries.
	CO5	Describe various techniques of computer simulated reality i.e. virtual realism.

Theory:

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	Introduction to Computer Graphics: Definitions, Classification, Architecture of Interactive Computer Graphics, Applications	1,11	7
	1.2	Display &Interactive devices	1,11	
	1.3	Scan Conversion: Pixel plotting, Scan Conversion of Line, Circle, Ellipse, Parabola, Hyperbola.	1,11	
	1.4	Effects of Scan conversion	1,11	
2	2.1	Object Transformations: 2D & 3D (Translation, Rotation, Reflection, Scaling, Shearing)	1,11	8
	2.2	Homogeneous Coordinates, Decomposition of combined transformation matrix into basic transformation matrices (limited to three) taken in order	1,11	
3	3.1	2-D Viewing & Clipping, 3D Viewing & Clipping Projections: Parallel &Perspective Projections	1,11	6

4	**4.1**	Curves: Spline curve, Bezier curve, DeCasteljau Algorithm for generating Bezier curves (limited to cubic curves), B-Spline curve, NURBS curve	1,11	**6**
	4.2	Surfaces: Hermite, Bezier & B-Spline surfaces	1,11	
5	**5.1**	Virtual Reality: Hidden Lines &Hidden Surfaces: Z-Buffer, Painters, Area-Subdivision, Scan Line algorithm	1,11	**6**
	5.2	Light, Color &Shading Models, Animation	1,11	
6	**6.1**	CAD &Geometric Modeling: Features of Modeling & Assembly Packages, Types of Geometric Modeling, Data Structures, Product Data Exchange Formats.	1,11	**6**
	6.2	Fundamentals of CAE: General procedures of Numerical methods like FEM & FDM, Kinematic Analysis & Animation, Features and Application of FEM.	1,11	
Total				**39**

Course Assessment:

Theory:

ISE-1: Quiz / Case Study Presentation / Presentation on thrust areas (20 marks)

ISE-2: Mini Project (20 marks)

MSE: Two hours 30 Marks written examination based on 50% syllabus

ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Tutorial:

1. **ISE-1** Two Assignments based on 50% Syllabus

Continuous pre-defined rubrics-based evaluation for 20 marks.

2. **ISE-2** Three Assignments based on remaining 50% Syllabus

Continuous pre-defined rubrics-based evaluation for 30 marks.

Recommended Books:

1. Computer Graphics –F.S Hill. Jr
2. Computer Graphics—Zhigang Xiang & Roy Plastock (Schaum's Outlines)
3. Computer Graphics—Hearn & Baker
4. Mathematical Elements for Computer Graphics—David F. Rogers, James Alan Adams
5. Procedural Elements for Computer Graphics—David F. Rogers, James Alan Adams
6. Mastering CAD/CAM—Ibrahim Zeid 7. Geometric Modelling—Mortenson, M.E.
8. Computer Graphics—Amarendra Sinha, ArunUdai
9. Fundamentals of Computer Graphics—Peter Shirley

10. CAD/CAM - Theory and Practice—Ibrahim Zeid, R Sivasubramanian
11. CAD/CAM—Mikell Groover, Emory Zimmers Jr.
12. CAD CAM - Principles, Practice, and Manufacturing Management—Chris McMahon, Jimmie Browne
13. Curves and Surfaces in Computer Aided Geometric Design—Fujio Yamaguchi
14. Computer Graphics – Principles & Practice—Foley, van Dam, Feiner, Hughes
15. Computer Aided Engineering Design—Anupam Saxena, Birendra Sahay

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
PCC21ME02	Mechatronics and Automation	L	T	P	L	T	P	Total
		3	1	0	3	1	0	4
		Examination Scheme						
			ISE1	MSE	ISE2	ESE		Total
		Theory	20	30	20	100 (30% weightage)		100
		Tutorial	20	--	30	--		50

Pre-requisite Course Codes		
Course Outcomes	CO1	Demonstrate the use of Low-cost automation
	CO2	Design of pneumatic and hydraulic system
	CO3	Understand mechatronics components for a given application
	CO4	Demonstrate team-oriented Skills within the field of mechatronics

Theory:

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	Definition; Automation in production systems; Automation principles and strategies; Levels of automation; Types of automation; Benefits and Impact of Automation on Manufacturing and Process Industries.	1	7
	1.2	Traditional and Mechatronics design, Mechatronics Key elements, Basic Components of Mechatronics Systems, Integrated design issues in Mechatronics, Mechatronics Design process, Mechatronics System in Factory, Home and Business Applications, Objectives, Advantages and Disadvantages of Mechatronics.	1	
2	2.1	**Overview of Sensors and Transducers** - Sensors for motion and position, Force Torque and Tactile Sensors, Range Sensors, Proximity Sensors, Ultrasonic Sensors. Interfacing of sensors with micro-computer system. Micro and Nano Sensors in Mechatronics.	1	7
3	3.1	**Pneumatic Circuit Design** : Types of Actuators , Direction Control Valves, , flow and pressure control valves, Timer. Cascading and Shift Register Circuit Upto 3 Cylinders.	1	8
	3.2	Design of Electro-Pneumatic Circuits using single solenoid and double solenoid valves; with and without grouping; Design of Pneumatic circuits using PLC Control (ladder programming only) up to 2 cylinders, with applications of Timers and Counters and concept of Flag and latching.		
4	4.1	**Overview of Micro-processors and Micro-controllers** - 8051 Micro-controllers, Functional Block diagram and Architecture, Instruction set and Assembly Language Programming.	4	7

5	**5.1**	**Interfacing hardware with real world** - Analog Interface and Data acquisition, Digital I/O interfacing, special function interfacing, signal conditioning, special utility support hardware Interfacing of: HEX-keyboards, LCD display, ADC, DAC and stepper motor with 8051 Micro controller.	4	**6**
6	**6.1**	**Case Studies of Mechatronics Systems** - Timed Switch, Pick and Place Robot, Car Park Barrier, Automatic Camera, Car Engine Management, Bar Code System, CNC Machine, ABS, Artificial Intelligence in Mechatronics, Fuzzy Logic applications in Mechatronics.	6	**4**
Total				**39**

Course Assessment:

Theory:

ISE-1: Quiz / Case Study Presentation / Presentation on thrust areas (20 marks)

ISE-2: Mini Project (20 marks)

MSE: Two hours 30 Marks written examination based on 50% syllabus

ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Tutorial:

3. **ISE-1** Two Assignments based on 50% Syllabus

Continuous pre-defined rubrics-based evaluation for 20 marks.

4. **ISE-2** Three Assignments based on remaining 50% Syllabus

Continuous pre-defined rubrics-based evaluation for 30 marks.

Recommended Books:

1. Joji P, Pneumatic Controls, Wiley India PVT. Ltd, 2008
2. Peter Croser, Frank Ebel, Pneumatics Basic Level, Festo Didactic GMbH & Co. Germany.
3. Prede G, Scholz D, Electro-pneumatics Basic level, Festo Didacic Gmbh & Co. Germany
4. The 8051 microcontroller Architecture, Programming and Applications Kenneth J T Ayala, Pemam International Publishing, (India).
5. The 8051 microcontroller and embedded systems using assembly and C by M.A. Mazidi, J. Mazidi and R. D. McKinlay. PHI, second edition
6. Mechatronics. HMT

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
PEC21ME011	Artificial Intelligence and Expert Systems	L	T	P	L	T	P	Total
		2	1	0	2	1	0	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100 (30% weightage)	100	
		Tutorial	20	--	30	--	50	

Pre-requisite Course Codes		
Course Outcomes	CO1	Understand knowledge base, search methods, heuristic and state space methods etc.
	CO2	Understand/Simulate/imitate an intelligent human being, in terms of conversation.
	CO3	Understand artificial intelligence, problem solving, intelligent agents, expert systems, search techniques.
	CO4	Develop a piece of software which is able to process natural language, knowledgerepresentation.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**AI and Internal Representation:** Introduction, definitions-Turing approach, Cognitive modeling approach, Laws of thought approach, The rational agent approach, Foundations of AI (history).	1	4
	1.2	**Intelligent Agents:** Concept of Rational Agent, Structure of Intelligentagents, agent program, Examples. Simple reflex agent, Goal based agent, Utility based agent, Agent Environments**,** environment programs, Examples.	1	
	1.3	**Problem Solving :** Solving problems by searching, Problem Formulation, Search Strategies, Uninformed Search Techniques, DFS, BFS, Uniform cost search, Iterative Deepening, Comparing different Techniques, Informed search methods – Best First Search, heuristic functions, Hill-Climbing, A*.IDA*. Crypt Arithmetic.	1	
2	2.1	**Game playing**: Perfect decisions in two person games, Imperfect decisions, Alpha-beta pruning, Games with element of chance.	1	4
	2.2	**Knowledge based agent,** WUMPUS simple environmental class game, knowledge representations, reasoning and logic, prepositional logic, Agentfor WUMPUS, translating knowledge into action, problems with prepositional agent. First order logics, (syntax and semantics), logical agent for WUMPUS, simple reflex agent, Representing change in the world, situation calculus, frame problems and relatives. Basic representations for planning, situation state and plan, representation for plans, practical planning.1	1	

3	**3.1**	**Expert Systems:** Characteristics, capabilities, components, limitations, applications with respect to manufacturing and mechanical engineering (case studies). Expert system technologies and its benefits.	1	**4**
	3.2	**Programming in LISP or PROLOG:** Lisps, Typing at Lisp, Defining Programs, Basic Flow of Control in Lisp, Lisp Style, Atoms and Lists, Basic Debugging, Building Up List Structure, More on Predicates, Properties, Pointers, Cell Notation and the Internals (Almost) of Lisp, Destructive Modification of Lists, The for Function, Recursion, Scope of Variables Input/output, Macros. Data warehousing & Data Mining. Online Analytic Processing [OLAP]: its architecture and its use. Java implementations.	1	
4	**4.1**	**Fundamentals Concepts and Models of Artificial Neural Systems:** Biological Neuron and their Artificial Models, Models of ANN, Learningand Adaptation, Neural Networking Learning Rules. Single-layer Perception Classifiers.	1	**4**
	4.2	**Multilayer Feed forward Networks :** Linearly Non-separable Pattern Classification, Delta Learning Rule, Feed forward Recall and Error Back-Propagation Training, Learning Factor	1	
5	**5.1**	**Uncertainty:** uncertainty, representation of knowledge in uncertain domain, semantics of belief network, Representing ignorance-Dempster-shafer theory.	1	**5**
	5.2	**Representing vagueness:** Fuzzy sets and fuzzy logics, Fuzzy Relations, Fuzzy Function, Fuzzy Measures, Probabilities & possibilities. Fuzzy Modeling and applications of Fuzzy Control, Neural and fuzzy machine Intelligence. Representing decision problems, Using decision networks, making simple decision and complex decision.	1	
6	**6.1**	**Genetic Algorithm:** Simple genetic algorithm, Simulation by hands, similarity templates (Schemata), Mathematical foundations, Schema Processing at work. The two- armed and k- armed Bandit Problem, The building block hypothesis, The minimal Deceptive Problem. Computer implementation of Genetic algorithm, Data Structures, Reproduction, Cross over and Mutation. Time to reproduce and time to Cross Mapping, Objective function to fitness, form, Fitness scaling. Applications of genetic algorithm, De-Jong and Function Optimization, Improvement in basic techniques. Introduction to Genetics based machine Learning its applications.	3	**5**
Total				**26**

Course Assessment:

Theory:

ISE-1: Quiz / Case Study Presentation / Presentation on thrust areas (20 marks)

ISE-2: Mini Project (20 marks)

MSE: Two hours 30 Marks written examination based on 50% syllabus

ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Tutorial:

1. **ISE-1** Two Assignments based on 50% Syllabus

   Continuous pre-defined rubrics-based evaluation for 20 marks.

2. **ISE-2** Three Assignments based on remaining 50% Syllabus

   Continuous pre-defined rubrics-based evaluation for 30 marks.

Recommended Books:

1. Artificial Intelligence, A modern approach By Staurt J Russel and Peter Norvig, by Prentice Hall Inc, 1995. New Jersey.
2. Introduction to Artificial intelligence By Eugene Charniak, Drew McDermott AddisonWesleyArtificial Neural Networks- B. Yegnanarayana, PHI, 1999.
3. Genetic Algorithms in search, Optimization & Machine Learning by David E Goldberg-Addison Wesley
4. Data Mining by Pieter Adriaans and Dolt Zantinge - Pearson Education Asia
5. Data Warehousing in the Real World by Sam Anahory and Dennis Murray.

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
PEC21ME012	Smart Materials	L	T	P	L	T	P	Total
		2	1	0	2	1	0	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100 (30% weightage)	100	
		Tutorial	20	--	30	--	50	

Pre-requisite Course Codes		
Course Outcomes	CO1	Understand working of smart materials and their application as actuator and sensor.
	CO2	Select an appropriate smart material for a given application.
	CO3	Identify applicability of smart materials for new prospective smart structures

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Introduction to Smart Materials:** Overview of the different types of Smart Materials, Smart materials used in structures, smart material for sensors, actuators controls, memory and energy storage and their inter-relationships.	1	4
2	2.1	**Important Concepts of Smart Materials:** Artificial skins, Artificial muscles, Biomimetic materials, materials with tunable responses, non-linear properties, self-healing materials, adaptive structures, self-replicating materials/structures, self-assembly, inch worm devices, hysteresis, integrated sensing and actuation.	1	5
3	3.1	**Overview of the following materials** with focus on synthesis, constitutive / governing relationships, strengths and weaknesses, and applications. 1. Piezoelectric Materials 2. Magnetostrictive Materials 3. Shape Memory Alloys 4. Electroactive Polymers	1	5
4	4.1	Overview of the following materials with focus on synthesis, strengths and weaknesses, and applications. 1.Ferrofluids and Magneto rheological Fluids and applications in dampers 2.Soft Matter and its applications as smart skins, smart textiles etc 3.Carbon Nanotubes and Carbon nano-structures and its applications 4.Thermoelectric Materials and Peltier devices	1	4

5	**5.1**	**Smart Materials for Energy Applications:** Materials used for energy storage, Hydrogen Storage Materials, Energy harvesting, Energy scavenging from vibrations.	1,8	**4**
6	**6.1**	**Composite Materials:** Introduction to Composite Materials, Nano Composite Materials, Soft conducting and magnetic solids, active fiber composites, Self-heating cement/ polymer matrix composites.	1,20	**4**
Total				26

Course Assessment:

Theory:

ISE-1: Quiz / Case Study Presentation / Presentation on thrust areas (20 marks)

ISE-2: Mini Project (20 marks)

MSE: Two hours 30 Marks written examination based on 50% syllabus

ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Tutorial:

1. **ISE-1** Two Assignments based on 50% Syllabus

Continuous pre-defined rubrics-based evaluation for 20 marks.

2. **ISE-2** Three Assignments based on remaining 50% Syllabus

Continuous pre-defined rubrics-based evaluation for 30 marks.

Recommended Books:

1. M.V. Gandhi and B.S. Thompson, "Smart Materials and Structures", Chapman & Hall, London; New York, 1992 (ISBN: 0412370107)
2. Mel Scwartz, "Encyclopedia of Smart Materials Vol. I and II", John Wiley & Sons
3. SenolUtku, "Theory of Adaptive Structures : Incorporating Intelligence into Engineered Products", CRC Press
4. A.V. Srinivasan, "Smart Structures: Analysis and Design", Cambridge University Press,Cambridge; New York, 2001 (ISBN: 0521650267)
5. G. Gautschi, "Piezoelectric Sensorics: Force, Strain, Pressure, Acceleration and Acoustic Emission Sensors, Materials and Amplifiers", Springer, Berlin; New York, 2002 (ISBN:3540422595)
6. K. Uchino, "Piezoelectric Actuators and Ultrasonic Motors", Kluwer Academic Publishers, Boston, 1997 (ISBN: 0792398114)
7. G. Engdahl, "Handbook of Giant Magnetostrictive Materials", Academic Press, San Diego, Calif.; London, 2000 (ISBN: 012 238640X)

8. K. Otsuka and C.M. Wayman, "Shape Memory Materials", Cambridge University Press, Cambridge; New York, 1998 (ISBN: 052144487X)
9. Eric Udd, "Fiber Optic Sensors: An Introduction for Engineers and Scientists", John Wiley & Sons, New York, 1991 (ISBN: 0471830070)
10. André Preumont, "Vibration Control of Active Structures: An Introduction", 2nd Edition, Kluwer Academic Publishers, Dordrecht; Boston, 2002 (ISBN: 1402004966)
11. HojjatAdeli, "Control, Optimization, and Smart Structures: High-Performance Bridges and Buildings of the Future", John Wiley, New York, 1999 (ISBN: 047135094X)
12. T.T. Soong, "Passive Energy Dissipation Systems in Structural Engineering", Wiley, Chichester; New York, 1997 (ISBN: 0471968218)
13. V.K. Wadhawan, *Smart Structures: Blurring the Distinction Between the Living and Nonliving,* Oxford University Press, Oxford (2007)
14. H.T. Banks, R.C. Smith and Y Wang, "*Smart Structures: Modeling, Estimation and Control"*, Wiley, New York (1996)
15. *Shape Memory Alloys,* (ed) D.C. Lagoudas, Springer Science (2008)
16. S.K. Ghosh , "*Self-healing Materials: Fundamentals, Design Strategies and Applications,* Wiley-VCH Verlag GmbH and Co. (2009)
17. Kwang J Kim and Satoshi Tadokore, *"Electroactive Polymers for Robotic Applications: Artificial Muscles and Sensors*", Springer-Verlag, London (2007)
18. S Priya and D J Inman, "*Energy Harvesting Technologies"*, Springer-Verlag (2008)
19. Moriaki Wakaki, "*Optical Materials and Applications*", CRC Press (2012)
20. S.S. Ray and M Bousmina, "*Polymer Nanocomposites and their Applications"*, American Scientific Publishers (2008)

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
PEC21ME013	Simulation and Modelling	L	T	P	L	T	P	Total
		2	1	0	2	1	0	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE		Total
		Theory	20	30	20	100 (30% weightage)		100
		Tutorial	20	--	30	--		50

Pre-requisite Course Codes		
Course Outcomes	CO1	Understand the system concept and apply functional modeling method to model the activities of a static system;
	CO2	Simulate the operation of a system and make improvement according to the simulation results.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Principle of computer modelling and simulation:** Monte Carlo simulation. Nature of computer- modeling and simulation. Limitations of simulation, areas of applications. Components of a system - discrete and continuous systems, Models of a system -a variety of modeling Approaches.	1-2	4
2	2.1	**Discrete Event Formalisms** Concepts of discrete event simulation, model components, a discrete event system simulation, simulation world views or formalisms. Characteristics of queueing systems, queueing notations, long run measures of performance of queueing systems, Steady state behaviour of Markovian models (M/G/1, M/M/1, M/M/c) overview of finite capacity and finite calling population models, Network of Queues simulation of single channel queue, multi channel queue, inventory system and dump truck problem using event scheduling approach.	1-2	5
3	3.1	**Statistical Models in Simulation** Overview of probability and statistics, useful statistical model, discrete distribution, continuous distribution, empirical distribution and Poisson process. Discrete uniform -distribution Poisson distribution -geometric distribution -acceptance -rejection technique for Poisson distribution gamma distribution.	1-2	5
4	4.1	**RANDOM NUMBER GENERATION:** Techniques for generating random numbers- Mid square method -the mod product method -Constant multiplier technique -Additive congruential method -Linear congruential method -Tests for random numbers -The Kolmogorov-Smimov test -the Chi-square test.	1-2	4
	4.2	**RANDOM VARIABLE GENERATION:** Inversion transforms technique-exponential distribution. uniform distribution, Weibull	1-2	

		distribution, continuous distribution, generating approximate normal variates-Erlang distribution.		
5	**5.1**	**Input Modeling** Introduction, steps to build a useful model of input data, data collection, identifying the distribution with data, parameter estimation, suggested estimators, goodness of fit tests, selection input model without data, covariance and correlation, multivariate and time series input models	1-2	**4**
6	**6.1**	**Verification and Validation of Simulation Model** Introduction, model building, verification of simulation models, calibration and validation of models:- validation process, face validity, validation of model, validating input-output transformation, t-test, power of test, input output validation using historical data and Turing test.	1-2	**4**
	6.2	**Output Analysis** Types of simulations with respect to output analysis, stochastic nature of output data, measure of performance and their estimation, output analysis of terminating simulators, output analysis for steady state simulation. variance reduction techniques -antithetic variables, variables-verification and validation of simulation models.	1-2	
Total				26

Course Assessment:

Theory:

ISE-1: Quiz / Case Study Presentation / Presentation on thrust areas (20 marks)

ISE-2: Mini Project (20 marks)

MSE: Two hours 30 Marks written examination based on 50% syllabus

ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Tutorial:

1. **ISE-1** Two Assignments based on 50% Syllabus

Continuous pre-defined rubrics-based evaluation for 20 marks.

2. **ISE-2** Three Assignments based on remaining 50% Syllabus

Continuous pre-defined rubrics-based evaluation for 30 marks.

Recommended Books:

1. Banks J., Carson J. S., Nelson B. L., and Nicol D. M., "Discrete Event System Simulation", 3rd edition, Pearson Education, 2001.
2. Gordon Geoffrey, "System Simulation", 2nd edition, PHI, 1978.
3. Law A. M., and Kelton, W. D., "Simulation Modeling and Analysis", 3rd edition, McGrawHill, 2000.
4. NarsingDeo, "System Simulation with Digital Computer", PHI.
5. Frank L. Severance, "System Modeling and Simulation"
6. Trivedi K. S., "Probability and Statistics with Reliability, Queueing, and Computer Science Applications", PHI, 1982.
7. Wadsworth G. P., and Bryan, J. G., "Introduction to Probability and Random Variables", McGraw-Hill, 1960.
8. Donald W. Body, "System Analysis and Modeling", Academic Press Harcourt India.
9. Bernard, "Theory Of Modeling and Simulation"
10. Levin & Ruben, "Statistics for Management"
11. Aczel and Sounderpandian, "Business Statistics"

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
PEC21ME021	Micro Electro Mechanical Systems	L	T	P	L	T	P	Total
		2	1	0	2	1	0	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100 (30% weightage)	100	
		Tutorial	20	--	30	--	50	

Pre-requisite Course Codes	Linear Algebra – Basics of Matrix Multiplication and Coordinate Geometry	
Course Outcomes	CO1	Understand the underlying fundamental principles of MEMS devices including physical operation, mathematical modeling.
	CO2	Select the appropriate material and processes while fabrication of MEMS devices.
	CO3	Design and simulate MEMS devices and system using standard simulation tools.
	CO4	Develop different concepts of micro system sensors and actuators for real-world applications.

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Introduction to MEMS**	1,2,6	4
	1.1	Introduction to MEMS & its characteristics, Real world Sensor/Actuator examples (DMD, Air-bag, pressure sensors). MEMS Sensors in Internet of Things (IoT), BioMedical Applications	1,2,6	
2		**MEMS Materials and their Properties**	1,2,6	4
	2.1	Materials (eg. Si, SiO2, SiN, Cr, Au, Ti, SU8, PMMA, Pt); Important properties: Young modulus, Poisson's ratio, density, piezoresistive coefficients, TCR, Thermal Conductivity, Material Structure. Understanding Selection of materials based on applications	1,2,6	
3		**Fabrication Processes common to MEMS**	1,2,6	4
	3.1	Understanding MEMS Processes & Process parameters for: Cleaning, Growth & Deposition, Ion Implantation & Diffusion, Annealing, Lithography. Understanding selection of Fab processes based on Applications	1,2,6	
4		**MEMS Specific Fabrication Processes**	1,2,6	5
	4.1	Understanding MEMS Processes & Process parameters for: Wet & Dry etching, Bulk & Surface Micromachining, Die, Wire & Wafer Bonding, Dicing, Packaging. Understanding selection of Fab processes based on Applications	1,2,6	

5		**MEMS Devices: Architecture and working**	1,2,6	**5**
	5.1	basic quantitative behaviour of Cantilevers, Micro-heaters, Accelerometers, Pressure Sensors, Micro-mirrors in DMD, Inkjet printer-head. Understanding steps involved in Fabricating above devices. Piezoresistance, TCR, Stiffness, Adhesion, Vibration, Resonant frequency, & importance of these measurements in studying device behavior, MEMS Reliability	1,2,6	
6		**Applications of MEMS devices**	1,2,6	**4**
	6.1	Industrial applications with detailed understanding of role of MEMS as sensors and actuators with proper case studies.	1,2,6	
Total				**26**

Course Assessment:

Theory:

ISE-1: Quiz / Case Study Presentation / Presentation on thrust areas (20 marks)

ISE-2: Mini Project (20 marks)

MSE: Two hours 30 Marks written examination based on 50% syllabus

ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Tutorial:

1. **ISE-1** Two Assignments based on 50% Syllabus

Continuous pre-defined rubrics-based evaluation for 20 marks.

2. **ISE-2** Three Assignments based on remaining 50% Syllabus

Continuous pre-defined rubrics-based evaluation for 30 marks.

Recommended Books:

1. An Introduction to Microelectromechanical Systems Engineering; 2nd Ed - by N.Maluf, K Williams; Publisher: Artech House Inc
2. Practical MEMS - by Ville Kaajakari; Publisher: Small Gear Publishing
3. Microsystem Design - by S. Senturia; Publisher: Springer
4. Analysis and Design Principles of MEMS Devices - MinhangBao; Publisher:Elsevier Science
5. Fundamentals of Microfabrication - by M. Madou; Publisher: CRC Press; 2 edition
6. Micro Electro Mechanical System Design - by J. Allen; Publisher: CRC Press Micromachined Transducers Sourcebook - by G. Kovacs; Publisher: McGraw-Hill

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
PEC21ME022	Optimization	L	T	P	L	T	P	Total
		2	1	0	2	1	0	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100 (30% weightage)	100	
		Tutorial	20	--	30	--	50	

Pre-requisite Course Codes		
Course Outcomes	CO1	Formulate the problem as LPP and analyse the sensitivity of a decision variable.
	CO2	Apply various linear and non linear techniques for problem solving in various domain.
	CO3	Apply decision making methods for problem in manufacturing environment and other domain.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Basic Concepts:** Statement of the Optimization Problem, Basic Definitions, Optimality Criteria for Unconstrained Optimization Optimality Criteria for Constrained Optimization, Engineering Application of Optimization, Overview of optimization technique, Interdisciplinary nature, Introduction to related software.	1,3	4
2	2.1	**Linear Programming Problem:** Formulation, Simplex method, Big M Method, Two Phase, Primal to Dual, Dual Simplex method, Sensitivity Analysis.	1,3	5
3	3.1	**Integer L.P. Model:** Gomory's cutting plane method, Branch & Bound Technique.	1,3	4
	3.2	**Non L.P. Model:** Lagrangian method & Kuhn tucker Method.	1,3	
4	4.1	**Multi Criterion Decision-making (MCDM) Methods:** Introduction to multi criterion optimization, Simple Additive Weighting (SAW) Method, Weighted Product Method (WPM), Analytic Network Process (ANP), Analytic Hierarchy Process (AHP) Method, TOPSIS Method, PROMETHEE	1,3	5
	4.2	**Multi Objective Decision making (MODM) Methods:** Introduction to Multi objective optimization, Traditional Techniques such as, quadratic programming, geometric programming, Numerical on goal programming and dynamic programming.	1,3	
5	5.1	**Newtonian Method:** Newton's method, Marquardt's method, Quasi Newton method.	1,3	4
	5.2	**Discrete Event Simulation:** Generation of Random Variable, Simulation Processes, Monte-Carlo Technique.	1,3	

6	**6.1**	**Robust Design Methods:** DOE and Taguchi techniques Response Surface Method : Response Surface, The Least-Squares Methods, Two-Level Factorial Design, Addition of Center Points, Central Composite Design(CCD), Sequential Nature of RSM.	1,3	**4**
Total				**26**

Course Assessment:

Theory:

ISE-1: Quiz / Case Study Presentation / Presentation on thrust areas (20 marks)

ISE-2: Mini Project (20 marks)

MSE: Two hours 30 Marks written examination based on 50% syllabus

ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Tutorial:

1. **ISE-1** Two Assignments based on 50% Syllabus

Continuous pre-defined rubrics-based evaluation for 20 marks.

2. **ISE-2** Three Assignments based on remaining 50% Syllabus

Continuous pre-defined rubrics-based evaluation for 30 marks.

Recommended Books:

1. Ranjan Ganguli, "Engineering Optimization - A Modern Approach" Universities Press
2. Pablo Pedregal, "Introduction to Optimization", Springer
3. S.S. Rao, "Engineering Optimization - Theory and Practice", John Wiley and Sons Inc.
4. L.C. Jhamb, "Quantitative Techniques Vol. 1 and 2", Everest Pub. House
5. Pierre D.A., "Optimization, Theory with Application", John Wiley & sons.
6. Decision Making in the Manufacturing Environment Using Graph Theory and Fuzzy Multiple Attribute Decision Making by R V Rao (Springer Publication).
7. Neural Computation and Self-Organizing Maps by Ritter, H., Martinetz, T., & Schulten, K., Addison-Wesley Publishing Company.

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
PEC21ME023	Advanced Manufacturing Technology	L	T	P	L	T	P	Total
		2	1	0	2	1	0	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100 (30% weightage)	100	
		Tutorial	20	--	30	--	50	

Pre-requisite Course Codes		
Course Outcomes	CO1	Understand and apply various advanced manufacturing techniques
	CO2	Analyze and optimize system requirements for advanced manufacturing systems
	CO3	Understand the relevance of cloud computing in manufacturing domain by integration of manufacturing elements and usage of web based elements

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Introduction to Advanced Manufacturing Technology** Need, examples with at least 2 case studies. Introduction to various processes of manufacturing and shaping of metals, ceramics, plastics, composites, polymers, and natural materials such as wood, rubber etc	1,5,8,10	4
2	2.1	**Advanced Manufacturing processes** – Introduction, Construction, Working principle, Types, Process parameters, problems, merits, demerits and applications of : Chemical Machining, Ultrasonic Machining, Electro-Chemical Machining, Electric Discharge Machining, Electron Beam Machining, Plasma Arc Machining, Laser beam Machining and Ion Beam Machining.	1,5,8,10	5
3	3.1	**Surface Treatments** – Scope, Cleaners, Methods of cleaning, surface coating types, Ceramic and organic methods of coating, economics of coating, Electro forming, CVD and PVD coating, Thermal spraying, Ion Implantations, Diffusion coating, Diamond coating and cladding.	1,5,8,10	4
4	4.1	**Advanced Manufacturing Systems**: Components of Manufacturing system, Single station manufacturing cell, Manual Assembly lines, line balancing Algorithm, Mixed model Assembly lines, Alternative Assembly systems, Automated production lines, Applications, Analysis of Transfer Lines. MRP-I & MRP-II Introduction to Rapid manufacturing and Tooling	1,5,8,10	5
5	5.1	**Integration of Manufacturing Elements** – Process Flow	1,5,8,10	4

		Design and Introduction toSimulated Factory project using case studies.		
	5.2	**E-Manufacturing** – Nano Manufacturing techniques and micro-machining, High speed machining and hot machining	1,5,8,10	
6	**6.1**	**Collaborative Manufacturing:** Definition and Concept, Aims of Collaborative Manufacturing, Business Process Change Considerations for Collaborative Manufacturing Enabling Technologies for Collaborative Manufacturing, Benefits and Limitations of Collaborative Manufacturing, Cloud Manufacturing Methods, Models and Tools for Enterprise Interoperability, Detail case studies on various aspects of Collaborative Manufacturing	1,5,8,10	**4**
Total				**26**

Course Assessment:

Theory:

ISE-1: Quiz / Case Study Presentation / Presentation on thrust areas (20 marks)
ISE-2: Mini Project (20 marks)
MSE: Two hours 30 Marks written examination based on 50% syllabus
ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Tutorial:

1. **ISE-1** Two Assignments based on 50% Syllabus

Continuous pre-defined rubrics-based evaluation for 20 marks.

2. **ISE-2** Three Assignments based on remaining 50% Syllabus

Continuous pre-defined rubrics-based evaluation for 30 marks.

Recommended Books:

1. Serope Kalpakjian and Stevan R. Schmid – Manufacturing Process Engg Materials – 2003.
2. Brehem T. Smith, Advanced Machining, I.F.S, UK, 1989
3. Nario Taniguchi, Nano Technology, Oxford University Press, 1996
4. HMT Manual, Non-Traditional Machining Methods
5. Automation, Production Systems and Computer Integrated Manufacturing– Mikell P. Groover, PHI – 3rd Edition, 2012
6. Material Science and Engineering – William Callister, John Wiley and Sons
7. Engg. Materials Technology, James A Jacob, Thomas F Kilduff – Pearson
8. Mechanical Metallurgy – George E. Dieter, McGraw Hill, 1998
9. Process and Materials of Manufacturing – R.A.Lindburg- PHI 1990
10. Advanced Machining Processes – V.K.Jain – Allied Publications
11. Introduction to Manufacturing Professes – John A Schey, McGraw Hill
12. Toyota Production System, TaichiOhno, Productivity Press, 1988, P.58
13. Womack, James P, Daniel T. Jones, Daniel Roos (1990), The Machine that changed the world.

14. MuammerKoc, Jun Ni, Jay Lee, PulakBandyopadhyay, Introduction to e-manufacturing,University of Michigan,2005, CRC Press. Pp.97.1 – 97.9

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
OE2111	Constitution of India and Professional Ethics	L	T	P	L	T	P	Total
		2	1	0	2	1	0	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE		Total
		Theory	20	30	20	100 (30% weightage)		100
		Tutorial	20	--	30	--		50

Pre-requisite Course Codes		
Course Outcomes	CO1	Adhere to the core rights and shape one's values.
	CO2	Display the role and responsibility of Engineering professionals
	CO3	Hold moral and Ethical solutions to problems through case studies.
	CO4	Apply the knowledge of human values to contemporary ethical and global issues.
	CO5	Compare the three-tier system of the local govt. under the Indian Constitution

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Background and Approach: Fundamental Rights and Duties**		
	1.1	Fundamental Rights and Duties, Right to Compensation for being Illegally Deprived of one's Right to Life or Liberty, Right to Travel Abroad and Return to one's Country	7	3
	1.2	Promotion of Inter-Religious harmony and inter-faith values, Composite Culture	8	1
	1.3	Local self- government in the Indian Constitution- Case Studies meaning-Three-tier-system-Village-panchayath-Taluka panchayath Zilla-panchayath -Local bodies -Municipalities and Corporations, Bruhath mahanagara Palike. Functions of Election commission, UPSC, MPSC. [Self-Study]	7	5
2		**Professional Ethics and Human Values**		
	2.1	Sense of Engineering Ethics - Variety of moral issues- Types of inquiry- Moral dilemmas –Moral Autonomy Moral dilemmas, Moral Autonomy, Kohlberg's theory Gilligan's theory, Consensus and Controversy, Profession& Professionalism, Models of professional roles, Theories about right action Codes of Ethics, Plagiarism	1,2, 3,4, 5	5
	2.2	Human Values. Morals, values, and Ethics – Integrity- Academic integrity- Work Ethics- Service Learning- Civic Virtue Respect for	4,5	4

		others- Living peacefully- Caring and Sharing- Honestly- Cooperation Commitment Empathy-Self Confidence -Social Expectations.		
	2.3	Managing conflict- Respect for authority- Collective bargaining- Confidentiality, Role of confidentiality in moral integrity-Conflicts of interest	2,5	3
3		**Global Ethical Concerns**		
	3.1	Multinational Corporations- Environmental Ethics- Business Ethics- Computer Ethics	2	3
	3.2	Engineers as Expert witnesses and advisors-Moral leadership- case studies		2
			Total	**26**

Course Assessment:

Theory:

ISE-1: Activity: Quiz and assignments **20 Marks**
ISE-2: Article Discussion, Quiz and Assignments **20 Marks**
MSE: Two hours 30 Marks written examination based on 50% syllabus
ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Tutorial

ISE-1: AICTE & UNESCO's certificate course on Self-directed Emotional Learning for Empathy and Kindness (SEEK) **20 marks**
Link : https://www.framerspace.com/course/seek (Select SEEK self- directed cohort under the category of youth courses)

ISE-2: AICTE & UNESCO'S certificate course on Social Emotional Learning for Youth Waging Peace (SEL4YWP)- UNESCO **20 Marks**
Link: https://www.framerspace.com/course/ywp?cid=5eaff2c239109c2c12ef8bd3

**Participants need to register themselves in the link https://docs.google.com/spreadsheets/d/1dECtZbAmcPhKKelSEimVv-hzPV7dA_g-Brty2rxC2vE/edit?usp=sharing, before accessing the course content.

Case Study: Module 1.3 **10 Marks**

Recommended Books:

[1] Mike W Martin and Roland Schinzinger, Ethics in Engineering,4th edition, Tata McGraw Hill Publishing Company Pvt Ltd, New Delhi,2014

[2] Charles D Fleddermann, Engineering Ethics, Pearson Education/ Prentice Hall of India, New Jersey,2004.

[3] Charles E Harris, Michael S Protchard and Michael J Rabins, Engineering Ethics-Concepts and cases, Wadsworth Thompson Learning, United States,2005.

[4] M Govindarajan, S Natarajan and V S Senthil Kumar, Engineering Ethics, PHI Learning Private Ltd, New Delhi,2012.

[5] R S Naagarazan, A textbook on professional ethics and human values, New Age International (P) limited,New Delhi,2006.

[6] http://www.slideword.org/slidestag.aspx/human-values-and-Professional-ethics.

[7] Subhash C. Kashyap, Indian Constitution, National Book Trust, New Delhi.

[8] Baden Powell, BH, The Indian Village Community.

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
OE2112	Digital Business Management	L	T	P	L	T	P	Total
		2	1	0	2	1	0	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100 (30% weightage)	100	
		Tutorial	20	--	30	--	50	

Pre-requisite Course Codes		
Course Outcomes	CO1	Identify drivers of digital business
	CO2	Illustrate various approaches and techniques for E-business and management
	CO3	Prepare E-business plan

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Introduction to Digital Business-** Introduction, Background and current status, E-market places, structures, mechanisms, economics and impacts Difference between physical economy and digital economy	1-4	5
	1.2	**Drivers of digital business**- Big Data & Analytics, Mobile, Cloud Computing, Social media, BYOD, and Internet of Things(digitally intelligent machines/services) Opportunities and Challenges in Digital Business	1-4	
2	2.1	**Overview of E-Commerce** **E-Commerce-** Meaning, Retailing in e-commerce-products and services, consumer behavior, market research and advertisement B2B-E-commerce-selling and buying in private e-markets, public B2B exchanges and support services, e-supply chains, Collaborative Commerce, Intra business EC and Corporate portals Other E-C models and applications, innovative EC System-From E-government and learning to C2C, mobile commerce and pervasive computing EC Strategy and Implementation-EC strategy and global EC, Economics and Justification of EC, Using Affiliate marketing to promote your e-commerce business, Launching a successful online business and EC project, Legal, Ethics and Societal impacts of EC	1-4	4
3	3.1	**Digital Business Support services**: ERP as e –business backbone, knowledge Tope Apps, Information and referral system	1-4	4
	3.2	**Application Development:** Building Digital business Applications and Infrastructure	1-4	

4	**4.1**	**Managing E-Business**-Managing Knowledge, Management skills for e-business, Managing Risks in e –business Security Threats to e-business -Security Overview, Electronic Commerce Threats, Encryption, Cryptography, Public Key and Private Key Cryptography, Digital Signatures, Digital Certificates, Security Protocols over Public Networks: HTTP, SSL, Firewall as Security Control, Public Key Infrastructure (PKI) for Security, Prominent Cryptographic Applications	1-4	4
5	**5.1**	**E-Business Strategy**-E-business Strategic formulation- Analysis of Company's Internal and external environment, Selection of strategy, E-business strategy into Action, challenges and E-Transition (Process of Digital Transformation)	1-4	4
6	**6.1**	**Materializing e-business: From Idea to Realization**-Business plan preparation **Case Studies and presentations**	1-4	5
				26

Course Assessment:

Theory:

ISE-1: Quiz / Case Study Presentation / Presentation on thrust areas (20 marks)

ISE-2: Mini Project (20 marks)

MSE: Two hours 30 Marks written examination based on 50% syllabus

ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Tutorial:

1. **ISE-1** Two Assignments based on 50% Syllabus

Continuous pre-defined rubrics-based evaluation for 20 marks.

2. **ISE-2** Three Assignments based on remaining 50% Syllabus

Continuous pre-defined rubrics-based evaluation for 30 marks.

Recommended Books:-

1. A textbook on E-commerce, Er Arunrajan Mishra, Dr W K Sarwade,Neha Publishers & Distributors, 2011

2. E-commerce from vision to fulfilment, Elias M. Awad, PHI-Restricted, 2002

3. Digital Business and E-Commerce Management, 6th Ed, Dave Chaffey, Pearson, August 2014

4. Introduction to E-business-Management and Strategy, Colin Combe, ELSVIER, 2006

5. Digital Business Concepts and Strategy, Eloise Coupey, 2nd Edition, Pearson

6. Trend and Challenges in Digital Business Innovation, VinocenzoMorabito, Springer

7. Digital Business Discourse Erika Darics, April 2015, Palgrave Macmillan

8. E-Governance-Challenges and Opportunities in : Proceedings in 2nd International Conference theory and practice of Electronic Governance

9. Perspectives the Digital Enterprise –A framework for Transformation, TCS consulting journal Vol.5

10. Measuring Digital Economy-A new perspective- DoI:10.1787/9789264221796-enOECD Publishing

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
OE2113	Design of Experiments	L	T	P	L	T	P	Total
		2	1	0	2	1	0	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100 (30% weightage)	100	
		Tutorial	20	--	30	--	50	

Pre-requisite Course Codes	Engineering Mathematics - III	
Course Outcomes	CO1	Plan data collection, to turn data into information and to make decisions that lead to appropriate action
	CO2	Apply the methods taught to real life situations
	CO3	Plan, analyze, and interpret the results of experiments

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Introduction** Strategy of Experimentation Typical Applications of Experimental Design Guidelines for Designing Experiments Response Surface Methodology	1-2	4
2	2.1	**Fitting Regression Models** Linear Regression Models Estimation of the Parameters in Linear Regression Models Hypothesis Testing in Multiple Regression Confidence Intervals in Multiple Regression Prediction of new response observation Regression model diagnostics Testing for lack of fit	1-2	5
3	3.1	**Two-Level Factorial Designs** The 2^2 Design The 2^3 Design The General 2^k Design A Single Replicate of the 2^k Design The Addition of Center Points to the 2^k Design, Blocking in the 2^k Factorial Design Split-Plot Designs	1-2	5
4	4.1	**Two-Level Fractional Factorial Designs** The One-Half Fraction of the 2^k Design The One-Quarter Fraction of the 2^k Design The General 2^{k-p} Fractional Factorial Design Resolution III Designs	1-2	4

		Resolution IV and V Designs Fractional Factorial Split-Plot Designs		
5	**5.1**	**Response Surface Methods and Designs** Introduction to Response Surface Methodology The Method of Steepest Ascent Analysis of a Second-Order Response Surface Experimental Designs for Fitting Response Surfaces	1-2	4
6	**6.1**	**Taguchi Approach** Crossed Array Designs and Signal-to-Noise Ratios Analysis Methods Robust design examples	1-2	4
				26

Course Assessment:

Theory:

ISE-1: Quiz / Case Study Presentation / Presentation on thrust areas (20 marks)

ISE-2: Mini Project (20 marks)

MSE: Two hours 30 Marks written examination based on 50% syllabus

ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Tutorial:

1. **ISE-1** Two Assignments based on 50% Syllabus
   Continuous pre-defined rubrics-based evaluation for 20 marks.
2. **ISE-2** Three Assignments based on remaining 50% Syllabus
   Continuous pre-defined rubrics-based evaluation for 30 marks.

Recommended Books:

1. Raymond H. Mayers, Douglas C. Montgomery, Christine M. Anderson-Cook, Response Surface Methodology: Process and Product Optimization using Designed Experiment, 3rd edition,John Wiley & Sons, New York, 2001
2. D.C. Montgomery, Design and Analysis of Experiments, 5th edition, John Wiley & Sons, New York, 2001
3. George E P Box, J Stuart Hunter, William G Hunter, Statics for Experimenters: Design, Innovation and Discovery, 2nd Ed. Wiley
4. W J Dimond, Practical Experiment Designs for Engineers and Scientists, John Wiley and Sons Inc. ISBN: 0-471-39054-2
5. Design and Analysis of Experiments (Springer text in Statistics), Springer by A.M. Dean, and D. T.Voss

Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P		L	T	P	Total
CCL21ME01	Program Lab-I CAD and Computer Aided Engineering	--	--	2		--	--	1	1
		Examination Scheme							
		ISE1		MSE	ISE2	ESE		Total	
		20		--	30	--		50	

Pre-requisite Course Codes		
Course Outcomes	CO1	Draft 3D-Modells of Assembly and Individual Components
	CO2	To apply principles of FEA and CFD using appropriate Software.

Module	Detailed Contents	Lab Sessions
01	3D - Modeling, Assembly & Drafting	5
02	Kinematic & Kinetic Analysis of Mechanisms	4
03	Finite Element Analysis (FEA) or Computational Fluid Dynamics (CFD) or Multibody dynamics (MBD)	4

Course Assessment:

1. **ISE-1** Continuous pre-defined rubrics-based evaluation for 20 marks.
2. **ISE-2** Continuous pre-defined rubrics-based evaluation for 30 marks.

Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P		L	T	P	Total
SBL21ME01	Skill Based Lab-I Simulation Based Optimization and Data Analytics	--	--	4		--	--	2	2

Examination Scheme				
ISE1	MSE	ISE2	ESE	Total
20	--	30	50	100

Pre-requisite Course Codes		
Course Outcomes	CO1	Simulate Manufacturing Process/Manufacturing Systems using suitable software
	CO2	To optimize various process parameters in Manufacturing Processes/Manufacturing System
	CO3	To apply data analytics tools to results obtained through simulation

The laboratory will focus on simulation of **any three** of following

Module	Detailed Contents	Lab Sessions
01	Simulation of Injection Moulding Process and analysis of simulation results using suitable optimization technique or data analytics tools	3
02	Simulation of Casting Process and analysis of simulation results using suitable optimization technique or data analytics tools	3
03	Simulation of Sheet Metal Forming Process and analysis of simulation results using suitable optimization technique or data analytics tools	3
04	Discrete Event Simulation applied in manufacturing system/logistic/Supply Chain or	3
05	Predictive Analytics of systems using Techniques like Monte Carlo Simulation/Markov Chains (Expected to apply these simulation tools to manufacturing related system)	3

Above list is indicative. Any other simulation tool/optimization tool/analytics tools applied to suitable problems can be considered

(Here learner is expected to acquire hands on experience on related simulation tool/optimization tool/Data analytics tool. Learner will document his /her report as case study. Minimum three case studies are required to be submitted by learner

Course Assessment:

1. **ISE-1** Continuous pre-defined rubrics-based evaluation for 20 marks.
2. **ISE-2** Continuous pre-defined rubrics-based evaluation for 30 marks.
3. **ESE** Practical/Oral examination is to be conducted by pair of examiners for 50 marks

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
PCC21ME03	Industrial Robotics	L	T	P	L	T	P	Total
		3	1	0	3	1	0	4
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100 (30% weightage)	100	
		Tutorial	20	--	30	--	50	

Pre-requisite Course Codes	Matrices, Kinematics and Dynamics	
Course Outcomes	CO1	To apply the robot systems and their applications in agile manufacturing.
	CO2	To Understand application of robotic peripherals, their selection and their utility.
	CO3	To have knowledge of basic robot kinematics.
	CO4	Be acquainted with various image processing techniques.
	C05	To know path control and different trajectory planning.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Introduction:** Evolution Automation & robotics, Laws of Robotics, Robotic System & Anatomy Classification, Future Prospects.	1-2	5
	1.2	**Robotic Application in Manufacturing:** Material transfer, Machine loading & unloading, Processing operations, Assembly & Inspectors.	1-2	
	1.3	**Social Issues and Economics of robotics** **Drives:** Control Loops, Basic Control System Concepts & Models, Control System Analysis, Robot Activation & Feedback Components, Position & Velocity Sensors, Actuators, Power Transmission Systems**.**	1-2	
2	2.1	**Robot & its Peripherals:** End Effecters - types, Mechanical & other grippers, Tool as end effecter	1-2	5
	2.2	**Sensors:** Sensors in Robotics, Tactile Sensors, Proximity & Range Sensors, Sensor Based Systems	1-2	
	2.3	**Robotic Cell Design & Control.**	1-2	
3	3.1	**Kinematic Modelling of Manipulator:** Mechanical Structure and Notations, Coordinate Frames, Denavit Hartenberg Notation, Arm Equation of Planer Robot, Four axis SCARA Robot, TCV, Inverse Kinematics of Planer Robot, Four Axis SCARA Robot. Inverse Kinematic	1-2	8
4	4.1	**Trajectory Planning & Robot Dynamics:**	1-2	8

		Manipulator Path Control- Linear, Quadratic and Cubic Interpolation, Work Space Analysis, Robot Dynamics – Lagrangian Dynamics of one and two link robot arm.		
5	**5.1**	**Machine Vision:** Introduction, Low level & High level vision, Sensing & Digitizing, Image processing & analysis, Segmentation, Edge detection, Object description & recognition, Interpretation, Noises in Image, Shape Recognition , Applications	1-2	8
6	**6.1**	**Programming For Robots:** Methods, Robot programme as a path in space, Motion interpolation, level & task level languages, Robot languages; Programming in suitable languages Characteristics of robot	1-2	5
	6.2	**Robot Intelligence & Task Planning:** Introduction, State space search, Problem reduction, Use of predictive logic, Means -Ends Analysis, Problem solving, Robot learning, Robot task planning.	1-2	
				39

Course Assessment:

Theory:

ISE-1: Quiz / Case Study Presentation / Presentation on thrust areas (20 marks)

ISE-2: Mini Project (20 marks)

MSE: Two hours 30 Marks written examination based on 50% syllabus

ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Tutorial:

1. **ISE-1** Two Assignments based on 50% Syllabus

Continuous pre-defined rubrics-based evaluation for 20 marks.

2. **ISE-2** Three Assignments based on remaining 50% Syllabus

Continuous pre-defined rubrics-based evaluation for 30 marks.

Recommended Books:

1. Robotics and Control by R. K. Mittal and I J Nagrath, Tata Mcgraw Hill
2. Industrial Robotics by Groover and Simmers
3. Handbook of Industrial Robotics, Shimon Y. Nof. Wiley Publications, ISBN: 978-0-471-17783-8
4. Robotics , Vision and Control by Peter Corke, Springer
5. Robotics: Control Sensing. Vis. K S Fu,Ralph Gonzalez,C S G Lee6. Energy Conservation Guidebook, Dale R. Patrick, S. Fardo, Ray E. Richardson, Fairmont Press

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
PCC21ME04	Computer Aided Machining (CAM)	L	T	P	L	T	P	Total
		3	1	0	3	1	0	4
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100 (30% weightage)	100	
		Tutorial	20	--	30	--	50	

Pre-requisite Course Codes	Basics machining operation.	
Course Outcomes	CO1	Write and run CNC program for Turning and Milling.
	CO2	Write program for CNC EDM and wire EDM
	CO3	Do simple hardware designs
	CO4	Do interfacing of drive systems with the machines

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Introduction to Computer Numerical Control**. History of various NC machines like TNC, NC, CNC, DNC, Elements of CAM, Various CNC applications in different industries, Computer control concepts, Data processing units, Binary execution	1,4	5
2	2.1	**CNC Hardware** Structure of CNC machine tools, Spindle design, Spindle and axis drives, Various actuation systems and feedback devices like encoder, tachogenerator, etc.	1,4	6
3	3.1	**CNC Control System and Machine Tools.** CNC motion controller, Linear, circular, helical interpolator, Positioning and contouring control loops, MCU, adaptive control system, CNC machining centre, turning, grinding, EDM, wire EDM, boring, turn mill and CNC gear cutting, Study of two control systems.	1,4	7
4	4.1	**CNC Tooling.** Latest CNC tool materials and manufacturing, Turning and milling tool geometry, Tool probing and presetting, Automatic Pallet Changer (APC) and Automatic Turret Changer (ATC), Study of various probes and special tools.	1,4	7
5	5.1	**CNC Programming.** Part programming fundamentals, Manual part programming methods, Various G & M codes, Absolute and incremental system, TNRC, Tool length and diameter compensation, Programming of turning, machining centre and EDM, Use of canned cycles, loop, jump, subroutines	1,4	8
6	6.1	R Parameter programming, Macros	1,4	6

Total	39

Course Assessment:

Theory:

ISE-1: Quiz / Case Study Presentation / Presentation on thrust areas (20 marks)

ISE-2: Mini Project (20 marks)

MSE: Two hours 30 Marks written examination based on 50% syllabus

ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Tutorial:

1. **ISE-1** Two Assignments based on 50% Syllabus
   Continuous pre-defined rubrics-based evaluation for 20 marks.
2. **ISE-2** Three Assignments based on remaining 50% Syllabus
   Continuous pre-defined rubrics-based evaluation for 30 marks.

Recommended Books:

1. P. Radhakrishnan& S. Subramanyan "CAD/CAM/CIM" Willey Eastern Limited New Delhi.
2. Hans B. Kief and J. Frederick Waters "CNC" Glencae Macmillan / McGraw Hill
3. Steve Krar and Arthar Gill "CNC Technology and Programming", McGraw Hill Pub. Company, New Delhi.
4. P.N. Rao, N. K. Tewariet el "CAM" Tata McGraw Hill Pub. New Delhi

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
PEC21ME031	Product Design	L	T	P	L	T	P	Total
		2	1	0	2	1	0	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100 (30% weightage)	100	
		Tutorial	20	--	30	--	50	

Pre-requisite Course Codes		
Course Outcomes	CO1	Design and develop products right from the conceptual level.
	CO2	Illustrate various modern approaches like concurrent engineering, product life cycle management, robust design, rapid prototyping / rapid tooling.
	CO3	Analyse products based on ergonomics and aesthetic aspects.
	CO4	Evaluate the economic aspects in product development.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Introduction:** Importance of product design, types of design, product definition, product specifications, product mix, Morphology of design, phases in product design and development, Market research, Benchmarking, Concept generation and evaluation methods, product architecture, Supplier involvement in product design, customer centric product design, Creativity and Idea generation techniques, importance of Quality Dimensions: Performance, Features, aesthetics, ergonomics, Reliability, Sustainability, Serviceability, Brand value, Value Vs cost	1-3	5
2	2.1	**Material selection:** Importance, classification material performance characteristic, selection criteria Ashby Material selection chart. New developments in materials: Special alloys, Composites and Ceramics.	1-3	4
	2.2	**Process selection:** Importance types of manufacturing process and their classification, Sources of information selection criteria Material and Process selection Methods, Expert systems. Computer Database Approach, performance indices decision matrix, AHP and fuzzy approach introduction to material and process selection software. Axiomatic design principles and case studies.	1-3	
3	3.1	**Design Principles:** Design for Manufacturing (DFM) and Design for Assembly (DFA), Designs for Maintainability, Designs for environment and other DFX principles.	1-3	4
	3.2	**Robust Design:** Taguchi Designs, Design of Experiments (DOE)	1-3	

	3.3	**Designing with plastics:** Mechanical behavior, special characteristics and considerations, Design concepts for plastic product features to be manufactured by various production process technologies	1-3	
4	**4.1**	**Product Ergonomics:** Anthropometry, Environmental conditions, thermal, noise, vibration, displays, illusions, Psycho and psychological aspects in design, Man-machine information exchange.	1-3	4
	4.2	**Product Aesthetics**: Visual awareness, Form elements in context of product design, Concepts of size, shape and texture, Introduction to colour and colour as an element in design, Colour classifications and dimensions of colour, Colour combinations and colour dynamics, Interaction / communication of colours, Psychological aspects of colours, generation of products forms with analogies from nature.	1-3	
5	**5.1**	**Value Engineering:** Product value and its importance, definition, Value analysis job plan, FAST, case studies.	1-3	5
	5.2	**Modern Applications:** Robust design, QFD, Design & process FMEA, Reverse Engineering, Concurrent engineering & Sequential engineering, Rapid Prototyping/Additive Manufacturing, Product life cycle Management techniques	1-3	
6	**6.1**	**Economics of Product Development:** Methods of cost Estimates, Cost Comparison, Depreciation, Taxes. Principals of Economy, Engineering Economy and Design Process, Economic Analysis, Inflation, Time Value of Money, Numerical on Net Present Value (NPV) method. Industrial Engineering Approach, parametric Approach, profitability of investment and Investment Decision Analysis, Legal and social issues, Patents and IP acts.	1-3	4
Total				**26**

Course Assessment:

Theory:

ISE-1: Quiz / Case Study Presentation / Presentation on thrust areas (20 marks)

ISE-2: Mini Project (20 marks)

MSE: Two hours 30 Marks written examination based on 50% syllabus

ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Tutorial:

1. **ISE-1** Two Assignments based on 50% Syllabus

Continuous pre-defined rubrics-based evaluation for 20 marks.

2. **ISE-2** Three Assignments based on remaining 50% Syllabus

Continuous pre-defined rubrics-based evaluation for 30 marks.

Recommended Books:

1. Product Design and Development by Ulirich Karl T. and Eppinger Steven D, McGraw Hill.

2. Product Design and Manufacturing by A.K.Chitale, R.C.Gupta, PHI.
3. Engineering Design by Dieter George E., McGraw Hill.
4. Design Fundamentals, R. G. Scott.
5. Handboook of Product Design for Manufacturing by Bralla, James G, McGraw Hill.
6. Product Design by Kevin Otto & Kristin

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
PEC21ME032	Advanced Finite Element Analysis	L	T	P	L	T	P	Total
		2	1	0	2	1	0	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100 (30% weightage)	100	
		Tutorial	20	--	30	--	50	

Pre-requisite Course Codes	Basic calculus, Differential Equations	
Course Outcomes	CO1	Generate the governing Finite element equations for systems governed by partial differential equations
	CO2	Solve problems related trusses, heat transfer, free vibrations and fluid flow problems
	CO3	Solve time dependent and / or non-linear problems
	CO4	Use commercial software package to perform structural analysis, heat transfer modeling, fluid flow modeling and interpret the results.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	Introduction to FEA, General FEM procedure, • Approximate solutions of differential equations: FDM method, W-R technique, collocation least square sub-domain and Galerkin method • Numerical integration, Gauss quadrature in 2-D and 3-D • Structure of FEA program, Pre and Post processor, commercially available standard packages, and desirable features of FEA packages. • Principal of minimum total potential, elements of variational calculus, minimization of functional, Rayleigh-Ritz method, Formulation of elemental matrix equation, and assembly concepts.	1-3,5	5
2	2.1	**One Dimensional FEM:** • Coordinate system: Global, local, natural coordinate system. • Shape functions: Polynomial shape functions, Derivation of shape functions, Natural co-ordinate and coordinate transformation, Linear quadratic and Shape functions using Lagrange polynomials • One dimensional field problems: structural analysis (step-bar, taper-bar). Structural analysis with temperature effect, Thermal analysis, heat transfer from composite bar, fins.	1-3,5	4

3	**3.1**	• Trusses, Thermal effects in truss members, Beams. • Two dimensional finite elements formulations, Three-noded triangular element, Four-noded rectangular element, Four-noded quadrilateral element, derivation of shape functions: natural coordinates, triangular elements, and quadrilateral elements • Six-noded triangular elements, Eight-noded quadrilateral elements, Nine-noded quadrilateral element; Strain displacement matrix for CST element	1-3,5	4
4	**4.1**	• Penalty Method, Lagrange methods, Multipoint Constraints • Concept of Master/Slave entities • Examples of Contact problems. • Iso-parametric concepts, basic theorem, Iso-parametric, super-parametric, sub- parametric elements, Concept of Jacobian	1-3,5	5
5	**5.1**	• Finite element formulation of Dynamics, application to free-vibration problems, Lump and consistent mass matrices, Eigen value problems. • Transient dynamic problems in heat transfer • Introduction to time-integration methods: Implicit and Explicit methods • Convergence, Impact of Mesh quality on convergence	1-3,5	4
6	**6.1**	• Three dimensional elements: Tetrahedron, Rectangular prism (brick), Arbitrary hexahedron; Three Dimensional polynomial shape functions, Natural co- ordinates in 3D, • Introduction to material models: Introduction to plasticity (Von-Mises ○ Plasticity, Hyper –elasticity. • Errors in FEA, sources of errors, method of elimination, Patch test.	1-3,5	4
Total				**26**

Course Assessment:

Theory:

ISE-1: Quiz / Case Study Presentation / Presentation on thrust areas (20 marks)

ISE-2: Mini Project (20 marks)

MSE: Two hours 30 Marks written examination based on 50% syllabus

ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Tutorial:

1. **ISE-1** Two Assignments based on 50% Syllabus

Continuous pre-defined rubrics-based evaluation for 20 marks.

2. **ISE-2** Three Assignments based on remaining 50% Syllabus

Continuous pre-defined rubrics-based evaluation for 30 marks.

Recommended Books:

1. O. C. Zienkiewicz, R. L. Taylor & J. Z. Zhu, "The Finite Element Method its Basis and Fundamentals", Butterworth-Heinemann, Elsevier
2. Reddy J. N., "Finite Element Method", McGraw-Hill
3. S. S. Rao, "The Finite Element Method in Engineering" , 4th Edition, Academic Press, Elsevier
4. U. S. Dixit, "Finite Element Methods for Engineers", Cengage Learning
5. P. Seshu, "Textbook of FE Analysis", Prentice Hall
6. Desai and Abel, "Introduction to Finite Elements Methods", CBS Publication
7. Tirupati R. Chandrupatla and Ashok D. Belegundu, "Introduction to Finite Elements in Engineering"
8. Erik Thompson, "Introduction to Finite Element Methods", Wiley India
9. H. Kardestuneer, "Finite Elements Hand Book"
10. R. D. Cook, "Concepts & Applications of Finite Element Analysis"
11. Bathe K.J., "Finite Element Procedures in Engineering Analysis", Prentice Hall of India
12. Huebener K.H., Dewhirst D.D., Smith D.E. and Byrom T.G., "The Finite Element Method for Engineers", John Wiley, New York
13. Logan, "Finite Element Methods" Cengage Learning
14. George Buchanan, "Finite Elements Analysis", McGraw Hill
15. C. S. Krishnamoorthy, "Finite Elements Analysis", Tata McGraw-Hill
16. Robert Cook, "Concept and Application of Finite Element Methods", Wiley India.

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
PEC21ME033	Control Engineering	L	T	P	L	T	P	Total
		2	1	0	2	1	0	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100 (30% weightage)	100	
		Tutorial	20	--	30	--	50	

Pre-requisite Course Codes	Laplace Transform	
Course Outcomes	CO1	Model system and find Transfer function.
	CO2	Check stability of a mechanical system.
	CO3	Understand response of second order system
	CO4	Understand controllability and observability of linear system

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	Introduction to control systems. Classification of control system, Effect of feedback. Mathematical modeling of control systems (mechanical, electrical systems), concept of transfer function. Block diagram algebra, and signal flow graphs.	1,2	4
2	2.1	Time response analysis: Time response of control system, standard test signal, Time Response Analysis of First and Second order system, Time Domain specifications. Step response of second order system. Steady-state errors, static error constants, steady state, analysis of different type of systems using step. Ramp and parabolic inputs. Response with P,PI,PD,PID Controller.	1,2	5
3	3.1	Classification of control systems according to 'TYPE' of systems, Stability analysis: Introduction to concepts of stability. The Routh and Hurwitz stability criteria. Relative stability analysis.	1,2	4
4	4.1	Root locus Techniques. Frequency Response Analysis, Frequency domain specifications Correlation between time and frequency response. Polar Plots. Bode Plots, Nyquist Plots	1,2	5
5	5.1	State space modeling: Concept of state, state variable, state model. State space representation using physical and phase variables, decomposition of transfer function, diagonalisation. State transition matrix. Transfer function from state model. Controllability and observably of linear system.	1,2	4
6	6.1	Compensation (Introduction only): Types of compensator, selection of compensator, Lead, Lag and Lag-Lead compensation. Control system Components : servomotor, stepper motors, Synchros, Potentiometer, amplifiers	1,2	4
Total				26

Course Assessment:

Theory:

ISE-1: Quiz / Case Study Presentation / Presentation on thrust areas (20 marks)
ISE-2: Mini Project (20 marks)
MSE: Two hours 30 Marks written examination based on 50% syllabus
ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Tutorial:

1. **ISE-1** Two Assignments based on 50% Syllabus

Continuous pre-defined rubrics-based evaluation for 20 marks.

2. **ISE-2** Three Assignments based on remaining 50% Syllabus

Continuous pre-defined rubrics-based evaluation for 30 marks.

Recommended Books:

1. Control System Engineering: by Nagrath LT. and Gopal .M., Wiley Eastern Lid.
2. Modem Control engineering: by K.Ogata, Prentice Hall.
3. Benjamin C. Kuo, Automatic Control Systems, Pearson education, seventh edition.
4. MadanGopal, Control Systems Principles and Design, Tata McGraw Hill, seventh edition, 1997
5. Nise, control system Engineering, John wiley& sons, 3rd edition

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
PEC21ME041	Rapid Manufacturing	L	T	P	L	T	P	Total
		2	1	0	2	1	0	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100 (30% weightage)	100	
		Tutorial	20	--	30	--	50	

Pre-requisite Course Codes	CAD modelling	
Course Outcomes	CO1	Demonstrate knowledge of different rapid manufacturing techniques.
	CO2	Gain experience in product design and development using rapid manufacturing technology.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Rapid Manufacturing** Historical Development Additive, Subtractive and Formative Manufacturing Applications: Design, Planning, Manufacturing and Tooling Applications: Automotive, Aerospace, Electronics, Jewelry, BioMedical Fundamentals of Rapid Prototyping and Manufacturing, Design Process Rapid Prototyping and Manufacturing Process Chain Classification of Additive Manufacturing Processes	1,2	6
2	2.1	**Rapid Manufacturing System and Methodology** Subsystems of RP machine Optical System Mechanical Scanning System Computer Interfacing hardware, DAQs Signal Flow, 3D Model to RP Prototype Introduction to 3D Modeling Softwares (Auto-CAD, PROE, CATIA, SOLIDWORKS, IDEAs etc.) File Formats: IGES, STEP, DXF, STL Slicing and Scan Path Generation Algorithms Data Conversion and Transmission Data Validity and Repair Preprocessing and Post-processing Properties of the prototype/part: Material properties, color, dimensional accuracy, stability, surface finish,	1,2	7

		machinability, environmental resistance, operational properties		
3	**3.1**	**Liquid Based Rapid Prototyping Systems** Materials Stereolithography Solid Ground Curing Solid Object UV (Ultra-Violet) Printer Micro-stereolithography	1,2	3
4	**4.1**	**Solid Based Rapid Prototyping Systems** Materials LOM (Laminated Object Manufacturing) System FDM (Fused Deposition Modeling) System Multi-Jet Modeling (MJM) System Model Maker and Pattern Master Shape Deposition Manufacturing Process	1,2	3
5	**5.1**	**Powder Based Rapid Prototyping Systems** Materials SLS (Selective Laser Sintering) (3DP) Three-Dimensional Printing (LENS) Laser Engineered Net Shaping (MJS) Multiphase Jet Solidification (EBM) Electron Beam Melting	1,2	3
6	**6.1**	**Advances in Rapid Manufacturing and Case Studies** Advances in Rapid Manufacturing: Resolution & Accuracy issues, Integrated Hardening Process, Reverse Engineering Process and Applications, Metal Additive Manufacturing, Two Photon Process for Micro/Nano Fabrication, Printing with Biocompatible Materials Case Study: Investment Casting with RP Case Study: Wind-Tunnel Testing with RP Models, Case Study: Manufacture of Human implants and prosthesis	1,2	4
				26

Course Assessment:

Theory:

ISE-1: Quiz / Case Study Presentation / Presentation on thrust areas (20 marks)

ISE-2: Mini Project (20 marks)

MSE: Two hours 30 Marks written examination based on 50% syllabus

ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Tutorial:

1. **ISE-1** Two Assignments based on 50% Syllabus

Continuous pre-defined rubrics-based evaluation for 20 marks.

2. **ISE-2** Three Assignments based on remaining 50% Syllabus

Continuous pre-defined rubrics-based evaluation for 30 marks.

Recommended Books:

1. Chua C.K., Leong K.F., and Lim C.S., "Rapid Prototyping Principles and Applications", World Publishing Co. Pte. Ltd.
2. Gibson, D.W. Rosen, and B. Stucker, "Additive Manufacturing Technologies Rapid Prototyping to Direct Digital Manufacturing", 2010, Springer Inc.
3. Ali Kamrani, Emad Abouel Nasr, "Rapid Prototyping Theory and Practice", 2006, Springer Inc.
4. Bopaya Bidanda, Paulo J. Bartolo, "Virtual Prototyping and Bio Manufacturing in Medical Applications", 2008, Springer Inc.
5. Rafiq Noorani, Rapid Prototyping: Principles and Applications, John Wiley & Sons, Inc., 2006, ISBN 0-471-73001-7
6. James O. Hamblen, and Michael D. Furman, "Rapid Prototyping of Digital Systems", Kluwer Academic Publishers.
7. Kenneth G. Cooper, "Rapid Prototyping Technology Selection and Application", 2001, Marcel Dekker Inc, New York.

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
PEC21ME042	Sustainable Manufacturing	L	T	P	L	T	P	Total
		2	1	0	2	1	0	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100 (30% weightage)	100	
		Tutorial	20	--	30	--	50	

Pre-requisite Course Codes		
Course Outcomes	CO1	Understand basic principles of sustainable developments for social, economical and technological growth of nation and to be aware of SDGs.
	CO2	To identify, evaluate, and improve the sustainability of manufacturing
	CO3	To research, innovate and design sustainable manufacturing, services for future needs.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Introduction:** A brief history of Manufacturing, Commerce and Sustainability. 3 pillars of Sustainability, What is Sustainable Development and its goals – SDGs, Relationship between workplace organization, inventory levels and sustainability, Green Expectations and Green Movement.	1,6	4
2	2.1	**Waste Management:** Types and categories of Industrial Wastes? Processing Techniques of Waste. Description of types of Manufacturing Wastes. Bio-Processing methods. Implication of 3R principles of Waste Management in Industry, Government Regulations and Subsidies provided for Waste Management (Case studies)	1,6	4
3	3.1	**Potential health and environmental effects** of International trade and manufacturing operations, Principles of pollution prevention, industrial ecology, environmental and life-cycle assessments , Recommendations for risk management in manufacturing.	1,6	4
4	4.1	**Environment friendly materials** : Materials for sustainability, alternative manufacturing practices , materials and selection of manufacturing processes , control on use of renewable materials , Bio-degradable materials, recycling of materials. Introduction to Environmental and economic effects of a good new product development process	1,6	5

5	**5.1**	**Energy Management:** renewable energy, Innovations in generation, conservation, recycling and usage of energy. Energy audit and implications.	1,6	5
	5.2	**Sustainability Awareness:** sustainability rating schemes, eco-labelling programmes, human values and professional ethics in sustainable manufacturing. Encouraging innovations in sustainable manufacturing (Case studies)	1,6	
6	**6.1**	**Continuous Improvement and Sustainability** : Importance and some recommendations on how to implement a continuous improvement project , Recommendations to enhance employee involvement in any continuous improvement project, Some recommended practices when implementing a continuous improvement project , Relationship between continuous improvement and sustainability	1,6	4
Total				**26**

Course Assessment:

Theory:

ISE-1: Quiz / Case Study Presentation / Presentation on thrust areas (20 marks)

ISE-2: Mini Project (20 marks)

MSE: Two hours 30 Marks written examination based on 50% syllabus

ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Tutorial:

1. **ISE-1** Two Assignments based on 50% Syllabus

Continuous pre-defined rubrics-based evaluation for 20 marks.

2. **ISE-2** Three Assignments based on remaining 50% Syllabus

Continuous pre-defined rubrics-based evaluation for 30 marks.

Recommended Books:

1. Strategic Management of Sustainable manufacturing operations (Advances in logistics operations & Management) By. Rameshwar Dubey & Angappa Gunabekaran by Imuste Productivity press.
2. Analysis for Smart energy management: Tools and applications for sustainable manufacturing. By Seog-chanoh and Alfred. J. Hildreth , Springer Series.
3. Advances in sustainable Manufacturing By Gunther Seliger and Marwan M.K. khraishah, Springer Series
4. Green Management by M.Karpagam, Geetha Jaikumar, Ane Books Pvt.Ltd.
5. Design for Environment: A guide to sustainable Product Development.
6. Sustainable Development By M.K. Ghosh Roy Ane Books Pvt.Ltd
7. Palevich, Robert. "The Lean Sustainable Supply Chain: How to Create a Green Infrastructure with Lean Technologies". FT Press, 2012

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
PEC21ME043	Internet of Things	L	T	P	L	T	P	Total
		2	1	0	2	1	0	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100 (30% weightage)	100	
		Tutorial	20	--	30	--	50	

Pre-requisite Course Codes	Mechatronics basics, Microprocessor	
Course Outcomes	CO1	Understand IoT and Various associative Technologies
	CO2	Implement Core IoT Functional Stack and Understand Application Protocols
	CO3	Apply IoT technologies to key Industries
	CO4	Examine various Hardware and software platforms used in IoT

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	Introduction and application to Internet of Things: Need of IoT, history of IOT, Impact of IOT – Roadways, factory building and Smart creatures, , IoT Challenges, Objects of IOT , the Iot World Forum Standard Architecture Level of IOT, Technologies in IOT,	1-3	4
2	2.1	Sensors/Transducers – Definition, Principles, Classifications, Types, Characteristics and Specifications, Actuators -– Definition, Principles, Classifications, Types, Characteristics and Specifications Smart Object – Definition, Characteristics and Trends,	1-3	4
3	3.1	Sensor Networks – Architecture of Wireless Sensor Network, Network Topologies, Wireless Technologies Supporting IoT: Protocol Standardization for IoT, Machine to machine (M2M) and WSN protocols, Basics of RFID , RFID Protocols, Issues with IOT Standardization, Protocols – IEEE 802.15.4, Zigbee, IPv6 Technologies for IOT	1-3	6
4	4.1	Data Analytics for IOT: Introduction Apache Hadoop, Using Hadoop MapReduce for Batch Data Analysis, Apache Oozie, Apache Spark, Apache Storm, Using Apache Storm for Real Tie Data Analysis, Structural Health Monitoring, Case Study :Chef Case Study, puppet Case Study	1-3	4
5	5.1	Introduction to Cloud Computing, Difference between Cloud Computing and FOG Computing: The Next Evolution of Cloud Computing, Role of Cloud Computing in IOT, Connecting Iot to Cloud, Cloud Storage for IoT Challenge in Integration of IoT with Cloud	1-3	4

6	**6.1**	Domain Specific IoT : Home Automation – Smart Lighting, Smart Appliances, Intrusion Detection, Smoke/Gas Detectors, Cities – Smart Parking, Smart Lighting, Smart Roads, Structural Health Monitoring, Surveillance, Environment – Weather Monitoring, Air Pollution Monitoring, Noise Pollution Monitoring, Forest Fire Detection, River Floods Detection, Energy – Smart Grids, Renewable Energy Systems, Prognostics, Retail – Inventory Management, Smart Payments, Smart Vending Machines, Logistics – Route Generation & Scheduling, Fleet Tracking, Shipment Monitoring, Agriculture – Smart Irrigation, Green House Control, Industry – Machine Diagnostics & Prognosis, Indoor Air Quality Monitoring, Health & Lifestyle – Health & Fitness Monitoring, Wearable Electronics	1-3	4
Total				**26**

Course Assessment:

Theory:

ISE-1: Quiz / Case Study Presentation / Presentation on thrust areas (20 marks)

ISE-2: Mini Project (20 marks)

MSE: Two hours 30 Marks written examination based on 50% syllabus

ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Tutorial:

1. **ISE-1** Two Assignments based on 50% Syllabus

Continuous pre-defined rubrics-based evaluation for 20 marks.

2. **ISE-2** Three Assignments based on remaining 50% Syllabus

Continuous pre-defined rubrics-based evaluation for 30 marks.

Recommended Books:

1. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton, Jerome Henry, "IoT Fundamentals – Networking Technologies, Protocols, and Use Cases for the Internet of Things", 1 st Edition, Published by Pearson Education, Inc, publishing as Cisco Press, 2017.
2. Hakima Chaouchi, "The Internet of Things - Connecting Objects to the Web", 1 st Edition, Wiley, 2010.
3. Perry Lea, "Internet of things For Architects", 1 st Edition, Packt Publication, 2018
4. Arshdeep Bahga, Vijay Madisetti, "Internet of Things – Hands-On Approach", 2 nd Edition, Universities Press, 2016.
5. Adrian McEwen & Hakim Cassimally, "Designing the Internet of Things", 1 st Edition, Wiley, 2014.
6. Donald Norris, "Raspberry Pi – Projects for the Evil Genius", 2 nd Edition, McGraw Hill, 2014.
7. Anand Tamboli ,"Build Your Own IoT Platform", 1 st Edition, Apress, 2019.

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
OE2121	Project Management	L	T	P	L	T	P	Total
		2	1	0	2	1	0	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100 (30% weightage)	100	
		Tutorial	20	--	30	--	50	

Pre-requisite Course Codes	-	
Course Outcomes	CO1	Apply selection criteria and select an appropriate project from different options.
	CO2	Write work break down structure for a project and develop a schedule based on it.
	CO3	Identify opportunities and threats to the project and decide an approach to deal with them strategically.
	CO4	Use Earned value technique and determine & predict status of the project.
	CO5	Capture lessons learned during project phases and document them for future reference

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Project Management Foundation:** Definition of a project, Project Vs Operations, Necessity of project management, Triple constraints, Project life cycles (typical & atypical) Project phases and stage gate process. Role of project manager, Negotiations and resolving conflicts, Project management in various organization structures, PM knowledge areas as per Project Management Institute (PMI)	1,2,3	4
2	2.1	**Initiating Projects:** How to get a project started, Selecting project strategically, Project selection models (Numeric /Scoring Models and Non-numeric models), Project portfolio process, Project sponsor and creating charter; Project proposal. Effective project team, Stages of team development & growth (forming, storming, norming &performing), team dynamics.	1,2,3	5
3	3.1	**Project Planning and Scheduling:** Work Breakdown structure (WBS) and linear responsibility chart, Interface Co-ordination and concurrent engineering, Project cost estimation and budgeting, Top down and bottoms up budgeting, Networking and Scheduling techniques. PERT, CPM, GANTT chart, Introduction to Project Management Information System (PMIS).	1,2,3	4
4	4.1	**Planning Projects:**	1,2,3	4

		Crashing project time, Resource loading and levelling, Goldratt's critical chain, Project Stakeholders and Communication plan Risk Management in projects: Risk management planning, Risk identification and risk register, Qualitative and quantitative risk assessment, Probability and impact matrix. Risk response strategies for positive and negative risks		
5	**5.1**	**Executing Projects:** Planning monitoring and controlling cycle, Information needs and reporting, engaging with all stakeholders of the projects, Team management, communication and project meetings	4,5	5
	5.2	**Monitoring and Controlling Projects:** Earned Value Management techniques for measuring value of work completed; Using milestones for measurement; change requests and scope creep, Project audit		
	5.3	**Project Contracting** Project procurement management, contracting and outsourcing		
6	**6.1**	**Project Leadership and Ethics:** Introduction to project leadership, ethics in projects, Multicultural and virtual projects	4,5	4
	6.2	**Closing the Project:** Customer acceptance; Reasons of project termination, Various types of project terminations (Extinction, Addition, Integration, Starvation), Process of project termination, completing a final report; doing a lessons learned analysis; acknowledging successes and failures; Project management templates and other resources; Managing without authority; Areas of further study.		
				26

Course Assessment:

Theory:

ISE-1: Quiz / Case Study Presentation / Presentation on thrust areas (20 marks)

ISE-2: Mini Project (20 marks)

MSE: Two hours 30 Marks written examination based on 50% syllabus

ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Tutorial:

1. **ISE-1** Two Assignments based on 50% Syllabus
   Continuous pre-defined rubrics-based evaluation for 20 marks.
2. **ISE-2** Three Assignments based on remaining 50% Syllabus
   Continuous pre-defined rubrics-based evaluation for 30 marks.

Recommended Books:-

1. Project Management: A managerial approach, Jack Meredith & Samuel Mantel, 7th Edition, Wiley India
2. A Guide to the Project Management Body of Knowledge (PMBOK® Guide), 5th Ed, Project Management Institute PA, USA
3. Project Management, Gido Clements, Cengage Learning

4. Project Management, Gopalan, Wiley India
5. Project Management, Dennis Lock, 9th Edition, Gower Publishing England

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
OE2122	Finance Management	L	T	P	L	T	P	Total
		2	1	0	2	1	0	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100 (30% weightage)	100	
		Tutorial	20	--	30	--	50	

Pre-requisite Course Codes	-	
Course Outcomes	CO1	Understand Indian finance system and corporate finance
	CO2	Take investment, finance as well as dividend decisions

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Overview of Indian Financial System:** Characteristics, Components and Functions of Financial System. Financial Instruments: Meaning, Characteristics and Classification of Basic Financial Instruments — Equity Shares, Preference Shares, Bonds-Debentures, Certificates of Deposit, and Treasury Bills. Financial Markets: Meaning, Characteristics and Classification of Financial Markets — Capital Market, Money Market and Foreign Currency Market Financial Institutions: Meaning, Characteristics and Classification of Financial Institutions — Commercial Banks, Investment-Merchant Banks and Stock Exchanges	1-4	3
2	2.1	**Concepts of Returns and Risks:** Measurement of Historical Returns and Expected Returns of a Single Security and a Two-security Portfolio; Measurement of Historical Risk and Expected Risk of a Single Security and a Two-security Portfolio.	1-4	3
	2.2	**Time Value of Money:** Future Value of a Lump Sum, Ordinary Annuity, and Annuity Due; Present Value of a Lump Sum, Ordinary Annuity, and Annuity Due; Continuous Compounding and Continuous Discounting.	1-4	
3	3.1	**Overview of Corporate Finance:** Objectives of Corporate Finance; Functions of Corporate Finance—Investment Decision, Financing Decision, and Dividend Decision.	1-4	7
	3.2	**Financial Ratio Analysis:** Overview of Financial Statements—Balance Sheet, Profit and Loss Account, and Cash Flow Statement; Purpose of Financial Ratio Analysis; Liquidity Ratios; Efficiency or Activity Ratios; Profitability Ratios; Capital Structure Ratios; Stock Market Ratios; Limitations of Ratio Analysis.	1-4	

4	**4.1**	**Capital Budgeting:** Meaning and Importance of Capital Budgeting; Inputs for Capital Budgeting Decisions; Investment Appraisal Criterion—Accounting Rate of Return, Payback Period, Discounted Payback Period, Net Present Value(NPV), Profitability Index, Internal Rate of Return (IRR), and Modified Internal Rate of Return (MIRR)	1-4	7
	4.2	**Working Capital Management:** Concepts of Meaning Working Capital; Importance of Working Capital Management; Factors Affecting an Entity's Working Capital Needs; Estimation of Working Capital Requirements; Management of Inventories; Management of Receivables; and Management of Cash and Marketable Securities.	1-4	
5	**5.1**	**Sources of Finance:** Long Term Sources—Equity, Debt, and Hybrids; Mezzanine Finance; Sources of Short Term Finance—Trade Credit, Bank Finance, Commercial Paper; Project Finance.	1-4	3
	5.2	**Capital Structure:** Factors Affecting an Entity's Capital Structure; Overview of Capital Structure Theories and Approaches— Net Income Approach, Net Operating Income Approach; Traditional Approach, and Modigliani-Miller Approach. Relation between Capital Structure and Corporate Value; Concept of Optimal Capital Structure	1-4	
6	**6.1**	**Dividend Policy:** Meaning and Importance of Dividend Policy; Factors Affecting an Entity's Dividend Decision; Overview of Dividend Policy Theories and Approaches—Gordon's Approach, Walter's Approach, and Modigliani-Miller Approach	1-4	3
				26

Course Assessment:

Theory:

ISE-1: Quiz / Case Study Presentation / Presentation on thrust areas (20 marks)

ISE-2: Mini Project (20 marks)

MSE: Two hours 30 Marks written examination based on 50% syllabus

ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Tutorial:

1. **ISE-1** Two Assignments based on 50% Syllabus

Continuous pre-defined rubrics-based evaluation for 20 marks.

2. **ISE-2** Three Assignments based on remaining 50% Syllabus

Continuous pre-defined rubrics-based evaluation for 30 marks.

Recommended Books:-

1. Fundamentals of Financial Management, 13th Edition (2015) by Eugene F. Brigham and Joel F. Houston; Publisher: Cengage Publications, New Delhi.

2. Analysis for Financial Management, 10th Edition (2013) by Robert C. Higgins; Publishers: McGraw Hill Education, New Delhi.

3. Indian Financial System, 9th Edition (2015) by M. Y. Khan; Publisher: McGraw Hill Education, New Delhi.

4. Financial Management, 11th Edition (2015) by I. M. Pandey; Publisher: S. Chand (G/L) & Company Limited, New Delhi.

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
OE2123	Environmental Management	L	T	P	L	T	P	Total
		2	1	0	2	1	0	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	100 (30% weightage)	100	
		Tutorial	20	--	30	--	50	

Pre-requisite Course Codes		
Course Outcomes	CO1	Understand the concept of environmental management
	CO2	Understand ecosystem and interdependence, food chain etc.
	CO3	Understand and interpret environment related legislations

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	Introduction and Definition of Environment: Significance of Environment Management for contemporary managers, Career opportunities, Environmental issues relevant to India, Sustainable Development, the Energy scenario	1-4	7
2	2.1	Global Environmental concerns : Global Warming, Acid Rain, Ozone Depletion, Hazardous Wastes, Endangered life-species, Loss of Biodiversity, Industrial/Man-made disasters, Atomic/Biomedical hazards, etc.	1-4	3
3	3.1	Concepts of Ecology: Ecosystems and interdependence between living organisms, habitats, limiting factors, carrying capacity, food chain, etc.	1-4	3
4	4.1	Scope of Environment Management, Role and functions of Government as a planning and regulating agency Environment Quality Management and Corporate Environmental Responsibility	1-4	7
5	5.1	Total Quality Environmental Management, ISO-14000, EMS certification.	1-4	3
6	6.1	General overview of major legislations like Environment Protection Act, Air (P & CP) Act, Water (P & CP) Act, Wildlife Protection Act, Forest Act, Factories Act, etc.	1-4	3
				26

Course Assessment:

Theory:

ISE-1: Quiz / Case Study Presentation / Presentation on thrust areas (20 marks)

ISE-2: Mini Project (20 marks)

MSE: Two hours 30 Marks written examination based on 50% syllabus

ESE: Three hours 100 Marks (30% weightage) written examination based on entire syllabus

Tutorial:

1. **ISE-1** Two Assignments based on 50% Syllabus
   Continuous pre-defined rubrics-based evaluation for 20 marks.
2. **ISE-2** Three Assignments based on remaining 50% Syllabus
   Continuous pre-defined rubrics-based evaluation for 30 marks.

Recommended Books:-

1. Environmental Management: Principles and Practice, C J Barrow, Routledge Publishers London, 1999
2. A Handbook of Environmental Management Edited by Jon C. Lovett and David G. Ockwell, Edward Elgar Publishing
3. Environmental Management V Ramachandra and Vijay Kulkarni, TERI Press
4. Indian Standard Environmental Management Systems — Requirements With Guidance For Use, Bureau Of Indian Standards, February 2005
5. Environmental Management: An Indian Perspective, S N Chary and Vinod Vyasulu, Maclillan India, 2000
6. Introduction to Environmental Management, Mary K Theodore and Louise Theodore, CRC Press
7. Environment and Ecology, Majid Hussain, 3rd Ed. Access Publishing.2015

Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P		L	T	P	Total
CCL21ME02	Program Lab-II CAM and Additive Manufacturing	--	--	2		--	--	1	1

Examination Scheme				
ISE1	MSE	ISE2	ESE	Total
20	--	30	--	50

Pre-requisite Course Codes		
Course Outcomes	CO1	Write and run CNC program for Turning and Milling.
	CO2	Gain experience in product design and development using rapid manufacturing technology.

Module	Detailed Contents	Lab Sessions
01	3D Modeling and creating STL files	2
02	3D Printing of components	3
03	Operation, programming of CNC turning and milling	4
04	Tool path Simulation using software.	4

Course Assessment:

1. **ISE-1** Continuous pre-defined rubrics-based evaluation for 20 marks.
2. **ISE-2** Continuous pre-defined rubrics-based evaluation for 30 marks.

Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P		L	T	P	Total
SBL21ME02	Skill Based Lab-II Mechatronics and Robotics	--	--	4		--	--	2	2

Examination Scheme				
ISE1	MSE	ISE2	ESE	Total
20	--	30	50	100

Pre-requisite Course Codes		
Course Outcomes	CO1	Design Pneumatic and Hydraulic Circuits for Industrial Applications
	CO2	Design the Direct or inverse kinematics for a given Industrial Robotic Arm

Module	Detailed Contents	Lab Sessions
01	Design and excecute Pneumatic and Hydraulic Circuit	5
02	Direct and Inverse Kinematic Simulation	5
03	Experiment on Robot Vision	3

Course Assessment:

1. **ISE-1** Continuous pre-defined rubrics-based evaluation for 20 marks.
2. **ISE-2** Continuous pre-defined rubrics-based evaluation for 30 marks.
3. **ESE** Practical/Oral examination is to be conducted by pair of examiners for 50 marks

Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P		L	T	P	Total
MP22ME01	Major Project: Dissertation – I	--	--	40#		--	--	20	20
		Examination Scheme							
		ISE1		MSE	ISE2	ESE		Total	
		20		--	30	50		100	

# indicates work load of Learner (Not Faculty)

Pre-requisite Course Codes		
Course Outcomes	CO1	Develop the understanding of the problem domain through extensive review of literature.
	CO2	Identify and analyze the problem in detail to define its scope with problem specific data.
	CO3	Identify various techniques to be implemented for the selected problem and related technical skills through feasibility analysis.
	CO4	Design solutions for real-time problems that will positively impact society and environment.
	CO5	Develop clarity of presentation based on communication, teamwork and leadership skills.
	CO6	Inculcate professional and ethical behavior.

Guidelines for Dissertation-I

Students should do literature survey and identify the problem for Dissertation and finalize in consultation with Guide/Supervisor. Students should use multiple literatures and understand the problem. Students should attempt solution to the problem by analytical/simulation/experimental methods. The solution to be validated with proper justification and compile the report in standard format. Guidelines for Assessment of Dissertation-I.

Dissertation-I should be assessed based on following points

- Quality of Literature survey and Novelty in the problem
- Clarity of Problem definition and Feasibility of problem solution
- Relevance to the specialization
- Clarity of objective and scope Dissertation-I should be assessed through a presentation by a panel of Internal examiners and external examiner appointed by the Head of the Department/Institute of respective Programme.

Course Assessment:

ISE-1:

Continuous Evaluation by project guide followed by presentation before a panel of examiners (10 marks)

Online Credit Course (OCC) available on NPTEL / Swayam /MOOC or similar platform approved by UoM/Institute related to Research Methodology to be completed by the candidate preferably by the end of semester III (10 marks)

ISE-2:
Continuous Evaluation by project guide followed by presentation before a panel of examiners (20 marks)
Online Credit Course (OCC) available on NPTEL / Swayam /MOOC or similar platform approved by UoM/Institute, related to the area of M. Tech dissertation to be completed by the candidate preferably by the end of semester III (10 marks)

ESE: Continuous Evaluation by project guide followed by presentation before a panel of examiners (50 marks)

Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P		L	T	P	Total
MP22ME02	Major Project: Dissertation – II	--	--	40#		--	--	20	20
		Examination Scheme							
		ISE1		MSE	ISE2	ESE		Total	
		50		--	50	100		200	

# indicates work load of Learner (Not Faculty)

Pre-requisite Course Codes		
Course Outcomes	CO1	Implement solutions for the selected problem by applying technical and professional skills.
	CO2	Analyze impact of solutions in societal and environmental context for sustainable development.
	CO3	Collaborate best practices along with effective use of modern tools.
	CO4	Excel in written and oral communication.
	CO5	Demonstrate capabilities of self-learning which leads to life long learning.
	CO6	Demonstrate project management principles during project work.

Guidelines for Assessment of Dissertation II

Dissertation II should be assessed based on following points:

- Quality of Literature survey and Novelty in the problem
- Clarity of Problem definition and Feasibility of problem solution
- Relevance to the specialization or current Research / Industrial trends
- Clarity of objective and scope
- Quality of work attempted or learner contribution
- Validation of results
- Quality of Written and Oral Presentation

Students should publish at least one paper based on the work in referred National/ International conference/Journal of repute.

Course Assessment:

ISE-1: Continuous Evaluation by project guide followed by presentation before a panel of examiners based on predefined rubrics (50 marks)

ISE-2: Continuous Evaluation by project guide followed by presentation before a panel of examiners (50 marks)

ESE: Continuous Evaluation by project guide followed by presentation before a panel of internal examiners and external examiner (100 marks)