Department of Mechanical Engineering

M.Tech. Materials and Manufacturing Technology
Curriculum and Syllabus

(Applicable to the students admitted from AY: 2023 onwards)

School of Engineering and Sciences
SRM University *AP*, Andhra Pradesh

Department Vision

To become distinct and renowned globally by graduating high-quality professionals through rigorous coursework and cutting-edge research.

Department Mission

1. Emerge as a world-class mechanical engineering department in exploring and providing knowledge through high-quality academic programs and experiential learning.
2. Create an ambience for impactful research aligning with the national mission and addressing societal needs.
3. Create entrepreneurs and leaders of the future imparted with knowledge, global awareness, and strategic thinking.
4. Promote high standards of integrity, and ethical behaviour among faculty members, staff, and students.

Program Educational Objectives (PEO)

1. Prepare graduates with a strong foundation in the fundamentals of advanced materials and manufacturing technologies, with a focus on new product and process development for various industrial applications.
2. Develop graduates who can conduct independent research and development (R&D) in materials and manufacturing technology, with a strong understanding and ability to design and implement sustainable and environmentally responsible solutions using data interpretation, design, experimentation, and analysis.
3. Prepare graduates for leadership roles in industry, academia, or government, with the ability to manage projects, teams, and resources effectively and encourage a sense of entrepreneurship

Mission of the Department to Program Educational Objectives (PEO) Mapping

	PEO 1	PEO 2	PEO 3
Mission Statement 1	3	2	3
Mission Statement 2	3	3	3
Mission Statement 3	2	3	3
Mission Statement 4	3	2	2

Program Specific Outcomes (PSO)

1. Apply advanced materials science and manufacturing principles to design, develop, and characterize novel materials and processes with tailored properties for specific applications and realize the dream of India to establish a world-class leader in manufacturing.
2. Employ advanced manufacturing techniques to fabricate high-performance materials and components with desired microstructures and functionalities. Utilize computational tools to simulate materials' behaviour, predict performance, and optimize manufacturing processes.
3. Conduct R&D to explore novel materials and manufacturing processes for advancing the field. Communicate technical findings through presentations, publications, and reports for diverse audiences. Collaborate with multidisciplinary teams to address complex challenges and contribute to innovative solutions.

Mapping Program Educational Objectives (PEO) to Program Learning Outcomes (PLO)

Program Learning Outcomes (PLO)													
PEOs	POs										PSOs		
	Engineering Knowledge	Design Development of Solutions	Conduct Investigations of Complex Problems	Modern Tools and ICT Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Teamwork Skills	Communication Skills	Lifelong Learning	PSO 1	PSO 2	PSO 3
PEO 1	3	3	2	3	2	2	3	2	2	2	2	3	2
PEO 2	3	3	3	3	3	2	3	3	2	2	3	3	2
PEO 3	2	2	3	3	3	2	3	3	3	3	2	3	2

Category Wise Credit Distribution			
Course Sub-Category	**Sub-Category Credits**	**Category Credits**	**Learning Hours**
Ability Enhancement Courses (AEC)		1	30
University AEC	0		
School AEC	1		
Value Added Courses (VAC)		1	30
University VAC	1		
School VAC	0		
Skill Enhancement Courses (SEC)		4	120
School SEC	2		
Department SEC	2		
SEC Elective	0		
Foundation/ Interdisciplinary courses (FIC)		4	120
S chool FIC	4		
Department FIC	0		
Core + Core Elective including Specialization (CC)		35	1050
Core	27		
Core Elective (Inc Specialization)	8		
Minor (MC) + Open Elective (OE)	0	0	0
Research / Design / Internship/ Project (RDIP)		35	1050
Internship / Design Project / Startup / NGO	3		
Internship / Research / Thesis	32		
Total		**80**	**2400**

Semester wise Course Credit Distribution Under Various Categories						
Category	**Semester**					
	I	**II**	**III**	**IV**	**Total**	**%**
Ability Enhancement Courses - AEC	0	1	0	0	1	**1**
Value Added Courses - VAC	0	1	0	0	1	**1**
Skill Enhancement Courses - SEC	2	2	0	0	4	**5**
Foundation / Interdisciplinary Courses - FIC	4	0	0	0	4	**5**
CC / SE / CE / TE / DE / HSS	15	20	0	0	35	**43**
Minor / Open Elective - OE	0	0	0	0	0	**0**
(Research/ Design/ Industrial Practice/Project/Thesis/Internship) -RDIP	0	3	17	15	35	**43**
Grand Total	**21**	**27**	**17**	**15**	**80**	**100**

Note: L-T/D-P/Pr and the class allocation is as follows.

a) Learning Hours : 30 learning hours are equal to 1 credit.

b) Lecture/Tutorial : 15 contact hours (60 minutes each) per semester are equal to 1 credit.

c) Discussion : 30 contact hours (60 minutes each) per semester are equal to 1 credit.

d) Practical : 30 contact hours (60 minutes each) per semester are equal to 1 credit.

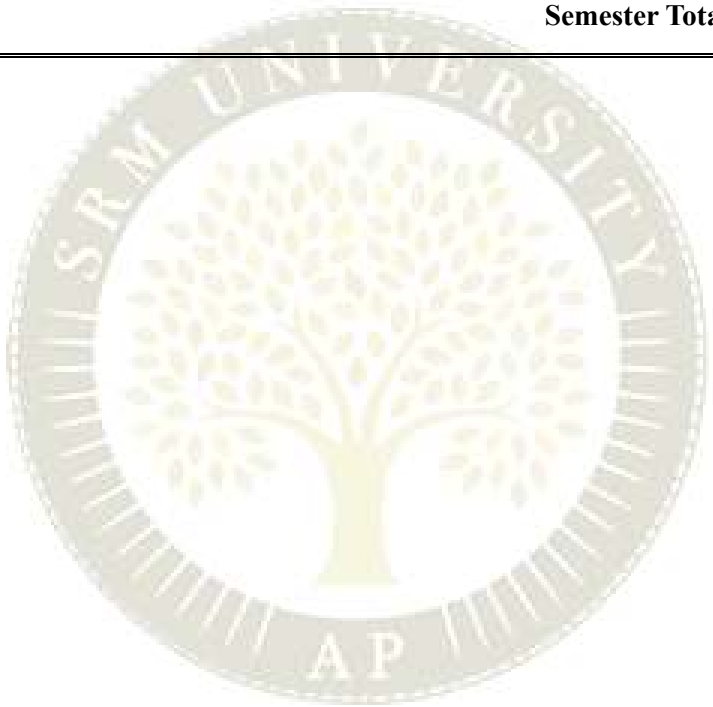
e) Project : 30 project hours (60 minutes each) per semester are equal to 1 credit.

SEMESTER - I								
S. No	**Category**	**Sub-Category**	**Course Code**	**Course Title**	**L**	**T/D**	**P/Pr**	**C**
1	VAC	U AEC	VAC 501	Community Engagement and Social Responsibility	0	0	1	1*
2	VAC	U AEC	AEC 502	Research Seminar - I	0	0	1	1*
3	SEC	D SEC	SEC 502	Design Thinking	1	0	1	2
4	FIC	S FIC	FIC 505	Advanced Numerical Techniques	2	1	1	4
5	Core	CC	MMT 501	Industrial Surface Engineering	3	0	1	4
6	Core	CC	MMT 502	Sustainable Manufacturing	3	0	1	4
7	Core	CC	MMT 503	Materials for Manufacturing	3	0	1	4
8	Core	CC	MMT 504	Production and operation management	3	0	0	3
				Semester Total	**15**	**1**	**7**	**21**

SEMESTER - II								
S. No	**Category**	**Sub-Category**	**Course Code**	**Course Title**	**L**	**T/D**	**P/Pr**	**C**
1	VAC	U VAC	VAC 502	Community Engagement and Social Responsibility	0	0	1	1
2	VAC	U AEC	AEC 503	Research Seminar - II	0	0	1	1
3	SEC	S SEC	SEC 103	Entrepreneurial Mindset	1	0	1	2
4	Elective	CE		Industry - Core Elective	3	0	1	4
5	Elective	CE		Industry - Core Elective	3	0	1	4
6	Core	CC	MMT 505	Advanced Materials Processing Technologies	3	0	1	4
7	Core	CC	MMT 506	Additive Manufacturing	3	0	1	4
8	Core	CC	MMT 507	Material Characterization Processes	3	0	1	4
9	RDIP	RDIP	MMT 508	Project Management	0	0	3	3
				Semester Total	**16**	**2**	**9**	**27**

SEMESTER - III								
S. No	**Category**	**Sub-Category**	**Course Code**	**Course Title**	**L**	**T/D**	**P/Pr**	**C**
1	RDIP	RDIP	MMT 509	Thesis - I	0	0	14	14
2	RDIP	RDIP	MMT 510	Industrial Practice	0	0	3	3
				Semester Total	**0**	**0**	**17**	**17**

SEMESTER - IV								
S. No	**Category**	**Sub-Category**	**Course Code**	**Course Title**	**L**	**T/D**	**P/Pr**	**C**
1	RDIP	RDIP	MMT 511	Thesis - II	0	0	15	15
				Semester Total	**0**	**0**	**15**	**15**



List of Core Electives								
S. No	**Category**	**Sub-Category**	**Course Code**	**Course Title**	**L**	**T/D**	**P/Pr**	**C**
1	Elective	CE	MMT 530	Analysis of machining processes	3	0	1	4
2	Elective	CE	MMT 531	Lasers in Manufacturing	3	0	1	4
3	Elective	CE	MMT 532	Lean manufacturing	3	0	1	4
4	Elective	CE	MMT 533	Reliability engineering	3	0	1	4
5	Elective	CE	MMT 534	Tool design	3	0	1	4
6	Elective	CE	MMT 535	Digital Manufacturing	3	0	1	4
7	Elective	CE	MMT 536	Advanced Metal Forming	3	0	1	4
8	Elective	CE	MMT 537	Precision and Micro Manufacturing	3	0	1	4
9	Elective	CE	MMT 538	Quality engineering	3	0	1	4
10	Elective	CE	MMT 539	Finite element methods for Manufacturing	3	0	1	4
11	Elective	CE	MMT 540	Inspection and Testing in Manufacturing	3	0	1	4
12	Elective	CE	MMT 541	Flexible Manufacturing System	3	0	1	4
13	Elective	CE	MMT 542	Product Design and Manufacturing	3	0	1	4
14	Elective	CE	MMT 543	Biomaterials Processing and Applications	3	0	1	4
15	Elective	CE	MMT 544	Powder Materials and Processing	3	0	1	4
16	Elective	CE	MMT 545	Design and Analysis of Experiments	3	0	1	4
17	Elective	CE	MMT 546	Robotics and AI/ML for Manufacturing	3	0	1	4
18	Elective	CE	MMT 547	Manufacturing Automation and Industry 4.0	3	0	1	4

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Research Seminar- I

Course Code	AEC 502	Course Category	AEC	L	T	P	C
				0	0	1	1
Pre-Requisite Course(s)		Co-Requisite Course(s)		Progressive Course(s)			
Course Offering Department	Mechanical Engineering	Professional / Licensing Standards					

Course Objectives / Course Learning Rationales (CLRs)

1. To learn how to prepare power point presentations effectively.
2. To learn the presentation skills and communications.
3. To gain knowledge through discussion.

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Describe the features and characteristics of seminars and presentations.	2	80%	80%
Outcome 2	Gain skills in methods of scientific presentations	2	65%	60%
Outcome 3	Respond to questions and answers effectively and manage conflict during the seminar	3	80%	75%
Outcome 4	Understand the basic structure of research paper	2	80%	75%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)												
	Engineering Knowledge	Design / Development of Solutions	Conduct Investigations of Complex Problems	Modern Tools and ICT Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Teamwork Skills	Communication Skills	Life-long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	3	3	1	3	2	2	2	3	3	3	3	2	3
Outcome 2	3	3	2	3	2	1	3	2	3	3	3	2	3
Outcome 3	3	3	2	3	2	2	3	2	3	3	3	2	3
Outcome 4	3	3	3	3	3	2	3	2	3	3	3	3	3
Average	3	3	2	3	2	2	3	2	3	3	3	2	3

Course Unitization Plan

Unit No.	Unit Name	Required Contact Hours	CLOs Addressed	References Used
Unit 1	Research Seminar -Structure: Explanation of what is a seminar and what is expected during the seminar, followed by student presentations	5	1	1
Unit 2	Ways and tools of presentation in the research seminar: Discussion on tools for effective presentation	5	1	1
Unit 3	Presentation skills: Discussion and presentation demonstration: Handling questioning sessions of presentation	7	2	2
Unit 4	Handling questioning sessions of presentation How to answer the questions during the presentation. Student presentation and discussion	8	2	3,4
Unit 5	Conflict management during presentation: How to manage the conflicts during the presentation	5	3	3
	Total Hours	**30**		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								Final Review (50%)	
		Review-1(25%)		Review-2(25%)		Review-3 (%)		Mid Term (%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	40%		50%							50%
	Understand										
Level 2	Apply	60%		50%							50%
	Analyse										
Level 3	Evaluate										
	Create										
Total		**100%**		**100%**							**100%**

Recommended Resources

1. Garr Reynolds Presentation Zen: Simple Ideas on Presentation Design and Delivery (ISBN: 0321811984)
2. Matt Carter Designing Science Presentations: A Visual Guide to Figures, Papers, Slides, Posters, and More (ISBN: 0123859697)
3. Vernon Booth, Communicating in Science: Writing a Scientific Paper and Speaking at Scientific Meetings (ISBN: 0521429153.

Other Resources

1. https://www.northwestern.edu/climb/resources/oral-communication-skills/creating-an-intro.html

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Design Thinking

Course Code	SEC 502	**Course Category**	SEC	**L**	**T**	**P**	**C**
				1	0	1	2
Pre-Requisite Course(s)		**Co-Requisite Course(s)**		**Progressive Course(s)**			
Course Offering Department	Management	**Professional / Licensing Standards**					

Course Objectives / Course Learning Rationales (CLRs)

1. Familiarize with the principles of Design Thinking
2. Learn to apply the principles of Design Thinking
3. Apply Design Thinking to solve problems.

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Grasp the Concepts and process of Design Thinking	2	85%	90%
Outcome 2	Learn the process of Design Thinking	2	85%	90%
Outcome 3	Solve a problem using Design Thinking Principles	5	75%	65%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

PEOs	Program Learning Outcomes (PLO)												
	POs										PSOs		
	Engineering Knowledge	Design / Development of Solutions	Conduct Investigations of Complex Problems	Modern Tool Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Teamwork	Communication	Life-long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	3									1	3	1	3
Outcome 2	3							3		2	3	2	3
Outcome 3	3	3	3	3				3	3	3	3	3	3
Average	3	3	3	3				3	3	2	3	2	3

Course Unitization Plan

Unit No.	Unit Name	Required Contact Hours	CLOs Addressed	References Used
Unit 1	**Incubation and understanding**			1,2
	Understanding of Design Thinking & its Importance	5	1	1,2
	Importance of Design Thinking	4	1	1,2
	Pillars of Design Thinking	3	1	1,2
Unit 2	**Process – Understanding the Stages of Design Thinking**			1,2
	Stage 1- Empathy	3	2	1,2
	Stage 2 - Define	3		
	Stage 3 – Ideate	3		
	Stage 4 – Prototype	3	2	1,2
	Stage 5 – Test & Implement	3	2	1,2
Unit 3	**Application**			
	Project Work	15	3	1,2
	Viva	3	3	1,2
Total Contact Hours		**45**		

Learning Assessment

Bloom's Level of Cognitive Task		**Continuous Learning Assessments (50%)**		**Final Project Review 50%**
		Project review-1 (25%)	**Project review -2 (25%)**	
Level 1	Remember	20	40	30
	Understand			
Level 2	Apply	30	30	30
	Analyse			
Level 3	Evaluate	50	30	40
	Create			
Total		**100%**	**100%**	**100%**

Recommended Resources

1. Design Thinking – Techniques and Approaches, N. Siva Prasad

Other Resources

1. HBS – Online – Design Thinking & Innovation – course material
2. Case studies
3. Nigel Cross , Design Thinking, BERG Publishing, (2011)
4. Thomas Lockwood , Design Thinking- Integrating Innovation, Customer Experience and Brand Value, , Design Management Institute, (2009)

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ADVANCED NUMERICAL TECHNIQUES

Course Code	FIC 505	Course Category	Core	L	T	P	C
				2	1	1	4
Pre-Requisite Course(s)	Linear Algebra Calculus	Co-Requisite Course(s)		Progressive Course(s)			
Course Offering Department	Mechanical Engineering	Professional / Licensing Standards					

Course Objectives / Course Learning Rationales (CLRs)

1. Understand and derive the solution methodologies
2. Understand the advantages and disadvantages of various numerical methods to solve a particular problem
3. Gain knowledge of the methods to the engineering applications
4. Learn the computational implementation of the methods

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Classify the numerical methods	2	80%	75%
Outcome 2	Solve given engineering problems based on numerical methods such as Gauss elimination, bisection, least squares regression and differential equations	3	75%	65%
Outcome 3	Solve given engineering problems using numerical techniques and MATLAB	3	70%	65%
Outcome 4	Demonstrate index notation methods for given equations using MATLAB	3	60%	55%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)												
	Engineering Knowledge	Design and Development	Analysis, Design and Research	Modern Tool and ICT Usage	Society and Multicultural Skills	Environment and Sustainability	Moral, and Ethical Awareness	Individual and Teamwork Skills	Communication Skills	Self-Directed and Lifelong Learning	PSO 1	PSO 2	PSO 3
Outcome 1	3	**2**	**2**	**2**	**2**	-	-	**2**	**-**	3	3	2	3
Outcome 2	3	**3**	**2**	**3**	**3**	-	**-**	**2**	**-**	3	3	3	3
Outcome 3	3	**3**	**3**	**3**	**3**	-	**-**	**3**	**-**	3	3	2	3
Outcome 4	2	**3**	**2**	**3**	**3**	-	**-**	**2**	**-**	3	3	3	3
Course Average	**3**	**3**	**2**	**3**	**3**	**-**	**-**	**2**	**-**	**3**	3	3	3

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Introduction to Numerical Techniques	2	1	1,3
	Scientific notation, Precision effects,	1		
	Accuracy, Error's Syntax	1		
Unit No. 2	Gauss elimination method	2	2	1,2
	LU decomposition, Tri diagonal Matrices, Thomas algorithm	3		
	Iterative methods (Jacobi, Gauss-Siedel)	2		
	Nonlinear equations solution using Bisection and Newton Raphson Nonlinear systems	3		
Unit No. 3	Linear, quadratic and cubic interpolation -- Direct methods	2	2	1,2,3
	Newton divided differences interpolation	2		
	Lagrange interpolation	1		
	Curve fitting and its applications	1		
	Regression analysis, error definitions	1		
	Linear least squares regression single variable, multi variable	1		
	Polynomial regression	2		
Unit No. 4	Ordinary differential equations integration using Euler and Runge Kutta methods	2	3,4	1,2
	Ordinary differential equations Predictor corrector methods, boundary and initial value problems	3		
	Discretisation, grid and boundaries	2		
	Finite differences (forward, backward and central) formulas upto 6th order derivations	3		
	Order of accuracy	2		
	Classification of partial differential equations (PDE)	1		
	Solution of elliptic, hyperbolic and parabolic PDE using finite differences	2		
Unit No. 5	Application of linear and nonlinear system solutions to various engineering problems	1.5	4	1,2
	Application of Curve fitting and interpolation in Mechanical engineering	1.5		
	ODE and PDE applications specific to mechanical engineering	3		
	Total Contact Hours	**45**		

Exp No	Experiment Name	Required Contact Hours	CLOs Addressed	References Used
1	Introduction to MATLAB Programming	2	1	1, 2
2	Solution of linear algebraic equations using direct methods	4	3,4	1, 2
3	Linear algebraic equations using iterative methods	4	3,4	1, 2
4	Nonlinear equations, using Newton Raphson and Bisection	4	3,4	1, 2
5	Regression implementation	6	3,4	1, 2
6	Euler, Runge Kutta 2nd and fourth order methods	4	3,4	1, 2
7	Finite differences	2	3,4	1, 2
8	Partial differential equations	4	3,4	1, 2
Total Contact Hours		**30**		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (60%)					End Semester Exam (40%)	
		CLA-1 (10%)	Mid Term (10%)	CLA-2 (10%)	CLA-3 (10%)	Prac (20%)		
		Th	Th	Th	Th	Prac	Th (20%)	Prac (20%)
Level 1	Remember	30%	40%	20%	20%	20%	30%	
	Understand							
Level 2	Apply	70%	60%	60%	60%	60%	70%	
	Analyse							
Level 3	Evaluate	-	-	20%	20%	20%	-	
	Create							
Total		**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	

Recommended Resources

1. Canale, Raymond P., and Steven C. Chapra. Numerical methods for engineers. Mcgraw-hill Education-Europe, 2014.
2. Numerical Methods using MATLAB, John H Mathews.
3. Numerical Methods with worked examples, Chris H. Woodford and Christopher Phillips, Springer

Other Resources

1. https://in.mathworks.com/help/matlab/getting-started-with-matlab.html
2. https://www.math.hkust.edu.hk/~machas/numerical-methods.pdf
3. https://ocw.mit.edu/courses/18-335j-introduction-to-numerical-methods-spring-2019

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Industrial Surface Engineering

Course Code	MMT 501	Course Category	CC	L	T	P	C
				3	0	1	4
Pre-Requisite Course(s)		Co-Requisite Course(s)		Progressive Course(s)			
Course Offering Department	Mechanical Engineering	Professional / Licensing Standards					

Course Objectives / Course Learning Rationales (CLRs)

1. To introduce surface engineering processes and its applications.
2. To understand the surface degradation process for engineering components.
3. To introduce a coating technique for protecting surfaces for engineering components.
4. To learn characterization methods for evaluating the properties and performance of engineered surfaces

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Describe the need for surface engineering	2	80%	70%
Outcome 2	Describe and develop the coating for surface engineering	2	70%	70%
Outcome 3	Evaluate the types of wear and corrosion leading to surface degradation and predict remedial measures.	3	80%	70%
Outcome 4	Able to characterize coating, interpret results, and predict properties	3	70%	65%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)												
	Engineering Knowledge	Design / Development of Solutions	Conduct Investigations of Complex Problems	Modern Tools and ICT Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Teamwork Skills	Communication Skills	Life-long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	3	3	1	3		2		3	3	3	3	2	3
Outcome 2	3	3	2	3		1		3	2	3	3	2	3
Outcome 3	3	3	2	3		2		3	3	3	3	2	3
Outcome 4	3	3	3	3		2		3	3	3	3	3	3
Average	3	3	2	3		2		3	3	3	3	2	3

Course Unitization Plan

Unit No.	Syllabus topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Introduction to Surface Engineering, Application of Surface Engineering, Purpose of Surface Engineering	**2**	**1**	**1,2**
	Introduction to materials, phases and phase diagram, Differences between surface and bulk properties of materials. Properties of surfaces: Physical, Optical, Mechanical.	**2**	**1**	**1,2**
	Surface properties and classification of surface modification techniques	**2**	**1**	**1,2**
	Degradation of surfaces, wear and its type, Adhesive, Abrasive, Fretting, Erosion, Corrosion	**2**	**1**	**1,2**
Unit No. 2	Changing the surface metallurgy: Localized surface hardening (flame, induction, laser, electron-beam hardening, Laser melting, shot peening)	2	**2**	1,2
	Changing the surface chemistry: Phosphating, Chromating, Anodizing electrochemical conversion coating.	2	**2**	1,2
	Carburizing, Nitriding, Ion implantation, Laser alloying, boriding, Organic coatings (paints and polymeric or elastomeric coatings and linings)	2	**2**	1,2
	Hot-dip galvanizing (zinc coatings), Ceramic coatings (glass linings, cement linings, and porcelain enamels)	1	**2**	1,2
	Advanced surface coating methods: Gaseous State (CVD, PVD, etc)	1	**2**	1,2
	Solution State (Chemical solution deposition, Electrochemical deposition, Sol-gel, electroplating), Molten or semi-molten State (Laser cladding and Thermal spraying)	2	**2**	1,2
	Molten or semi-molten State (Laser cladding and Thermal spraying, HVOF, Cold Spraying, High-pressure cold spraying)	2	**2**	1,2
	Changing the surface metallurgy: Localized surface hardening (flame, induction, laser, electron-beam hardening, Laser melting, shot peening)	2	**2**	1,2
Unit No. 3	Wear and Assessing Surface damage types and categories, Fundamentals of friction and lubrication, Friction heat, and calculation.	**2**	**3**	**3,4**
	Investigating and characterization of the surface damage due to Abrasive wear and adhesive wear, Design of Surface Modification,	**2**	**3**	**3,4**
	Lubricants and additives, mechanism of solid, liquid, and gaseous lubricants	**2**	**3**	**3,4**
	Numerical Problem on wear and coefficient of friction, Erosion wear erosion rate	**2**	**3**	**3,4**
Unit No. 4	Corrosion: Different types of Corrosion and its prevention	**1**	**3**	**4**
	Galvanic corrosion, Passivation, Pitting, Crevice, Mircobial, High-temperature corrosion	**2**	**3**	**4**
	Corrosion in nonmetals, polymers, and glasses	**2**	**3**	**4**
	Protection from corrosion through surface modifications	**1**	**3**	**4**
Unit No. 5	Phase and structure of coating by X-ray diffraction	**1**	**3**	**5**
	Surface Characterization (physical and chemical methods, XPS, AES, RAMAN, FTIR etc)	**3**	**4**	**5**
	Metallographic Preparation of Samples for Microscopy Characterization of surface- Optical and Scanning Electron Microscopy	**2**	**4**	**5**
	Mechanical Characterization (Adhesion, Hardness, Scratch and Indentation etc.)	**2**	**4**	**5**
	Analysis of Properties of Surface degradation examples.	**1**	**4**	**2**
	Total Contact Hours	**45**		

Course Unitization Plan (Laboratory)

Expt No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
1	Introduction to the working process of various coating setups.	**3**	**2**	**1,2**
2	Depositing of coating using Physical Vapor Deposition	**2**	**2**	**1,2**
3	Deposition of coating using Chemical Vapor Deposition	**2**	**2**	**1,2**
4	Preparation of coating using Sputtering	**2**	**2**	**1,2**
5	Metallographic preparation of thin film for microscopy.	**6**	**4**	**5**
6	Characterization of Coating (XRD, Optical Microscope, RAMAN Spectroscopy, UV-Visible)	**5**	**4**	**5**
7	To investigate the properties of Coating (Hardness, Surface Roughness, Wear test, Friction in the presence of lubricant, Corrosion in Salt).	**10**	**4**	**5**
	Total Contact Hours	**30**		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments								End Semester Exam (50%)	
		CLA-1 (15%)		CLA-2 (10%)		CLA-3(10%)		Mid Term (15%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	30%		40%		40%		50%		40%	
	Understand		30%		30%		30%				30%
Level 2	Apply	70%	60%	60%	50%	60%	50%	50%		60%	30%
	Analyse										20%
Level 3	Evaluate		10%		20%		20%				20%
	Create										
Total		**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**		**100%**	**100%**

Recommended Resources

1. Introduction to Surface Engineering and Functionally Engineered Materials, Peter Martin; Wiley, 2011
2. Materials degradation and its control by surface engineering, A. W. Batchelor, L. N. Lam and M. Chandrasekaran, Imperial college press
3. Tribology for Scientists and Engineers", Pradeep L. Menezes, "Springer, 2013
4. Handbook, Friction, Lubrication and Wear Technology, Vol. 18, ASM
5. Krishna, R., Anantraman, T.R., Pande, C.S., Arora, O.P., Advanced techniques for microstructural characterization (ed), Trans Tech Publication.

Other Resources

1. https://archive.nptel.ac.in/courses/112/107/112107248/

SRM University *AP*, Andhra Pradesh
Neerukonda, Mangalagiri Mandal,
Guntur District, Mangalagiri, Andhra Pradesh – 522240.

Sustainable Manufacturing

Course Code	MMT 502	**Course Category**	CC	**L**	**T**	**P**	**C**
				3	0	1	4
Pre-Requisite Course(s)		**Co-Requisite Course(s)**		**Progressive Course(s)**			
Course Offering Department	Mechanical Engineering	**Professional / Licensing Standards**					

Course Objectives / Course Learning Rationales (CLRs)

1. Understand the concept of Sustainable manufacturing
2. Understand the several techniques of the Precision Machining processes
3. Understand the advanced welding processes with their applications
4. Understand the metal forming processes, surface modification techniques and additive manufacturing processes

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	**Bloom's Level**	**Expected Proficiency Percentage**	**Expected Attainment Percentage**
Outcome 1	Define and articulate the core principles of sustainable manufacturing	3	75%	70%
Outcome 2	Identify various precision manufacturing technologies	2	80%	65%
Outcome 3	Distinguish various advanced welding processes based on principle of working	3	70%	65%
Outcome 4	Distinguish various metal forming processes and surface modification techniques based on principle of working	2	80%	75%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	**Program Learning Outcomes (PLO)**												
	Engineering Knowledge	**Design / Development of Solutions**	**Conduct Investigations of Complex Problems**	**Modern Tools and ICT Usage**	**The Engineer and Society**	**Environment and Sustainability**	**Ethics**	**Individual and Teamwork Skills**	**Communication Skills**	**Life-long Learning**	**PSO 1**	**PSO 2**	**PSO 3**
Outcome 1	3	1	3	2				1		3	3	2	3
Outcome 2	3	1	3	2				2		3	2	3	2
Outcome 3	3	1	3	2				2		3	3	3	3
Outcome 4	3	1	3	2				2		3	3	3	2
Average	3	1	3	2				2		3	3	3	3

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Introduction to Sustainable Manufacturing, Sustainability, Clean Technologies, Industrial Ecology, Lean & Green, Precision Machining: Ultra Precision turning and grinding: Chemical Mechanical Polishing (CMP), ELID process,	4	1	1,2
	Partial ductile mode grinding, Ultra precision grinding-Binder less wheel – Free form optics. aspherical surface generation Grinding wheel- Design and selection of grinding wheel-High-speed grinding High-speed milling-Diamond turning	4	1,2	1,3
	Micro Machining and Nano Fabrication: micro fabrication – types - top down– bottom up approaches, Micro Electro-Mechanical Systems (MEMS), LIGA process –lithography steps, X ray lithography – masks – mask materials.	4	1,2	1,3
	Micromachining – theory of micromachining – types – concepts – tools used in micromachining – micro EDM, micro wire cut EDM, micro ECM, micro EDG, AJMicro-M, water jet micromachining	4	1,2	1,2
Unit No. 2	Laser based micromachining – types of Lasers – diode, Excimer and Ti: Sapphire lasers – nanosecond pulse micro fabrications – shielding gas.	2	1,2	1,2
	Nano machining techniques- Sub micron lithographic technique, conventional film growth technique,	2	1,2	1,2,3
	Chemical etching, Quantum dot fabrication techniques	2	1,2	1
	MOCVD – Epitaxy techniques	1	1,2	1,2
Unit No. 3	Introduction to laser beam welding, Laser surfacing, laser hardening and cladding	2	3	1,2,3
	Electron beam welding, process, ultrasonic welding,	2	3	1,3
	Plasma arc welding, explosive welding,	2	3	1,2,3
	Cladding process, under water welding,	2	3	1,2,3
Unit No. 4	Surface modification Techniques: Physical and chemical vapour deposition techniques,	2	1,4	1,2
	Thermal spray coating processes, vacuum arc deposition	1	1,4	1,2
	Sputter deposition, surface hardening, e-beam, laser and plasma processing	2	1,4	1,2,3
	Diffusion bonding, hot isostatic pressing	1	1,4	1,2,3
Unit No. 5	Introduction forming processes, advantages, limitations and applications, Vacuum forming	2	4	3
	Explosive forming, and hydro forming, advantages and applications	2	4	1,2,3
	High velocity forming and Mar forming, advantages and applications,	2	4	1,2,3
	Electromagnetic forming, advantages and applications, Electro-hydraulic forming, Additive Manufacturing processes	2	4	1,2,3
	Total Contact Hours	**45**		

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Introduction to Sustainable manufacturing	2	1	1
	Introduction to various traditional sustainable manufacturing techniques	1	1	1
	Introduction to various casting process	2	1	1
	Introduction to various welding process	1	1	1
Unit No. 2	Design consideration for casting process	2	1	1
	Design consideration for welding process	2	1,2	1,2,3
	Arc welding experiment	1	1,2	4
	Sand casting experiment	1	1,2	4
Unit No. 3	Introduction to micro-machining process	1	1,2	1,2,3
	Introduction various surface modification techniques	2	1,2	1,2,3
	Make spur gear using wire electric discharge machining (WEDM)	1	1,2	4
	Experiment on electrochemical machining (ECM)	2	1,2	4
Unit No. 4	Experiment on Ultrasonic machining (USM)	1	1,2,3,4	4
	Experiment on laser beam welding (LBW)	1	1,2,3,4	4
	Experiment on ultrasonic welding (USW)	2	2,3	4
	Experiment on squeeze casting	2	3,4	4
Unit No. 5	Experiment on centrifugal casting	1	3,4	4
	Experiment on evaporative pattern casting	1	3,4	4
	Experiment on vacuum forming process	2	3,4	4
	Experiment on hydraulic forming	2	3,4	4

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								End Semester Exam (50%)	
		CLA-1 (10%)		CLA-2 (10%)		CLA-3 (15%)		Mid Term (15%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
	Understand	30%	30%	30%	30%	20%	30%	30%	30%	30%	30%
Level 2	Apply	10%	20%	30%	30%	20%	20%	30%	20%	20%	20%
	Analyse	40%	30%	20%	20%	40%	30%	20%	30%	30%	30%
Level 3	Evaluate										
	Create										
Total		**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Recommended Resources

1. P. N. Rao, "Manufacturing Technology", Mc Grawhill, 2017
2. Marc J. Madou, "Fundamentals of Microfabrication", Second Edition, CRC Press, 2002
3. V. K. Jain, "Advanced machining processes", Allied Publications, 2007
4. Sustainable Manufacturing Lab Manual, 2023

SRM University *AP*, Andhra Pradesh
Neerukonda, Mangalagiri Mandal,
Guntur District, Mangalagiri, Andhra Pradesh – 522240.

Materials for Manufacturing

Course Code	MMT 503	**Course Category**	CC	**L**	**T**	**P**	**C**
				3	0	1	4
Pre-Requisite Course(s)		**Co-Requisite Course(s)**		**Progressive Course(s)**			
Course Offering Department	Mechanical Engineering	**Professional / Licensing Standards**					

Course Objectives / Course Learning Rationales (CLRs)

1. Understand a broad range of Manufacturing processes
2. Select a suitable process (or sequence of processes) for the manufacture of a given component
3. Perform force and power calculations for manufacturing processes
4. Suggest changes in component design for the improvement of manufacturability

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Identify, formulate, and solve engineering problems relating to manufacturing	4	85%	75%
Outcome 2	Apply mathematics, basic science, and engineering science to the solution of manufacturing problems	2	85%	75%
Outcome 3	Design a component and select a manufacturing process or sequence of processes suitable for its production;	3	85%	70%
Outcome 4	Interpret the results of engineering investigations.	3	85%	70%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)												
	Engineering Knowledge	Design / Development of Solutions	Conduct Investigations of Complex Problems	Modern Tools and ICT Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Teamwork Skills	Communication Skills	Life-long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	3	1	3	2	2		3	3	3		2	3	3
Outcome 2	3	2	3	2	1		3	3	3		2	3	3
Outcome 3	3	2	3	2	2		3	3	3		2	3	3
Outcome 4	3	3	3	3	2		3	3	3		3	3	3
Average	3	2	3	3	2		3	3	3		2	3	3

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Special Steels -Metallurgical aspects, Composition, Properties and applications of: different types of Stainless steels, Dual phase steels, TRIP steels, Maraging steels, High speed steels, Hadfield steels, Free cutting steels, Ausformed steels, Tool Steels, manganese steels, chrome steels, electrical steels, bearing steels, spring steels, heat resistant steels, creep steels, HSLA steels and ODS steel etc.	6	1	1,2
	Alloy Cast Iron- Need of alloying. Silal, Nicrosilal, High silicon cast iron, Ni-hard, Heat resistant cast iron: Composition, Properties, and their applications	6	1	1
Unit No. 2	Models of various materials properties of composites:	3	2	1,3
	density, modulus, strength, specific heat, coefficient of thermal expansion,	3	2	1,3
	thermal conductivity and diffusivity, electrical conductivity and dielectric constant.	3	2	1,3
Unit No. 3	Metal casting; forging; wire drawing; extrusion; rolling; sheet metal shearing; bending; deep drawing; manufacturing with polymers and composites; powder metallurgy; material removal basics; tool wear and tool life; cutting tool materials; turning, milling, and drilling; grinding; non-traditional material removal processes; rapid prototyping; soldering; microelectronic component manufacturing.	**6**	**2**	**1,4**
Unit No. 4	Selection of matrices: physical and mechanical properties. Bonding mechanisms.	3	3	4
	Types of reinforcement distributions: uniform, gradient and surface. Factors in composite design. Structure-property relationships.	3	3	4
	Isotropic and anisotropic properties. Fabrication techniques: infiltration, casting, reaction sintering, electro-deposition, diffusion bonding, thermal and plasma spray forming, laser method,	3	3	4
	Powder forming, additive processes, crystal growth and physical vapour deposition. Testing and inspection methods. Laminated Composites, Sample level lamination, case studies.	3	3	4
Unit No. 5	Experimental techniques, compositional analyses (introduction) and qualification of composites.	3	4	2
	Instrumental characterization and introduction to advanced characterization techniques (XRD, XRF, ITFR, SEM, TEM, TGA etc). Non-Destructive Analyses of Composites.	3	4	1,3
	Total Contact Hours	**45**		

S. No.	Description of experiments	Required Contact Hours	CLOs Addressed	References Used
1	Performing plain turning, step turning and chamfering in Lathe	3	1	1-2
2	Performing taper turning by compound rest/offset method and drilling in Lathe	3	1	1-2
3	Performing External threading, Internal thread cutting and eccentric turning in Lathe.	2	1	1-2
4	Performing Taper boring and knurling in Lathe	2	1	1-2
5	Performing V block shaping in shaper machine	2	2	1-2
6	Performing Polygon milling in milling machine	2	3	1-2
7	Spur Gear cutting in milling machine	2	3	1-2
8	Helical Gear cutting in Hobbing machine	2	3	1-2
9	Performing surface grinding in Grinding machine	3	4	1-2
10	Performing cylindrical grinding in Grinding machine	3	4	1-2
11	Grinding of single point cutting tool in Tool and Cutter grinding machine	3	4	1-2
12	Preparation of Sand mould using solid/split pattern with loose-piece pattern	3	4	1-2
	Total Contact Hours	**30**		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)					End Semester Exam (50%)	
		Theory (30%)				Practical (20%)		
		CLA-1 (5%)	Mid-1 (15%)	CLA-2 (5%)	CLA-2 (5%)		Th 30%	Prac 20%
Level 1	Remember	60%	70%	60%	70%	30%	60%	50%
	Understand							
Level 2	Apply	40%	30%	40%	30%	70%	40%	50%
	Analyse							
Level 3	Evaluate							
	Create							
Total		**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Recommended Resources

1. S. Kalpakjian and S. R. Schmid, Manufacturing Processes for Engineering Materials, 4th Edition, Prentice Hall, 2003
2. Mikell P Groover, Fundamentals of Modern Manufacturing, Materials, Processes and Systems, 4 th Edition, JOHN WILEY & SONS, INC., 2010
3. Matthews, F. L. and Rawlings, R. D., "Composite Materials: Engineering and Science", Chapman & Hall, London, 1994.
4. Kainer, K.U., "Metal Matrix Composites: custom-made materials for automotive and aerospace engineering", Wiley-VCH, 2006.

Other Resources

1. A. Ghosh and A.K. Mallik, Manufacturing Science, 2nd Edition,2012.
2. P.N. Rao, Manufacturing Technology, 3rd Edition, Tata McGraw Hill Edu Pvt Ltd, 2012.

SRM University *AP*, Andhra Pradesh
Neerukonda, Mangalagiri Mandal,
Guntur District, Mangalagiri, Andhra Pradesh – 522240.

Production and operation management

Course Code	MMT 504	Course Category	CC	L	T	P	C
				3	0	0	3
Pre-Requisite Course(s)		Co-Requisite Course(s)		Progressive Course(s)			
Course Offering Department	Mechanical Engineering	Professional / Licensing Standards					

Course Objectives / Course Learning Rationales (CLRs)

1. To understand the fundamentals of production and operations management.
2. To learn about capacity planning, plant layout, scheduling, and sequencing
3. To learn about operation management, work-study, time study
4. To understand about Inventory control, supply chain management

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Define and explain the basic concepts and principles of production and operations management (POM)	1	80%	75%
Outcome 2	Develop proficiency in capacity planning, plant layout etc.	2	70%	75%
Outcome 3	Able to perform work study, time study, gantt chart	3	80%	70%
Outcome 4	Explain supply chain management functions and applications	2	80%	75%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)												
	Engineering Knowledge	Design / Development of Solutions	Conduct Investigations of Complex Problems	Modern Tools and ICT Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Teamwork Skills	Communication Skills	Life-long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	3	1	3	2		1		1		2	3	2	3
Outcome 2	3	2	3	2		1		1		2	3	2	3
Outcome 3	3	2	3	3		2		3		2	3	2	3
Outcome 4	3	3	3	2		2		1		2	3	3	3
Average	3	2	3	2		2		2		2	3	2	3

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Production planning and control	5	1	1
	New product development	3	1,2	1
Unit No. 2	Capacity planning, facility planning	2	1,2	1,2
	Plant location and layout	4	1,2	1,2
	Scheduling and sequencing	2	1,2	1,2
Unit No. 3	PERT, CPM	3	3	2
	Gantt chart	3	3	1
	Work study, time study	3	3	2
Unit No. 4	ABC analysis, EOQ	4	1	2
	Supply chain management	4	3,4	1
	Preventive maintenance	2	4	1,2
Unit No. 5	Six Sigma, Poka-yoke	2	4	1,2
	BPR, ERP	2	4	1,2
	Kanban, ISO 9000, JIT	3	2,4	1
	TQM, FMS, Push/Pull, Kaizen, CAD CAM	3	4	1,2
	Total Contact Hours	**45**		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								End Semester Exam (50%)	
		CLA-1 (10%)		CLA-2 (10%)		CLA-3 (15%)		Mid Term (15%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	20%	-	20%	-	20%	-	20%	-	20%	-
	Understand	30%	-	30%	-	20%	-	30%	-	30%	-
Level 2	Apply	10%	-	30%	-	20%	-	30%	-	20%	-
	Analyse	40%	-	20%	-	40%	-	20%	-	30%	-
Level 3	Evaluate										
	Create										
Total		**100%**		**100%**		**100%**		**100%**		**100%**	

Recommended Resources

1. S. K. Bhattacharyya, *Production and Operations Management*, 2nd edition, Universal Press
2. R. Panneerselvam, *Production and Operations Management*, Prentice Hall of India

SRM University *AP*, Andhra Pradesh
Neerukonda, Mangalagiri Mandal,
Guntur District, Mangalagiri, Andhra Pradesh – 522240.

COMMUNITY SERVICE AND SOCIAL RESPONSIBILITY

Course Code	VAC 502	**Course Category**	VAC	**L**	**T**	**P**	**C**
				0	0	2	2
Pre-Requisite Course(s)		**Co-Requisite Course(s)**		**Progressive Course(s)**			
Course Offering Department	CEL	**Professional / Licensing Standards**					

Course Objectives / Course Learning Rationales (CLRs)

1. Encourage initiatives that address local needs, foster self-sufficiency, and promote environmental sustainability within the community.
2. Equip participants with a deeper understanding of social issues and a sense of responsibility towards marginalized communities.
3. Inspire active participation in community service programs and foster a culture of giving back among individuals and organizations.
4. Develop and implement programs that contribute to skill development, economic empowerment, and equal opportunities for underprivileged sections of society.

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	**Bloom's Level**	**Expected Proficiency Percentage**	**Expected Attainment Percentage**
Outcome 1	Develop effective strategies for identifying and addressing community needs.	3	80%	80%
Outcome 2	Demonstrate empathy and cultural sensitivity when engaging with diverse community groups.	4	80%	75%
Outcome 3	Implement sustainable solutions and evaluate their impact on social well-being.	5	90%	85%
Outcome 4	Collaborate effectively within teams to design and lead community service projects.	6	90%	80%

Learning Assessment

Bloom's Level of Cognitive Task		**Continuous Learning Assessments 50%**				**End Semester Exam 50%**
		CLA-1 20%	**Mid-1 20%**	**CLA-2 20%**	**CLA-3 20%**	
Level 1	Remember	10%	10%			20%
	Understand					
Level 2	Apply		10%	10%		20%
	Analyse					
Level 3	Evaluate				10%	10%
	Create					
Total		**10%**	**20%**	**10%**	**10%**	**50%**

SRM University *AP*, Andhra Pradesh
Neerukonda, Mangalagiri Mandal,
Guntur District, Mangalagiri, Andhra Pradesh – 522240.

Research Seminar- II

Course Code	AEC 503	Course Category	AEC		L	T	P	C
					0	0	1	1
Pre-Requisite Course(s)		Co-Requisite Course(s)		Progressive Course(s)				
Course Offering Department	Mechanical Engineering	Professional / Licensing Standards						

Course Objectives / Course Learning Rationales (CLRs)

1. To learn how to prepare power point presentations effectively.
2. To learn the presentation skills and communications.
3. To gain knowledge through discussion.

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Describe the features and characteristics of seminars and presentations.	2	80%	80%
Outcome 2	Gain skills in methods of scientific presentations	2	65%	60%
Outcome 3	Respond to questions and answers effectively and manage conflict during the seminar	3	80%	75%
Outcome 4	Understand the basic structure of research paper	2	80%	75%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)												
	Engineering Knowledge	Design / Development of Solutions	Conduct Investigations of Complex Problems	Modern Tools and ICT Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Teamwork Skills	Communication Skills	Life-long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	3	3	1	3	2	2	2	3	3	3	3	2	3
Outcome 2	3	3	2	3	2	1	3	2	3	3	3	2	3
Outcome 3	3	3	2	3	2	2	3	2	3	3	3	2	3
Outcome 4	3	3	3	3	3	2	3	2	3	3	3	3	3
Average	3	3	2	3	2	2	3	2	3	3	3	2	3

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Research Seminar -Structure: Explanation of what is a seminar and what is expected during the seminar, followed by student presentations	**5**	1	**1**
Unit No. 2	Ways and tools of presentation in the research seminar: Discussion on tools for effective presentation	5	**1**	**1**
Unit No. 3	Presentation skills: Discussion and presentation demonstration: Handling questioning sessions of presentation	**7**	**2**	**2**
Unit No. 4	Handling questioning sessions of presentation How to answer the questions during the presentation. Student presentation and discussion	**8**	**2**	**3,4**
Unit No. 5	Conflict management during presentation: How to manage the conflicts during the presentation	**5**	**3**	**3**

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								End Semester Exam (50%)	
		CLA-1(15%)		CLA-2(10%)		CLA-3(10%)		Mid Term (15%)			
		Th	**Prac**	**Th**	**Prac**	**Th**	**Prac**	**Th**	**Prac**	**Th**	**Prac**
Level 1	Remember	40%		50%		60%		40%		50%	
	Understand										
Level 2	Apply	60%		50%		40%		60%		50%	
	Analyse										
Level 3	Evaluate										
	Create										
Total		**100%**		**100%**		**100%**		**100%**		**100%**	

Recommended Resources

1. Garr Reynolds Presentation Zen: Simple Ideas on Presentation Design and Delivery (ISBN: 0321811984)
2. Matt Carter Designing Science Presentations: A Visual Guide to Figures, Papers, Slides, Posters, and More (ISBN: 0123859697)
3. Vernon Booth, Communicating in Science: Writing a Scientific Paper and Speaking at Scientific Meetings (ISBN: 0521429153)

Course Designers

SRM University *AP*, Andhra Pradesh
Neerukonda, Mangalagiri Mandal,
Guntur District, Mangalagiri, Andhra Pradesh – 522240.

Entrepreneurial Mindset

Course Code	SEC 103	Course Category	SEC	L	T	P	C
				1	0	1	2
Pre-Requisite Course(s)		Co-Requisite Course(s)		Progressive Course(s)			
Course Offering Department	Management	Professional / Licensing Standards					

Course Objectives / Course Learning Rationales (CLRs)

1. To develop a foundation in innovation and entrepreneurship among the students
2. To enhance analytical skills of students for practical application of their ideas
3. To make students proficient in designing solutions
4. To introduce students to different phases of entrepreneurship.

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Describe and classify the basic concepts of Innovation and Entrepreneurship	2	90%	80%
Outcome 2	Discuss the concept of Design Thinking and prototyping	2	80%	70%
Outcome 3	Apply design thinking to generate innovative ideas and strategize implementation plan	3	65%	60%
Outcome 4	Prepare a business plan by assessing customer segment, market validation and product development	4	60%	60%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)														
	Engineering Knowledge	Problem Analysis	Design and Development	Analysis, Design and Research	Modern Tool and CT Usage	Society and Multicultural Skills	Environment and Sustainability	Moral, and Ethical Awareness	Individual and Teamwork Skills	Communication Skills	Project Management and Finance	Self-Directed and Life Long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	1	3	1	1	1			1			2		2	3	2
Outcome 2	2	2	2	2	2			2			1		3	2	2
Outcome 3	2	1	3	3				2	3		1	3	2	3	2
Outcome 4	2	3	2	3				2	3	2	3	3	3	3	3
Average	2	2	2	3	2			2	2	1	2	2	3	2	3

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Entrepreneurship and Types of Entrepreneurship	2	1	3,4
	Entrepreneurs and their Characteristics	1	1	3,4
	Innovation & its Types	2	1	1
	Structured exploration and quantifying the data	2	3,4	3,4
Unit No. 2	Analysing the data	1	3,4	3,4
	Summarizing facts and designing a workable model	3	3,4	3,4
	Definition and Basics of Prototyping	2	2,3,4	2
	Types and methods of Prototyping	4	2,3,4	2
Unit No. 3	Innovations in prototyping	2	2,3,4	2
	Importance of Idea	1	3,4	1,2
	Idea Generation Techniques	1	3,4	1,2
	Validating the idea	1	3,4	1,2
Unit No. 4	Definition and Basics of Design Thinking	2	2	5
	Stages of Design Thinking	3	2	5
	Concept of Market Validation and its importance	2	3,4	3,4
	Customer survey	1	3,4	3,4,5
Unit No. 5	Feedback and modifying the idea	2	3,4	3,4,5
	Customer segment and its types, Understanding niche customer segment, Reaching the real customers	4	4	3,4
	Industry validation and mentoring	2	3,4	3,4,5
	Generate an Innovative Idea, Develop a Business Plan	8	3,4	1,2,3,4,5

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								End Semester Exam (50%)	
		CLA-1 (10%)		CLA-2 (10%)		CLA-3 (0%)		Mid Term (15%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	90		50				60		40	
	Understand										
Level 2	Apply	10		50				40		60	
	Analyse										
Level 3	Evaluate										
	Create										
Total		**100%**		**100%**		**100%**		**100%**		**100%**	

Recommended Resources

1. Larry Keeley Brian Quinn Ryan Pikkel, Ten types of innovation -the discipline of building breakthroughs, John Wiley& Sons, Inc; 2013
2. Eric Ries, The lean startup how constant innovation creates radically successful businesses, Penguin Books, 2022
3. Bruce R. Barringer, R. Duane Ireland, Entrepreneurship Successfully Launching New Ventures, Pearson; 2020
4. Robert D. Hasrich, Dean A. Shepherd, Michael P. Peters, Entrepreneurship, McGraw Hill, 2020
5. N Siva Prasad, Design Thinking : Techniques And Approaches, Ane Books, New Delhi; 2023

Course Designers

SRM University *AP*, Andhra Pradesh
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Guntur District, Mangalagiri, Andhra Pradesh – 522240.

Advanced Materials Processing Technologies

Course Code	MMT 505	Course Category	CC	L	T	P	C
				3	0	1	4
Pre-Requisite Course(s)		Co-Requisite Course(s)		Progressive Course(s)			
Course Offering Department	Mechanical Engineering	Professional / Licensing Standards					

Course Objectives / Course Learning Rationales (CLRs)

1. To learn the principle and methodology of the metal casting and powder production process.
2. To introduce the principle and practice of the metal joining process.
3. To introduce a methodology for varying microstructures to meet a range of properties.
4. To understand the fabrication and characteristics of conventional and novel composite

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Describe the principles and methods to produce material by as-cast and powder processing routes..	2	80%	70%
Outcome 2	Define, classify, and sketch the various welding processes and defects.	2	70%	70%
Outcome 3	Development of methods using mechanical working and heat treatment effectively	3	70%	70%
Outcome 4	Describe the method of preparation of composites and determine their properties	2	70%	70%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)												
	Engineering Knowledge	Design / Development of Solutions	Conduct Investigations of Complex Problems	Modern Tools and ICT Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Teamwork Skills	Communication Skills	Life-long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	3	3	1	3				3	3	3	3	2	3
Outcome 2	3	3	2	3				3	3	3	3	2	3
Outcome 3	3	3	2	3				3	3	3	3	2	3
Outcome 4	3	3	3	3				3	3	3	3	3	3
Average	3	3	2	3				3	3	3	3	2	3

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Course Unitization Plan (Theory)

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Introduction to metal casting processes, Pattern making, moulding methods (sand), material, and processes with special references to patterns, sands, and binders. Design of gating etc	2	1	1
	Segregation during casting: its effect and remedial measures. Melt treatment – degassing, grain refining, filtration etc.	2	1	1
	Casting processes: Die casting, investment casting, Squeeze casting, Thixo casting, Rheocasting.	1	1	1
	Solidification: Thermodynamics of homogeneous and heterogeneous nucleation and kinetics of growth. Interface morphologies.	3	1	1
	Heat treatment of cast alloys. Casting defects and remedies, comparison of casting methods.	1	1	1
Unit No. 2	Introduction to metal joining processes: Principles to Soldering, Brazing and Welding.	**1**	2	**2**
	Types of fusion welding processes, gas welding, solid state welding,	**2**	2	**2**
	Special welding processes, such as friction stir welding, electron beam welding and ultrasonic welding.	**2**	2	**2**
	Metallurgical principles involved in welding of carbon, alloy steels and important nonferrous alloys such as aluminium and magnesium-based alloys.	**2**	2	**2**
	Welding defects and their remedies: microstructural features of Heat Affected Zone (HAZ) and their effect on mechanical properties.	**2**	2	2
Unit No. 3	Hot deformation processes, Microstructural evolution, Recovery, Recrystallization, Dynamic recrystallization,	**2**	3	**3**
	SPD-based thermo-mechanical processes, friction stir processing, equal channel angular processing, and high-pressure torsion case study.	**2**	3	**3**
	Flow curves as a function of strain rate and temperature, Stress, strain, strain rate sensitivity	**2**	3	**3**
	Thermo-chemical surface treatments	**2**	3	**3**
Unit No. 4	Introduction to composites, types of reinforcements, matrix materials, matrix and reinforcement interfaces	2	4	**4**
	Polymer composites, thermosetting and thermoplastic composites, ceramics	2	4	4
	Fibre-reinforced ceramics, metal matrices,	2	4	**4**
	Micro and Macro Mechanics of composites, monotonic strength and fracture, fatigue and creep	1	4	4
	Designing with composites, Nonconventional composites	1	4	**4**
Unit No. 5	Production of metal powders, recent developments in powder production, mechanical alloying.	2	1	**5**
	Development of nanostructures and composite materials via powder processing route.	2	1	**5**
	Characteristics of powders,	2	1	**5**
	Compaction in rigid dies, hot and cold isostatic compaction.	1	1	**5**
	Mechanisms involved in the sintering of metal powders,	2	1	**5**
	Dispersion and solution processes like shape casting, extrusion, injection molding, tape casting, and application of powder metallurgy products.	2	1	**5**
	Total Contact Hours	**45**		

Course Unitization Plan (Laboratory)

Sl. No.	Description of experiments	Required Contact Hours	CLOs Addressed	References Used
	Preparing materials by melting casting and powder processing Welding of Materials Characterization of prepared materials and heat-affected zone (HAZ) Production of Composite by powder processing route Design a Method to Produce a new Material/Composite/Foams/Multicomponent alloy Mini Project based on any topic related to materials processing	30	1-5	1-5

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments								End Semester Exam (50%)	
		CLA-1 (15%)		CLA-2(10%)		CLA-3(10%)		Mid Term (15%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	30%		40%		40%		50%		40%	
	Understand		50%		20%		20%				30%
Level 2	Apply	70%	30%	60%	50%	60%	40%	50%		60%	30%
	Analyse		20%								20%
Level 3	Evaluate				30%		40%				20%
	Create										
Total		**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**		**100%**	**100%**

Recommended Resources

1. Principles of Metal Casting, 2nd Edition, by R W Heine, C R Loper and P C Rosenthal Tata-Mc-Graw Hill 2.
2. A textbook of Welding Technology by O P Khanna, Dhanpat Rai Publications
3. Thermomechanical processing of metallic Materials, Elsevier publisher, Edited by Robert W. Cahn
4. K.K. Chawla, (1998), Composite Materials, Springer-Verlag, New York
5. Powder Metallurgy – Science, Technology and Materials by A Upadhay, G S Upadhaya

Other Resources

1. https://www.youtube.com/playlist?list=PLLy_2iUCG87BImYCWOqwbGwY_4P62a35N

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Additive Manufacturing

Course Code	MMT 506	Course Category	CC	L	T	P	C
				3	0	1	4
Pre-Requisite Course(s)		Co-Requisite Course(s)		Progressive Course(s)			
Course Offering Department	Mechanical Engineering	Professional / Licensing Standards					

Course Objectives / Course Learning Rationales (CLRs)

1. To understand the basic principle and terminology of rapid prototyping
2. Understand the various techniques of the additive manufacturing.
3. Understand the optimum part deposition technique in 3D printing.
4. To understand the application of additive manufacturing in rapid tooling and reverse engineering.

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Define the concept of additive manufacturing and file formats required by additive manufacturing.	1	80%	75%
Outcome 2	Understand the unique capabilities and various techniques of Additive Manufacturing.	2	77%	70%
Outcome 3	Develop and slice CAD model for printing with any kind of Additive Manufacturing technique.	3	80%	70%
Outcome 4	Apply the additive manufacturing in the application ofrapid tooling and reverse engineering.	2	80%	75%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)												
	Engineering Knowledge	Design / Development of Solutions	Conduct Investigations of Complex Problems	Modern Tools and ICT Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Teamwork Skills	Communication Skills	Life-long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	3	1	3	2		1		1		2	3	2	3
Outcome 2	3	2	3	2		1		1		2	3	2	3
Outcome 3	3	3	3	3		2		3		2	3	2	3
Outcome 4	3	2	3	2		2		1		2	3	3	3
Average	3	2	3	2		2		2		2	3	2	3

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Rapid Prototyping - An Integral Part of Time Compression Engineering, Historical Development, Need of Additive Manufacturing Technology, Additive Manufacturing (AM) – Layered manufacturing, Principles of layer-based manufacturing	3	1	1,2,3,4
	AM process chain, Various data/file formats for AM, STL file, STL File Problems, STL File Repair, various technologies of AM	2	1,2	1,2,3,4
	Hierarchical Structure of Additive Manufacturing Processes, Integration of Additive Manufacturing in the Product Development Process,	2	1	1,2,3,4
	Advantages and limitations of AM, Applications	1	1	1,2,3,4
Unit No. 2	Classification of additive manufacturing processes, Guidelines for Process Selection, Common additive manufacturing technologies; Fused Deposition Modeling (FDM), Selective Laser Sintering(SLS),	3	1,2	1,2,3,4
	Stereo Lithography(SLA), Selection Laser Melting (SLM), Jetting, 3D Printing	2	1,2	1,2,3
	Laser Engineering Net Shaping (LENS), Laminated Object Manufacturing (LOM),	2	1,2	1,2,3
	Electron Beam Melting (EBM). Capabilities, materials, costs, advantages and limitations of different systems	1	1,2	1,2,3,4
Unit No. 3	Cad model preparation, Data interfacing for rapid prototyping Part orientation and support generation	3	3	1,2,3,4
	Model slicing and contour data organization	2	3	1,2,3,4
	Direct and adaptive slicing, A selective hatching strategy for AM,	2	3	1,2,3,4
	Tool path generation	3	3	1,2,3
Unit No. 4	Rapid Tooling - Classification and Definition, Properties of Additive Manufactured Tools, Indirect Rapid Tooling Processes like Metal Deposition Tools	3	1	1,2,3
	RTV Tools, Epoxy Tools, Ceramic Tools, Cast Metal Tools, Investment Casting, Fusible Metallic Core, Sand Casting	3	3,4	1,2,3
	Keltool™ Process, Direct Rapid Tooling Processes like Direct ACESTM Injection Moulds (AIMTM), Laminated Object Manufactured (LaM) Tools, DTM RapidToo1™ Process, SandForm™,	2	4	1,2,3,4
	EOS DirectTool™ Process, Direct Metal Tooling using 3Dp™. Applications of Rapid Tooling Technology	2	4	1,2,3,4
Unit No. 5	Reverse Engineering (PPT), Design Methodology in reverse engineering, 3D scanning	2	2,4	1,2,3,4
	3D Scanners and photogrammetry, Data Acquisition, Processing of Cloud Points,	2	2,4	1,2,3,4
	Data reduction: Data reduction in percentage, Data reduction by bounded error,	2	2,4	1,2,3
	Data Reduction Using Uniform Grids and non-uniform grids methods	3	2,4	1,2,3
	Total Contact Hours	45		

Lab Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Concepts of CAD, Algorithms used in design,	2	1	1
	Design of Assembly (Spur gear)	1	1	1
	Design of Assembly (Helical screw)	2	1	1
	Introduction to G Code	2	1	1
	Lab practice of Solid works software	1	1	1

Unit No. 2	What is a Mesh? Historical Review of 3DP	1	1,2	1,2,3,4
	From CAD to CAM, CAD Overview	1	1,2	1
	Introductory lecture on 3D printer and Rapid Prototyping	2	1,2	1,2,3,4
Unit No. 3	Introduction to different types of 3D Printers,	1	1,2	1,2,3,4
	Introduction to RepRap, Materials used for printing	1	1,2	1,2,3,4
	Design for 3DP, Understand the basics of G code generation	2	1,2	1,2,3,4
	CAM Skills, Mesh Repair	1	1,2	1,2,3,4
Unit No. 4	Basics of 3D Scanner, 3D Product to CAD model generation	1	1,2,3,4	1,2,3,4
	Get to Know the different Printers	1	1,2,3,4	1,2,3,4
	Installation of FDM Printer, bed levelling	1	2,3	1,2,3,4
	Filament loading and unloading, preheating, nozzle cleaning	1	3,4	1,2,3,4
Unit No. 5	Photopolymer Resin Selection	1	3,4	1,2,3,4
	Printing of complex components in SLA Printer	3	3,4	1,2,3,4
	Metal Powder and Process parameter selection of DED Process	1	3,4	1,2,3,4
	Practice on Bio-Printer and DED Printer	3	3,4	1,2,3,4
	Total Contact Hours	**30**		

Learning Assessment

Bloom's Level of Cognitive Task		**Continuous Learning Assessments (50%)**								**End Semester Exam (50%)**	
		CLA-1 (10%)		**CLA-2 (10%)**		**CLA-3 (15%)**		**Mid Term (15%)**			
		Th	**Prac**	**Th**	**Prac**	**Th**	**Prac**	**Th**	**Prac**	**Th**	**Prac**
Level 1	Remember	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
	Understand	30%	30%	30%	30%	20%	30%	30%	30%	30%	30%
Level 2	Apply	10%	20%	30%	30%	20%	20%	30%	20%	20%	20%
	Analyse	40%	30%	20%	20%	40%	30%	20%	30%	30%	30%
Level 3	Evaluate										
	Create										
Total		**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Recommended Resources

1. P N Rao, "CAD/CAM: Principles and Applications", Mc Graw Hill, 2017
2. Gibson, I., Rosen, D.W. and Stucker, B., "Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 2010.
3. Chua, C.K., Leong K.F. and Lim C.S., "Rapid prototyping: Principles and applications", second edition, World Scientific Publishers, 2010.
4. Liou, L.W. and Liou, F.W., "Rapid Prototyping and Engineering applications : A tool box for prototype development", CRC Press, 2011.

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Materials Characterisation Processes

Course Code	MMT 507	**Course Category**	CC		**L**	**T**	**P**	**C**
					3	0	1	4
Pre-Requisite Course(s)		**Co-Requisite Course(s)**		**Progressive Course(s)**				
Course Offering Department	Mechanical Engineering	**Professional / Licensing Standards**						

Course Objectives / Course Learning Rationales (CLRs)

1. To learn the sample preparation methods and sample handling.
2. To introduce the materials characterization tools and techniques.
3. To introduce instrumentation aspects of sophisticated characterization equipment.
4. To provide hands-on experience with the characterization techniques

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Describe principles and methods of sample preparation and characterization.	2	80%	75%
Outcome 2	Describe the microscopic and spectroscopy method of materials characterization	3	80%	70%
Outcome 3	Determine the crystal structure, phase, morphology, Chemistry, and properties of materials.	3	70%	65%
Outcome 4	Design and conduct experiments, gather data, analyze and interpret results.	3	80%	70%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)												
	Engineering Knowledge	Design / Development of Solutions	Conduct Investigations of Complex Problems	Modern Tools and ICT Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Teamwork Skills	Communication Skills	Life-long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	3	3	1	3			2	3	3	3	3	2	3
Outcome 2	3	3	2	3			3	2	3	3	3	2	3
Outcome 3	3	3	2	3			3	2	3	3	3	2	3
Outcome 4	3	3	3	3			3	2	3	3	3	3	3
Average	3	3	2	3			3	2	3	3	3	2	3

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Elements of quantitative metallography and sample preparation techniques.	1	1,2	1
	Image formation, resolving power, numerical aperture, empty magnification, depth of focus, components of microscopes	2	1,2	1
	Important lens defects and their correction, principles of phase contrast, interference, and polarized light microscopy.	2	1,2	1
	Introduction to materials, basics of crystal structure, planes, and direction, miller indices.	3	1,2	1
Unit No. 2	Production and properties of X-ray, absorption of X-rays and filters, X-ray - diffraction, diffraction methods.	2	1,3	2
	X-ray - diffraction intensities, factors affecting intensity, Working principles of diffractometer, counters, and cameras	2	1,3	2
	Indexing of XRD patterns. Precise lattice parameter determination, Analytical line profile fitting using various models.	3	3,4	2
	Chemical analysis by X-ray diffraction & fluorescence. determination of particle size and micro/macro strains.	2	3,4	2
Unit No. 3	Introduction to electron microscopes, basic electron scattering, concepts of resolution, Transmission electron microscope; Construction and working principles of transmission electron microscopes	4	2	3
	Image formation, resolving power, magnification, depth of focus, elementary treatment of image contrasts important lens defects, and their correction. Bright field and dark field images, electron energy loss spectroscopy	4	2	3
	Formation of selected area diffraction patterns, reciprocal lattice indexing of diffraction patterns, sample preparation techniques	6	1.2	3
	Scanning electron microscope; Rutherford backscattering spectrometry, construction, interaction of electrons with matter, modes of operation, image formation of plane and fractured surfaces, AFM, scanning probe microscopy.	6	2	1
Unit No. 4	Differential thermal analysis (DTA), differential scanning calorimetry (DSC), thermal gravimetric analysis (TGA), and dilatometry.	4	3,4	4
Unit No. 5	UV-VIS spectroscopy, Fourier transform infrared spectroscopy, Raman spectroscopy, and X-ray photoelectron spectroscopy.	4	2,4	1
	Total Contact Hours	**45**		

Course Unitization Plan (Lab)

Expt. No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
1	Optical microscopy and image analysis- Sample preparation, Qualitative and quantitative measurement of Ferrous and Non-Ferrous Materials micro-etching techniques for ferrous and non-ferrous alloys, dark/bright field imaging, differential interference contrast technique, phase contrast technique. Quantitative analysis. - Grain size analysis, Graphite flake size determination, Phase fraction, Nodularity and Pore size analysis c) To determine the hardness of the given Specimen using Vicker‟s hardness test.	8	4	1
2	X-ray Diffraction- Phase analysis of ferrous and non-ferrous materials, crystallite size calculation, residual stress calculation	3	4	2
3	Differential Scanning Calorimetry (DSC) Determining glass transition temperature of polymeric materials sample preparation, determination of thermodynamic parameters, measurements on precipitation-hardened Al alloys	3	4	4
4	Measurement of Coefficient of Thermal Expansion	2	4	4
4	Scanning electron microscopy: sample preparation techniques, secondary electron and backscattered electron imaging, point, line, and area mapping, X-ray mapping	4	4	1
5	Study micrographs of differently heat-treated materials and compare them	4	4	1
6	Transmission electron microscopy: sample preparation, bright/dark field imaging, Selected area diffraction and indexing	3	4	3
7	The spectroscopic method for the analysis of a sample	3	4	1
	Total Contact Hours	30		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								End Semester Exam (50%)	
		CLA-1 (15%)		CLA-2 (10%)		CLA-3(10%)		Mid Term (15%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	40%		50%		30%		40%		50%	
	Understand		20%		20%		20%				20%
Level 2	Apply	60%		50%		70%		60%		50%	
	Analyse		50%		50%		50%				50%
Level 3	Evaluate		30%		30%		30%				30%
	Create										
Total		100%	100%	100%	100%	100%	100%	100%		100%	100%

Recommended Resources

1. Encyclopedia of Materials Characterization, Surfaces, Interfaces, Thin Films,' Editors C. Richard Brundle, Charles A. Evans, Jr., Shaun Wilson, Butterworth-Heinemann, Boston, US
2. Element of X-ray diffraction, B D Cullity, Addison Wesley Publishing Company Inc.
3. Transmission electron microscopy" D.B. Williams and C. Barry Carter, 4 volumes, Springer, 1996. USA
4. Thermal Methods of Analysis, W. W. Wendlandt, John Wiley, 1974.

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Project Management

Course Code	MMT 508	**Course Category**	RDIP		**L**	**T**	**P**	**C**
					0	2	1	3
Pre-Requisite Course(s)		**Co-Requisite Course(s)**		**Progressive Course(s)**				
Course Offering Department	Mechanical Engineering	**Professional / Licensing Standards**						

Course Objectives / Course Learning Rationales (CLRs)

1. Understand Project Management Principles
2. Develop Planning and Organizational Skills
3. Enhance Communication and Leadership Abilities
4. Apply Project Management Tools and Techniques

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Demonstrate proficiency in applying project management principles and practices to real-world projects	1	80%	75%
Outcome 2	Create detailed project plans, schedules, and budgets, and successfully manage project execution and control processes	2	80%	70%
Outcome 3	Exhibit Team Leadership and Communication Skills	3	80%	70%
Outcome 4	Use project management software and tools to plan, monitor, and close projects	2	80%	75%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)												
	Engineering Knowledge	Design / Development of Solutions	Conduct Investigations of Complex Problems	Modern Tools and ICT Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Teamwork Skills	Communication Skills	Life-long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	2	1	2	1			1	1		3	2	3	2
Outcome 2	2	3	3	2			2	3		2	3	2	2
Outcome 3	3	3	2	2			2	3	3	3	2	3	2
Outcome 4	2	1	3	2			2	3	2	3	3	3	3
Average	3	2	2	2			2	2	2	2	3	2	3

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Introduction to Project Management- Definition and Importance, Project Life Cycle	3	1,2	1,2,3
	Project Initiation- Project Selection Criteria, Feasibility Studies	3	1	1,2,3
	Project Planning- Defining Project Scope, Work Breakdown Structure (WBS)	2	1	1,2,3
	Project Scheduling- Gantt Charts and Milestones, Critical Path Method (CPM)	2	1	1,2,3
Unit No. 2	Project Cost Management- Budgeting and Cost Estimation, Cost Control Techniques	2	2	1,2
	Resource Management, Human Resource Planning, Resource Allocation and Optimization	2	1,2,3,4	1,2
	Risk Management- Risk Identification and Analysis, Risk Mitigation Strategies	3	1,3	1,2,3
	Project Quality Management - Quality Planning and Assurance, Quality Control Tools and Techniques	2	1,3	1,2,3
Unit No. 3	Project Communication - Communication Planning, Stakeholder Engagement	2	2,3	1,2,3
	Project Procurement Management- Procurement Planning, Vendor Selection and Management	3	2,3,4	1,2
	Project Integration Management- Project Plan Development, Project Execution and Monitoring	3	1,4	1,2,3
	Project Monitoring and Control - Performance Measurement, Change Control Process	2	1	1,2
Unit No. 4	Project Closure - Closing Process and Documentation, Post-Project Evaluation	2	1	1,2,3
	Agile Project Management- Agile Principles and Methodologies, Scrum Framework	2	2	1,2,3
	Project Management Software Tools- Overview of PM Software, Practical Applications and Case Studies	2	4	1,2,3
	Leadership and Team Building- Leadership Styles and Techniques, Building and Leading Effective Teams	2	2,4	1,2,3
Unit No. 5	Ethical Considerations in Project Management- Ethical Decision-Making, Professional Responsibility	2	2,4	1,2,3
	Cultural and Global Project Management- Managing Cross-Cultural Teams, Global Project Challenges	2	1,2	1,2,3
	Project Management Trends and Innovations - Emerging Trends in PM, Technological Advancements	2	1,4	1,2,3
	Capstone Project- Real-World Project Simulation, Presentation and Evaluation	2	1,4	1,2,3
	Total Contact Hours	**45**		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								End Semester Exam (50%)	
		CLA-1 (10%)		CLA-2 (10%)		Project (15%)		Mid Term (15%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	90		50		40		60		40	
	Understand										
Level 2	Apply	10		50		60		40		60	
	Analyse										
Level 3	Evaluate										
	Create										
Total		**100%**		**100%**		**100%**		**100%**		**100%**	

Recommended Resources

1. Kerzner, H., "Project Management: A Systems Approach to Planning, Scheduling, and Controlling," Wiley, 2017.
2. Meredith, J. R., Shafer, S. M., & Mantel, S. J., "Project Management: A Managerial Approach," Wiley, 2017.

SRM University *AP*, Andhra Pradesh
Neerukonda, Mangalagiri Mandal,
Guntur District, Mangalagiri, Andhra Pradesh – 522240.

Thesis I

Course Code	MMT 509	Course Category	RDIP		L	T	P	C
					0	0	14	14
Pre-Requisite Course(s)		Co-Requisite Course(s)		Progressive Course(s)				
Course Offering Department	Mechanical Engineering	Professional / Licensing Standards						

Course Objectives / Course Learning Rationales (CLRs)

1. To learn how to define the research objective.
2. To acquire skills to solve the problem statement.
3. To learn how to prepare scientific presentations.
4. To develop skills for project management and writing scientific reports

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Formulate research objective	2	80%	80%
Outcome 2	Describe the method (experiments or simulation to attain the objective) and its principle.	2	85%	70%
Outcome 3	Analyse the results and describe the research outcome through the presentation	3	95%	90%
Outcome 4	Learn how to write a thesis and manuscript.	2	90%	85%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)												
	Engineering Knowledge	Design / Development of Solutions	Conduct Investigations of Complex Problems	Modern Tools and ICT Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Teamwork Skills	Communication Skills	Life-long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	3	3	1	3	2	2	2	3	3	3	3	2	3
Outcome 2	3	3	2	3	2	1	3	2	3	3	3	2	3
Outcome 3	3	3	2	3	2	2	3	2	3	3	3	2	3
Outcome 4	3	3	3	3	3	2	3	2	3	3	3	3	3
Average	3	3	2	3	2	2	3	2	3	3	3	2	3

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	**Definition of Problem**: Clearly articulating the problem that the project aims to solve, Describing the current state of affairs and why a solution is necessary	60	1	1
Unit No. 2	Methods: Application of various methods and approaches to ensure the successful execution of the Project	90	2	2
Unit No. 3	Description of Results: The results must be interpreted using appropriate software, tools, and techniques. Validation of results with standard database	100	3	3
Unit No. 4	Poster Presentation: Making a scientific presentation of the results obtained with appropriate reasoning.	70	3	3
Unit No. 5	Writing of manuscript or thesis. Obtained results are summarized in the form thesis/manuscript/report	100	4	4,5
	Total Contact Hours	**420**		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (__%)								End Semester Exam (50%)	
		CLA-1 (15%)		CLA-2 (10%)		CLA-3 (10%)		Mid Term (15%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember										
	Understand		70%		60%		50%		50%		40%
Level 2	Apply										
	Analyse		30%		30%		30%		30%		30%
Level 3	Evaluate				10%		10%		10%		10%
	Create						10%		10%		20%
Total			**100%**		**100%**		**100%**		**100%**		**100%**

Recommended Resources

1. Problem-Solving for Engineers and Scientists: A Creative Approach (https://doi.org/10.1007/978-1-4615-3906-3)
2. Characterization of Materials (Materials Science and Technology: A Comprehensive Treatment, Vol 2A & 2B, VCH (1992).
3. Matt Carter Designing Science Presentations: A Visual Guide to Figures, Papers, Slides, Posters, and More (ISBN: 0123859697)
4. Article, how to write consistently boring scientific literature by Kaj Sand-Jensen. doi/10.1111/j.0030-1299.2007. 15674.x.

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Industrial Practice/Internship

Course Code	MMT 510	Course Category	RDIP		L	T	P	C
					0	0	3	3
Pre-Requisite Course(s)		Co-Requisite Course(s)		Progressive Course(s)				
Course Offering Department	Mechanical Engineering	Professional / Licensing Standards						

Course Objectives / Course Learning Rationales (CLRs)

1. To gain practical experience: engage in real-world industrial problems, and gain hands-on experience in the field.
2. To develop professional skills: communication, teamwork, time management, and technical proficiency in relevant software and equipment.
3. To understand industry practices and standards
4. To foster networking opportunities

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Gain hands-on experience in industrial problems	2	80%	70%
Outcome 2	Develop various professional skills	2	70%	70%
Outcome 3	Understand the industry practices and standards and develop new solutions	3	80%	70%
Outcome 4	Make various networks with industry professionals, Explore various career opportunities	3	70%	65%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)												
	Engineering Knowledge	Design / Development of Solutions	Conduct Investigations of Complex Problems	Modern Tools and ICT Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Teamwork Skills	Communication Skills	Life-long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	2		3	2			1	2		1	1	2	2
Outcome 2	1		1	1			3	1		2	2	2	1
Outcome 3	3		2	2			1	2		1	2	2	1
Outcome 4	1		1	1			2	1		2	2	2	1
Average	2		2	2			2	2		2	2	2	2

Course Unitization Plan

Unit No.	Syllabus topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1 Definition of Problem	Clearly articulating the problem that the project aims to solve, Describing the current state of affairs and why a solution is necessary	15	1,3	1
Unit No. 2 Method	Application of various methods and approaches to ensure successful execution of Project	15	1,3	1
Unit No. 3 Description of results	The obtained results must be interpreted utilising appropriate software, tools, and techniques.	15	3	1
Unit No. 4 Project Presentation and thesis report	Making a scientific presentation of the results obtained with appropriate reasoning. Obtained results is summarized in the form thesis/manuscript/report	15	2,3	1
Unit No. 5 Interaction with company and feedback	Communicate the results and seek feedback. Review the results with the supervisor and discuss about future engagements with the company.	30	4	1

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments Report (50%)	Presentation (50%)
Level 1	Remember		
	Understand	30%	30%
Level 2	Apply	60%	30%
	Analyse		20%
Level 3	Evaluate	10%	20%
	Create		
Total		**100%**	**100%**

Recommended Resources

1. Industry Manuals, Guidelines from the university

Course Designers

SRM University *AP*, Andhra Pradesh
Neerukonda, Mangalagiri Mandal,
Guntur District, Mangalagiri, Andhra Pradesh – 522240.

Thesis - II

Course Code	MMT 511	Course Category	RDIP	L	T	P	C
				0	0	15	15
Pre-Requisite Course(s)		Co-Requisite Course(s)		Progressive Course(s)			
Course Offering Department	Mechanical Engineering	Professional / Licensing Standards					

Course Objectives / Course Learning Rationales (CLRs)

1. To learn how to define the research objective.
2. To acquire skills to solve the problem statement.
3. To learn how to prepare scientific presentations.
4. To develop skills for project management and writing scientific reports

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Formulate research objective	2	80%	80%
Outcome 2	Describe the method (experiments or simulation to attain the objective) and its principle.	2	85%	70%
Outcome 3	Analyse the results and describe the research outcome through the presentation	3	95%	90%
Outcome 4	Learn how to write a thesis and manuscript.	2	90%	85%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)												
	Engineering Knowledge	Design / Development of Solutions	Conduct Investigations of Complex Problems	Modern Tools and ICT Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Teamwork Skills	Communication Skills	Life-long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	3	3	1	3	2	2	2	3	3	3	3	2	3
Outcome 2	3	3	2	3	2	1	3	2	3	3	3	2	3
Outcome 3	3	3	2	3	2	2	3	2	3	3	3	2	3
Outcome 4	3	3	3	3	3	2	3	2	3	3	3	3	3
Average	3	3	2	3	2	2	3	2	3	3	3	2	3

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Definition of Problem: Clearly articulating the problem that the project aims to solve, Describing the current state of affairs and why a solution is necessary	**30**	**1**	**1**
Unit No. 2	Methods: Application of various methods and approaches to ensure the successful execution of the Project	**70**	**2**	**2**
Unit No. 3	Description of Results: The results must be interpreted using appropriate software, tools, and techniques. Validation of results with standard database	**100**	**3**	**3**
Unit No. 4	Poster Presentation: Making a scientific presentation of the results obtained with appropriate reasoning.	**100**	**3**	**3**
Unit No. 5	Writing of manuscript or thesis. Obtained results are summarized in the form thesis/manuscript/report	**150**	**4**	**4**
	Total Contact Hours	**450**		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								End Semester Exam (50%)	
		CLA-1 (20%)		CLA-2 (10%)		CLA-3		Mid Term (20%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember										
	Understand		70%		60%				50%		50%
Level 2	Apply										
	Analyse		30%		40%				30%		30%
Level 3	Evaluate								20%		
	Create										20%
Total			**100%**		**100%**				**100%**		**100%**

Recommended Resources

1. Problem-Solving for Engineers and Scientists: A Creative Approach (https://doi.org/10.1007/978-1-4615-3906-3)
2. Characterization of Materials (Materials Science and Technology: A Comprehensive Treatment, Vol 2A & 2B, VCH (1992).
3. Matt Carter Designing Science Presentations: A Visual Guide to Figures, Papers, Slides, Posters, and More (ISBN: 0123859697)
4. Article, how to write consistently boring scientific literature by Kaj Sand-Jensen. doi/10.1111/j.0030-1299.2007. 15674.x.

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Analysis of Machining processes

Course Code	MMT 530	**Course Category**	CE		**L**	**T**	**P**	**C**
					3	0	1	4
Pre-Requisite Course(s)		**Co-Requisite Course(s)**	Manufacturing Processes	**Progressive Course(s)**				
Course Offering Department	Mechanical Engineering	**Professional / Licensing Standards**						

Course Objectives / Course Learning Rationales (CLRs)

1. Comprehensive Understanding of Machining Processes
2. Analyze cutting surface finish, temperatures, and tool wear
3. Analyze Machining Parameters for Efficiency and Quality
4. Understand Advanced Machining Techniques

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	**Bloom's Level**	**Expected Proficiency Percentage**	**Expected Attainment Percentage**
Outcome 1	Describe machining, classification of the machining processes, concept of orthogonal and oblique cutting	1	80%	75%
Outcome 2	Explain the single-point tool geometry, tool specification systems	2	75%	70%
Outcome 3	Describe theory of metal cutting, thermal aspects and friction in metal cutting	3	80%	70%
Outcome 4	Explain abrasive machining processes	2	80%	75%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	**Program Learning Outcomes (PLO)**												
	Engineering Knowledge	**Design / Development of Solutions**	**Conduct Investigations of Complex Problems**	**Modern Tools and ICT Usage**	**The Engineer and Society**	**Environment and Sustainability**	**Ethics**	**Individual and Teamwork Skills**	**Communication Skills**	**Life-long Learning**	**PSO 1**	**PSO 2**	**PSO 3**
Outcome 1	3	1	3	2		1		1		2	3	2	3
Outcome 2	3	2	3	2		1		1		2	3	2	3
Outcome 3	3	3	3	3		2		3		2	3	2	3
Outcome 4	3	2	3	2		2		1		2	3	3	3
Average	3	2	3	2		2		2		2	3	2	3

Course Unitization Plan Theory

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	The influence of the material selection on the machinability and the interaction with other method groups such as casting, forging and joining (welding).	3	1	1,2
	Classification of cutting processes., Cutting- and process data., Application areas for metal cutting, Theoretical surface roughness during machining processes, Chip thickness parameters.	2	1,2	1,2
	Cutting Tool materials, coating and selection, tool life, tool wear.	2	1	1,2
	Basic tool kinematics and chip formation. Intro to chip formation models.	1	1	1
Unit No. 2	Single-point tool geometry,	1	1,2	1,2,3
	Tool specification systems and establish tool angle relationships in ASA, ORS and NRS system.	4	1,2	1,2,3
	Conversion of tool angles from different systems.	2	1,2	1,2,3
	Mechanical analysis of the machining process: Static cutting forces and their measurement, Modeling of cutting forces,	2	1,2	1,2,3
Unit No. 3	Cutting resistance and specific cutting force. Intermittent machining processes, Dynamic effects during intermittent machining, Tool stresses.	2	3	1,2,3
	Thermal analysis of the machining process: Energy development during the machining process, The adiabatic temperature, The temperature of the machining process, Introduction to time dependent temperature fields. Cutting temperatures, empirical models for measuring cutting temperature, cooling strategies and type of coolants.	4	3	1,2,3,4
	Tribological analysis of the machining process: Contact conditions during the machining process, Built-up edges, layers and TPL-principles Tool wear models and tool life models	2	3	1,2,3
	Introduction to Archard's wear model, Taylor's equation, Colding's equation. Type of cutting tool wear, measurement of wear and tool life studies.	2	3	1,2,3
Unit No. 4	Surface Finish and Integrity: Introduction to surface integrity, Introduction to burr formation, surface roughness models.	3	1	1,2,3
	Machinability: Machinability definition, Machinability of selected workpiece materials,	3	3,4	1,2,3,4
	Abrasive machining processes such as grinding, honing	2	4	1,2,3
	lapping and understanding the mechanics of the grinding process.	2	4	1,2,3
Unit No. 5	Reverse Engineering (PPT), Design Methodology in reverse engineering, 3D scanning	2	4	1,2,3
	3D Scanners and photogrammetry, Data Acquisition, Processing of Cloud Points,	2	4	1,2,3
	Data reduction: Data reduction in percentage, Data reduction by bounded error,	2	2,4	1,2,3
	Data Reduction Using Uniform Grids and non-uniform grids methods	2	4	1,2,3
	Total Contact Hours	**45**		

Course Unitization Plan Lab

S. No.	Description of experiments	Required Contact Hours	CLOs Addressed	References Used
1	Machine tools, nomenclature and specifications	3	1	4
2	Practice on turning, facing and thread cutting	3	1	4
3	Identifying unknown tool angles using tool nomenclature in ASA, ORS and NRS system using drawing sheet	4	1	4
4	Calculating machining time in turning, facing, shaper and planer	3	1	4
5	Investigate chip morphology at different cutting conditions	3	4	4
6	Investigate the MRR in machining process	3	3	4,5
7	Investigating surface finish in machining process	3	3	4,5
8	Investigating tool temperature in machining process	3	3	4,5
9	Tool life studies in machining process	3	4	4,5
	Total Contact Hours	**30**		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								End Semester Exam (50%)	
		CLA-1 (10%)		CLA-2 (10%)		CLA-3 (15%)		Mid Term (15%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
	Understand	30%	30%	30%	30%	20%	30%	30%	30%	30%	30%
Level 2	Apply	10%	20%	30%	30%	20%	20%	30%	20%	20%	20%
	Analyse	40%	30%	20%	20%	40%	30%	20%	30%	30%	30%
Level 3	Evaluate										
	Create										
Total		**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Recommended Resources

1. G K Lal, Introduction to Machining Science, 3rd edition, New Age International Pvt Ltd., 2007.
2. A Ghosh and A K Mallik, Manufacturing Science, 2nd edition, Affiliated East-West Press Pvt. Ltd., 1986.
3. G Boothroyd and W. A. Knight, Fundamentals of Machining and Machine Tools, CRC-Taylor and Francis, 2006.
4. A Bhattacharya, Metal Cutting: Theory and Practice, New Central Book Agency, 2012.
5. Analysis of Machining processes, Lab Manual, 2023

SRM University *AP*, Andhra Pradesh

Neerukonda, Mangalagiri Mandal,
Guntur District, Mangalagiri, Andhra Pradesh – 522240.

Lasers in Manufacturing

Course Code	MMT 531	Course Category	CE	L	T	P	C
				3	0	1	4
Pre-Requisite Course(s)		Co-Requisite Course(s)		Progressive Course(s)			
Course Offering Department	Mechanical Engineering	Professional / Licensing Standards					

Course Objectives / Course Learning Rationales (CLRs)

1. Understand the Principles of Laser Technology
2. Explore Laser Material Interaction
3. Apply Laser-Based Manufacturing Processes
4. Analyze and Optimize Economics of Laser Applications in Manufacturing

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Define and explain the fundamental principles of laser technology	1	80%	75%
Outcome 2	Gain insight into the interaction between lasers and materials	2	70%	75%
Outcome 3	Develop proficiency in applying lasers for various manufacturing processes	3	80%	70%
Outcome 4	Understand the importance of process monitoring, economics and control in laser-based manufacturing to ensure consistent, high-quality and economical results.	2	80%	75%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)												
	Engineering Knowledge	Design / Development of Solutions	Conduct Investigations of Complex Problems	Modern Tools and ICT Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Teamwork Skills	Communication Skills	Life-long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	3	2	2	3				3		3	3	2	3
Outcome 2	3	2	3	3				3		3	3	2	3
Outcome 3	3	2	3	3				3		3	3	2	3
Outcome 4	3	3	3	3				3		3	3	3	3
Average	3	3	3	3				3		3	3	2	3

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Introduction to Lasers: Basic principle of laser generation	2	1	1
	Stimulated Emission; Properties of laser beam	1	1	1,2
	Industrial, medical and scientific applications of Laser	2	1	1,2
	Basic concept of the Laser System: Gain Medium	1	1	1,2
	Optical Resonator, Pump Source, Laser beam delivery systems	2	1	1,2
Unit No. 2	Introduction and basic fundamentals and characteristics of different industrial lasers: He-Ne, CO2, Nd:YAG	2	1	1
	Excimer, Fiber, Diode and Ultra-short pulse lasers;	2	1,2	1,2,3
	Laser processing fundamentals: Laser beam interaction with metal	2	1,2	1,2,3
	Semiconductor and insulator;	1	1,2	1,2,3
	Ultra-short laser pulse interaction; heat flow theory;	1	1,2	1,2,3
Unit No. 3	Laser Material Processing Applications; process characteristics,	2	3	3,4
	Mode of material removal: Laser Cutting and Drilling;	2	3	3,4
	Laser Welding; Laser Surface Modifications; Laser Additive Manufacturing;	2	3	3,4,5,6
	Laser Metal Forming; Laser shock peening; Laser Etching and Paint Striping; LCVD and LPVD;	2	3	3,4,5,6
	Laser hybrid machining	1	3	3,4,5
Unit No. 4	Liquid assisted laser machining: applications and advantages;	3	3,4	3,4,5
	Overview of Industrial & Scientific Applications of laser: Metrological applications,	4	3,4	3,4,5
	Holography (Non-destructive Testing), Laser Isotope Separation, Laser fusion	3	3,4	4,5,7
Unit No. 5	Theoretical modeling of laser material processing;	3	3,4	4,5,7
	Economics of Laser Applications in Manufacturing,	3	3,4	4,5
	Laser Based Additive Manufacturing	3	3,4	4,5,7
	Total Contact Hours	**45**		

Laboratory Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Introduction to Laser Technology	1	1	1
	Overview of laser principles, Laser safety guidelines	1	1	1
	Types of lasers and their characteristics, Personal protective equipment (PPE), Emergency procedures	1	1	1
	Understanding the Essentials of Laser Behavior & Applications of lasers in material processing	2	1	1
	Exploration of Laser-Induced Material Interaction	1	1	1
	Investigating the Precision and Accuracy of Laser-Based Manufacturing Processes	2	1	1
Unit No. 2	Laser Application in Material Removal and Joining Process	1	1	1,2,3
	Optimizing Laser Parameters for Metal Engraving	1	1	1,2,3
	Investigating the Effects of Laser Power on Polymer Cutting Precision	2	1	1
	Characterization of Weld Quality in Laser Welded Stainless Steel Joints	2	1,2	1,2,3
	Optimizing Laser Beam Welding Parameters for Enhanced Joining Performance	1	1,2	1,2,3
	Comparative Study of Laser Drilling Techniques in Composite Materials	1	1,2	1,2,3
Unit No. 3	Laser Application in Surface Modification Process	1	1,2	1,2,3
	Laser Heat Treatment of Titanium Alloys for Improved Mechanical Properties	1	2,3,4	2,3

	Assessment of Laser Cladding for Wear Resistance Enhancement in Tool Steel	2	2,3	2,3
	Surface Texture Modification of Polymers via Laser Surface Ablation	2	2,3,4	2,3
	Assessing the Impact of Laser Power and Focus on Manufacturing Quality	1	2,3,4	2,3
Unit No. 4	Laser Application in Additive Manufacturing	1	2,3,4	2,3
	Studying the Impact of Laser parameters on Microstructure in Additive Manufacturing Products	2	3	2,3
	Laser Additive Manufacturing of Complex Geometries in Aerospace Alloys	2	3	2,3
	Effect of Laser Beam Scanning Strategies on Porosity in 3D Printed Metals	2	3	2,3
	Total Contact Hours	**30**		

Learning assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								End Semester Exam (50%)	
		CLA-1 (10%)		CLA-2 (10%)		CLA-3 (15%)		Mid Term (15%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
	Understand	30%	30%	30%	30%	20%	30%	30%	30%	30%	30%
Level 2	Apply	10%	20%	30%	30%	20%	20%	30%	20%	20%	20%
	Analyse	40%	30%	20%	20%	40%	30%	20%	30%	30%	30%
Level 3	Evaluate										
	Create										
Total		**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Recommended Resources

1. Gibson, I., Rosen, D.W. and Stucker, B., "Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 2010.
2. Chua, C.K., Leong K.F. and Lim C.S., "Rapid prototyping: Principles and applications", second edition, World Scientific Publishers, 2010.
3. Laser Fundamentals by William T. Silfvast, Cambridge University Press, New Delhi, 2nd South Asian Edition, 2004.
4. Principles of Lasers by Svelto Orazio, Springer, 5th Ed. 2010
5. Laser Material Processing by W. M. Steen and J. Mazumder, Springer, 4th Ed. 2010
6. Laser Materials Processing by Elijah Kannatey–Asibu, Jr, Wiley, 2009
7. Laser Fabrication and Machining of Materials By Narendra B. Dahotre & Sandip P. Harimkar, Springer, 2008.

SRM University *AP*, Andhra Pradesh
Neerukonda, Mangalagiri Mandal,
Guntur District, Mangalagiri, Andhra Pradesh – 522240.

Lean Manufacturing

Course Code	MMT 532	Course Category	CE	L	T	P	C
				3	0	1	4
Pre-Requisite Course(s)		Co-Requisite Course(s)		Progressive Course(s)			
Course Offering Department	Mechanical Engineering	Professional / Licensing Standards					

Course Objectives / Course Learning Rationales (CLRs)

1. Understand the Principles of Lean Manufacturing
2. Apply Lean Tools and Techniques
3. Implement Lean Strategies for Process Optimization
4. Evaluate and Monitor Lean Performance

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Define and explain the core principles of lean manufacturing,	3	80%	75%
Outcome 2	Develop proficiency in using key lean tools and techniques	2	70%	65%
Outcome 3	Explore strategies for optimizing manufacturing processes through the application of lean principles	3	70%	70%
Outcome 4	Develop skills in assessing the performance of lean manufacturing initiatives	2	80%	75%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)												
	Engineering Knowledge	Design / Development of Solutions	Conduct Investigations of Complex Problems	Modern Tools and ICT Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Teamwork Skills	Communication Skills	Life-long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	3	1	2	2		2		1		2	3	2	3
Outcome 2	3	3	2	2		3		1		2	3	2	2
Outcome 3	3	2	3	3		3		3		2	2	2	3
Outcome 4	3	2	3	2		3		1		3	3	3	3
Average	3	2	3	2		2		2		2	3	2	3

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Lean Manufacturing – Introduction, History of Lean, Toyota Production System	2	1	1,2
	Comparison to other methods - The 7 Wastes, their causes and the effects, An overview of Lean Principles/ concepts / tools - Stockless Production	2	1	1,2,3
	An overview of Lean Principles/ concepts / tools - Stockless Production, Tools of Lean Manufacturing, Error Proofing and Set-up Reduction	2	1	1,3
	Continuous Flow, Continuous Flow Manufacturing and Standard Workflow, 5S and Pull Systems (Kanban and Con WIP systems)	3	1	1,2
Unit No. 2	Total Productive Maintenance (TPM)	2	1,2	1,2,3
	Kaizen Event examples, Value Stream Mapping	2	1,2	1,2,3
	Current state and Future State, Ford Production Systems.	2	1,2	1
	Building a Current State Map (principles, concepts, loops, and methodology), Application to the factory Simulation scenario	3	1,2	1,2,3
Unit No. 3	Key issues in building the Future State Map	2	1	1,2,3
	Process tips in building the map and analysis of the customer loop	2	2	1,2,3
	Supplier loop, manufacturing loop and information loop, Example of completed Future State Maps Factory simulation	2	1,2	1,2,3
	Implementation of lean practices, Best Practices in lean Manufacturing	3	1,2,4	1,2,3
Unit No. 4	Six Sigma Fundamentals, Selecting Projects	2	1,3	3
	Six Sigma Statistics, Measurement System Analysis -	2	1,3	3
	DMAIC – Define, Measure, Analyze, Improve, Control, Process Capability – Lean Six Sigma	2	1,3	3
	Four Keys to Lean Six Sigma - Key #1: Delight Your Customers with Speed and Quality Key #2: Improve Your Processes Key #3: Work Together for Maximum Gain Key #4	3	1,3,4	3
Unit No. 5	Base Decisions on Data and Facts - Case Studies, Five Laws of Lean Six Sigma	3	1,3,4	3
	Ergonomics-as enabler of lean manufacturing, Ergonomic consideration at work	2	1,4	1,2,3
	Principles related to the use of human body,	2	1,3	1,2,3
	Arrangement of workplace, the design of tools and equipment's.	2	1,2	1,2,3
	Total Contact Hours	**45**		

Lab Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Introduction to Lean Manufacturing	2	1	1
	Basics of Lean Manufacturing Definition and Principles	1	1	1
	Overview of Lean Manufacturing principles Core concepts: waste elimination, continuous improvement, value stream mapping	2	1	1
	Evolution and adoption in various industries	1	1	1
Unit No. 2	Value Stream Mapping (VSM) in Lean Manufacturing Understanding Value Stream Mapping	2	1	1
	Identifying value and waste in processes Creating a value stream map	2	1,2	1,2,3
	Application of VSM in Lean Manufacturing Steps in creating a value stream map	1	1,2	1,2,3
	Symbols and notations used in VSM Implementing changes based on VSM findings	1	1,2	1,2,3
Unit No. 3	Lean Manufacturing in Production Processes	1	1,2	1,2,3
	Just-In-Time (JIT) Production Principles of JIT	2	1,2	1,2,3
	Cellular Manufacturing	1	1,2	1,2,3
	Grouping processes into cells	2	1,2	1,2,3

Unit No. 4	Lean Tools for Quality Improvement	1	1,2,3,4	2,3
	Total Productive Maintenance (TPM)	1	1,2,3,4	2,3
	Maximizing equipment effectiveness	2	2,3	2,3
	Layout design for cellular manufacturing	2	3,4	2,3
Unit No. 5	Involving employees in equipment maintenance	1	3,4	2,3
	Designing and implementing error-proofing mechanisms	1	3,4	2,3
	Assessing the impact on quality	2	3,4	2,3
	Measuring and sustaining improvements	2	3,4	2,3
	Total Contact Hours	**30**		

Learning Assessment

Bloom's Level of Cognitive Task		**Continuous Learning Assessments (50%)**								**End Semester Exam (50%)**	
		CLA-1 (10%)		**CLA-2 (10%)**		**CLA-3 (15%)**		**Mid Term (15%)**			
		Th	**Prac**	**Th**	**Prac**	**Th**	**Prac**	**Th**	**Prac**	**Th**	**Prac**
Level 1	Remember	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
	Understand	30%	30%	30%	30%	20%	30%	30%	30%	30%	30%
Level 2	Apply	10%	20%	30%	30%	20%	20%	30%	20%	20%	20%
	Analyse	40%	30%	20%	20%	40%	30%	20%	30%	30%	30%
Level 3	Evaluate										
	Create										
Total		**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Recommended Resources

1. **James P. Womack, Daniel T. Jones, and Daniel Roos, "The Machine that Changed the World: The Story of Lean** Production", Simon & Schuster, 1996.
2. Jeffrey K. Liker, "Becoming Lean", Industrial Engineering and Management Press, 1997.
3. Larson, Alan, "Demystifying six sigma: a company-wide approach to continuous improvement", Jaico, Mumbai, 2007

SRM University *AP*, Andhra Pradesh
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Reliability Engineering

Course Code	MMT 533	Course Category	CE	L	T	P	C
				3	0	1	4
Pre-Requisite Course(s)		Co-Requisite Course(s)		Progressive Course(s)			
Course Offering Department	Mechanical Engineering	Professional / Licensing Standards					

Course Objectives / Course Learning Rationales (CLRs)

1. Understand the Fundamentals of Reliability Engineering.
2. Apply Reliability Analysis Techniques..
3. Implement Preventive Maintenance Strategies.
4. Utilize Statistical Methods for Reliability Modeling

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Define and explain the key concepts and principles of reliability engineering	2	80%	75%
Outcome 2	Apply these techniques to identify potential failure modes, assess their impact, and prioritize actions to enhance system reliability	3	70%	75%
Outcome 3	Explore and implement preventive maintenance strategies to minimize the likelihood of equipment failures and maximize system reliability.	3	80%	70%
Outcome 4	Apply the concepts of statistical methods used in reliability modeling	2	80%	75%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)												
	Engineering Knowledge	Design / Development of Solutions	Conduct Investigations of Complex Problems	Modern Tools and ICT Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Teamwork Skills	Communication Skills	Life-long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	3	2	3	2				2		3	3	2	3
Outcome 2	3	3	3	2				2		3	3	3	3
Outcome 3	3	3	2	2				3		2	2	3	3
Outcome 4	3	2	3	2				2		3	2	3	3
Average	3	2	3	2				2		3	3	2	3

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Concept and Definition of reliability (reliability mathematics)	3	1	1,2
	Failure distributions, Hazard models – exponential	2	1	1,2
	Rayleigh, Weibull, Normal and Lognormal distributions.	2	1	1,2
	MTTF, MTBF	1	1	1
Unit No. 2	Reliability of systems – series and parallel configurations	3	1,2	1,2,3
	Reliability improvement, Redundancy, k-out-of-n system	2	1,2	1,2,3
	Reliability of complex configurations, Reliability of three-state devices	2	1,2	1,2,3
	Markov Analysis-Physical reliability models, Random stress and random strength.	1	1,2	1,2,3
Unit No. 3	Design for reliability-Reliability allocation,	3	3	1,2,3
	Derating-Maintainability	2	3	1,2,3,4
	Design for maintainability	2	3	1,2,3
	Availability-Maintenance and space provisioning	3	3	1,2,3
Unit No. 4	Failure data analysis	2	1	1,2,3
	Reliability Testing-	3	3,4	1,2,3
	Identifying failure distributions	2	4	1,2,3
	Parameter estimation.	2	4	1,2,3,4
Unit No. 5	Approaches to intelligent control	3	2,4	1,2,3
	AI approach, Concept of artificial neural network and its model.	2	2,4	1,2,3
	Fuzzy logic and its model	2	2,4	1,2,3
	Case study.	3	2,4	1,2,3,4
	Total Contact Hours	**45**		

Lab Unitization Plan

S. No.	Description of experiments	Required Contact Hours	CLOs Addressed	References Used
1	Introduction to Reliability Engineering	3	1	3
2	Statistical Analysis of Reliability Data	3	1	3
3	Reliability Block Diagrams (RBD)	3	1	3
4	Fault Tree Analysis (FTA)	3	1	3
5	Failure Modes and Effects Analysis (FMEA)	3	4	3
6	Reliability Prediction and Allocation	3	3	3
7	Accelerated Life Testing (ALT)	3	3	3
8	Maintenance Strategies and Optimization	3	3	3
9	Reliability Growth Modeling	3	4	3
10	Reliability Testing and Standards	3	4	3
	Total Contact Hours	30		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								End Semester Exam (50%)	
		CLA-1 (10%)		CLA-2 (10%)		CLA-3 (15%)		Mid Term (15%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
	Understand	30%	30%	30%	30%	20%	30%	30%	30%	30%	30%
Level 2	Apply	10%	20%	30%	30%	20%	20%	30%	20%	20%	20%
	Analyse	40%	30%	20%	20%	40%	30%	20%	30%	30%	30%
Level 3	Evaluate										
	Create										
Total		**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Recommended Resources

1. Charles Ebeling, "An introduction to Reliability and Maintainability Engineering", Tata McGraw Hill, 2000.
2. Lewis E. E., "Introduction to Reliability Engineering", Second Edition, John Wiley &Sons, 1995.
3. Srinath L.S., "Mechanical Reliability", East-West Press,2002.
4. Simon Haykins, "Neural network: A comprehensive foundation", Pearson Edition, 2003.

Tool Design

Course Code	MMT 534	**Course Category**	CE		**L**	**T**	**P**	**C**
					3	0	1	4
Pre-Requisite Course(s)	Basic mathematics, CAD/CAM software	**Co-Requisite Course(s)**	Manufacturing Processes	**Progressive Course(s)**				
Course Offering Department	Mechanical Engineering	**Professional / Licensing Standards**						

Course Objectives / Course Learning Rationales (CLRs)

1. Understand the fundamentals of tool design.
2. Gain proficiency in designing various types of tools and fixtures.
3. Learn about the materials used in tool making.
4. Develop skills in using CAD software for tool design, apply knowledge through practical projects and case studies

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Understand the fundamental principles of tool design.	2	80%	75%
Outcome 2	Understand design considerations, material selection and manufacturing processes.	3	70%	75%
Outcome 3	Manipulate and use CAD/CAM tools to create, simulate and optimize tool design	3	80%	70%
Outcome 4	Design tools that are not only functional but also optimized for ease of manufacturing by reducing production costs.	2	80%	75%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)												
	Engineering Knowledge	Design / Development of Solutions	Conduct Investigations of Complex Problems	Modern Tools and ICT Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Teamwork Skills	Communication Skills	Life-long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	3	2	3	2				2		3	3	2	3
Outcome 2	3	3	3	2				2		3	3	3	3
Outcome 3	3	3	2	2				3		2	2	3	3
Outcome 4	3	2	3	2				2		3	2	3	3
Average	3	2	3	2				2		3	3	2	3

Course Unitization Plan

Unit No.	Unit Name	Required Contact Hours	CLOs Addressed	References Used

Unit 1	Overview of tool design and its importance in manufacturing.	3	1	1,2
	Materials for Tool Design	2	1	1,2
	Properties of tool materials. Dynamics of machine tools: General procedure for assessing the dynamic stability of the cutting process, closed loop system, chatter in machine tool.	2	1	1,2
	Selection criteria for tool materials. Commonly used materials: High-speed steel, carbide, ceramics, etc, Heat treatment and its effect on tool performance.	1	1	1
Unit 2	Cutting Tools Design	2	1,2	1,2,3
	Types of cutting tools (e.g., drills, mills, reamers).	2	1,2	1,2,3
	Design of Machine Tool Structures: Function & Requirement of Machine Tool Structure, Design Criteria from Strength & Stiffness Considerations, Role of Static & Dynamic Stiffness in the design.	2	1,2	1,2,3
	Wear and failure mechanisms of cutting tools.	2	1,2	1,2,3
Unit 3	Jigs and Fixtures	3	3	1,2,3
	Purpose and types of jigs and fixtures, Principles of jig and fixture design.	2	3	1,2,3,4
	Factors affecting stiffness of machine tool structures & methods of improving it, Basic Design procedure of machine tool structures, Design of bed, head stock etc	2	3,4	1,2,3
	Design of Guideways: Function and Types, Design of hydrostatic, hydrodynamic and antifriction guideways; Design of spindles and spindle supports: Function & Requirements of Spindle Units, their Materials, Design of Spindle, Requirements of Spindle Supports, Selection of sliding and antifriction bearings;	3	3	1,2,3
Unit 4	Press Tools Design	2	1	1,2,3
	Introduction to press tools and their applications.	3	3,4	1,2,3
	Types of press tools (e.g., blanking, piercing, bending).	2	4	1,2,3
	Tool Wear and Maintenance	2	4	1,2,3,4
Unit 5	Machine Tool Drives: Introduction to kinematics of machine tools, Mechanical, hydraulic and electrical drives, Stepped and step less regulations of speed and feed, Layout of spindles drive and feed drive in machine tools, Structural diagram, Ray diagram, Design of speed box and feed box;	3	4	1,2,3
	Control Systems: Functions, requirements & types of machine tool controls, controls for speed &feed change.	2	2,4	1,2,3
	Automatic and manual Controls. Basics of numerical controls. Machine tool; and Multi-functional machine tools.	2	2,4	1,2,3
	Practical Projects and Case Studies	3	2,4	1,2,3,4
	Total Contact Hours	**45**		

Lab Unitization Plan

S. No.	Description of experiments	Required Contact Hours	CLOs Addressed	References Used

1	Cutting Tool Geometry Analysis	3	1	3
2	Tool Material Hardness Testing	3	1	3,4
3	Design and Fabrication of a Simple Jig	3	1	3
4	Press Tool Design and Simulation	3	1	3
5	Wear Testing of Cutting Tools	3	4	3,4
6	Practical examples on lathe machine	3	3	3
7	CNC milling	3	3	3
8	Multifunctional machine tool	3	3	3,4
9	Tool lubrication	3	4	3
10	Cutting processes	3	4	3
	Total Contact Hours	**30**		

Learning Assessment

Bloom's Level of Cognitive Task		**Continuous Learning Assessments (50%)**								**End Semester Exam (50%)**	
		CLA-1 (10%)		**CLA-2 (10%)**		**CLA-3 (15%)**		**Mid Term (15%)**			
		Th	**Prac**	**Th**	**Prac**	**Th**	**Prac**	**Th**	**Prac**	**Th**	**Prac**
Level 1	Remember	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
	Understand	30%	30%	30%	30%	20%	30%	30%	30%	30%	30%
Level 2	Apply	10%	20%	30%	30%	20%	20%	30%	20%	20%	20%
	Analyse	40%	30%	20%	20%	40%	30%	20%	30%	30%	30%
Level 3	Evaluate										
	Create										
Total		**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Recommended Resources

1. Sharma, P. C., Machine Tools & Tool Design, S A Chand Limited, 2005.
2. Mehta, N. K., Machine Tool Design & Numerical Control, McGraw Hill, 2012.
3. Rao P N, Manufacturing Technology: Metal cutting and Machine Tools, McGraw Hill, 2013
4. Basu, S. K. and Pal, D.K, Design of Machine Tools, Allied Publishers, 2008.

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Digital Manufacturing

Course Code	MMT 535	Course Category	CE	L	T	P	C
				3	0	1	4
Pre-Requisite Course(s)		Co-Requisite Course(s)		Progressive Course(s)			
Course Offering Department	Mechanical Engineering	Professional / Licensing Standards					

Course Objectives / Course Learning Rationales (CLRs)

1. Comprehend the Fundamentals of Digital Manufacturing
2. Apply Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM)
3. Implement Digital Prototyping and Simulation
4. Understand and Implement Industry 4.0 and 5.0 Principles

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Define and explain the core concepts of digital manufacturing	3	70%	75%
Outcome 2	Develop proficiency in using CAD software for creating digital models of products	2	80%	75%
Outcome 3	Develop skills in simulation techniques to analyze and optimize manufacturing processes, including predicting performance, identifying potential issues, and improving efficiency	3	80%	70%
Outcome 4	Gain knowledge of Industry 4.0 principles and the integration of technologies such as the Internet of Things (IoT), artificial intelligence, and big data analytics into manufacturing systems	2	80%	75%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)												
	Engineering Knowledge	Design / Development of Solutions	Conduct Investigations of Complex Problems	Modern Tools and ICT Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Teamwork Skills	Communication Skills	Life-long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	3	1	3	2				1		3	3	2	3
Outcome 2	3	1	3	3				1		3	3	3	2
Outcome 3	3	3	3	3				3		3	3	2	3
Outcome 4	3	2	3	3				3		3	3	3	3
Average	3	2	3	3				2		3	3	3	3

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Digital design: Geometrical design of curves, Surfaces and solids	2	1	1,2
	Introduction to computer aided	2	1	1,3
	Engineering analysis and optimum design	2	1	1,3
	Consideration of manufacturing and assembly aspects in design	3	1	1,2
Unit No. 2	Shape digitization: 3D object scanning,	2	1	1,2
	Solid reconstruction from point cloud and tessellated data, Down stream applications	2	1	1,2,3
	Digital manufacturing: Subtractive manufacturing: Basic architecture, Control hardware and software details	2	1	1
	Tooling, Sculptured surface machining;	3	1	1,2
Unit No. 3	Additive Manufacturing: Basics,	2	1	1,2,3
	Hardware details and capabilities of commercial systems,	2	1,3	1,3
	Planning of material addition, Rapid tooling solutions;	2	1,3,4	1,2,3
	Computer Aided Process Planning: CAPP and route sheet development,	3	1,3,4	1,2,3
Unit No. 4	CAPP system, Computer aided plant layout	3	1,3	1,2
	Computer Aided Production Planning and Control	2	1,3	1,2
	Algorithms for CAPP	2	1,3	1,2,3
	Product Database Management Systems: Types, Management Information	2	1	1,2,3
Unit No. 5	System, Manufacturing	2	1,4	3
	data preparation, Shop-floor control,	2	4	1,2,3
	Automatic identification systems (sensors, trackers), Product life cycle management;	3	1,4	1,2,3
	Industry 4.0 and 5.0	3	4	1,2,3
	Total Contact Hours	**45**		

Lab Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Cad modelling	2	1	1
	Concepts of CAD, Algorithms used in design,	1	1	1
	Design of Assembly (Spur gear)	2	1	1
	Design of Assembly (Helical screw)	1	1	1
Unit No. 2	Introduction to G Code	2	1	1
	Lab practice of Solid works software	2	1,2	1,2,3
	Introduction to 3DP	1	1,2	1,2,3
	What is a Mesh? Historical Review of 3DP	1	1,2	1,2,3
Unit No. 3	From CAD to CAM, CAD Overview	1	1,2	1,2,3
	Introductory lecture on 3D printer and Rapid Prototyping	2	1,2	1,2,3
	Introduction to different types of 3D Printers,	1	1,2	1,2,3
	Introduction to RepRap, Materials used for printing	2	1,2	1,2,3
Unit No. 4	Design for 3DP	1	1,2,3,4	4
	Understand the basics of G code generation	1	1,2,3,4	2,3
	CAM Skills, Mesh Repair	2	2,3	2,3
	Get to Know the 3D Printers	2	3,4	4
Unit No. 5	Hands on experience with trouble shooting	1	3,4	4
	Installation of 3DP, bed levelling	1	3,4	4
	Filament loading and unloading, preheating, nozzle cleaning	2	3,4	4
	Practice on SLA, Bio-printer and DED Printer	2	3,4	4
	Total Contact Hours	**45**		

Learning assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								End Semester Exam (50%)	
		CLA-1 (10%)		CLA-2 (10%)		CLA-3 (15%)		Mid Term (15%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
	Understand	30%	30%	30%	30%	20%	30%	30%	30%	30%	30%
Level 2	Apply	10%	20%	30%	30%	20%	20%	30%	20%	20%	20%
	Analyse	40%	30%	20%	20%	40%	30%	20%	30%	30%	30%
Level 3	Evaluate										
	Create										
Total		**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Recommended Resources

1. Fundamentals of Digital Manufacturing Science, by Z.Zhou,S.Xie, D. Chen, Springer, 2012
2. Gibson, I., Rosen, D.W. and Stucker, B., "Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 2010.
3. M P Groover, "Automation, production systems, and computer-aided manufacturing" Pearson, 2016
4. Additive Manufacturing Lab Manual, 2023.

SRM University *AP*, Andhra Pradesh
Neerukonda, Mangalagiri Mandal,
Guntur District, Mangalagiri, Andhra Pradesh – 522240.

Advanced Metal Forming

Course Code	MMT 536	**Course Category**	CE			**L**	**T**	**P**	**C**
						3	0	1	4
Pre-Requisite Course(s)	Basic metal forming processes	**Co-Requisite Course(s)**	Manufacturing Processes	**Progressive Course(s)**					
Course Offering Department	Mechanical Engineering	**Professional / Licensing Standards**							

Course Objectives / Course Learning Rationales (CLRs)

1. Understand the Principles of Advanced Metal Forming Processes.
2. Analyse and Optimize Metal Forming Operations.
3. Understand Material Behaviours and Formability.
4. Implement Innovative Forming Technologies.

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	**Bloom's Level**	**Expected Proficiency Percentage**	**Expected Attainment Percentage**
Outcome 1	Have a comprehensive understanding of advanced metal forming processes beyond conventional methods, such as incremental forming, hydroforming, and electromagnetic forming.	2	80%	75%
Outcome 2	Capability to Analyse and Solve Complex Forming Problems	3	70%	75%
Outcome 3	Predict material behaviours, optimize process parameters, and design tooling for advanced metal forming applications.	3	80%	70%
Outcome 4	Understand the challenges and opportunities associated with forming advanced materials, and they will be able to design and optimize processes for the efficient shaping of these materials.	2	80%	75%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	**Program Learning Outcomes (PLO)**												
	Engineering Knowledge	**Design / Development of Solutions**	**Conduct Investigations of Complex Problems**	**Modern Tools and ICT Usage**	**The Engineer and Society**	**Environment and Sustainability**	**Ethics**	**Individual and Teamwork Skills**	**Communication Skills**	**Life-long Learning**	**PSO 1**	**PSO 2**	**PSO 3**
Outcome 1	3	2	3	2				2		3	3	2	3
Outcome 2	3	3	3	2				2		3	3	2	3
Outcome 3	3	2	3	2				3		2	2	3	3
Outcome 4	3	2	3	2				2		3	3	3	3
Average	3	2	3	2				2		3	3	2	3

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Introduction and fundamentals of metal forming	2	1	1,2
	Metalworking, forming equipment presses(mechanical, hydraulic)	2	1	1,2
	Theory of plasticity, mechanical behaviour of metals and alloys under plastic deformation	2	1	1,2
	Stress strain relationship, Strain hardening and work hardening hypotheses, Flow stress and flow curves	2	1,2	1,2
Unit No. 2	Material incompressibility; Yield criteria: von Mises' and Tresca's Yield criteria, Levy Mises and Prandtl-Reuss stress-strain relationship	3	1,2	1,2,3
	Yield criterion and flow rule for Anisotropic materials	2	1,2	1,2,3
	Introduction to Slab analysis, Slip line theory, Upper bound and Lower bound techniques	2	1,2	1,2,3
	Basic heat treatment processes, Iron-carbon diagram	3	1,2	1,2,3
Unit No. 3	TTT diagram - Their relation with Metal forming	3	3	1,2,3
	Different forming processes (Rolling, Drawing, Extrusion, Forging)	2	3	1,2,3,4
	Analysis (Slab analysis, Slip line theory, Upper bound and Lower bound techniques)Sheet Metal Forming	2	3	1,2,3
	Different processes and analysis, Formability; of the sheet, Formability tests, Forming limit diagrams	3	3	1,2,3
Unit No. 4	Material behavior in forming	2	1	1,2,3
	Die design	3	4	1,2,3
	Numerical methods in metal forming	2	4	1,2,3
	Surface Engineering in Metal Forming, Surface treatments for improved formability	3	4	1,2,3,4
Unit No. 5	Coatings and lubricants in metal forming	3	4	1,2,3
	Surface defects and their prevention	2	2	1,2,3
	Metal Forming in Manufacturing Systems	2	4	1,2,3
	Failure Analysis in Forming, applications of metal forming	3	4	1,2,3,4
	Total Contact Hours	**45**		

Lab Unitization Plan

S. No.	Description of experiments	Required Contact Hours	CLOs Addressed	References Used
1	High-Speed Forming	3	1	3,4
2	Deep Drawing of Metal Sheets	3	1	3
3	Hydroforming of Tubular Structures	3	1	3
4	Electromagnetic Forming	3	1	3,4
5	Superplastic Forming	3	4	3
6	Microforming of Metal Foils	3	3	3,4
7	Electrohydraulic Forming	3	3	3
8	Laser-Assisted Forming	3	3	3
9	Forming of Lightweight Alloys	3	4	3
10	Hot Forming	3	4	3,4
	Total Contact Hours	**30**		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								End Semester Exam (50%)	
		CLA-1 (10%)		CLA-2 (10%)		CLA-3 (15%)		Mid Term (15%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
	Understand	30%	30%	30%	30%	20%	30%	30%	30%	30%	30%
Level 2	Apply	10%	20%	30%	30%	20%	20%	30%	20%	20%	20%
	Analyse	40%	30%	20%	20%	40%	30%	20%	30%	30%	30%
Level 3	Evaluate										
	Create										
Total		**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Recommended Resources

1. Ghosh and Mallik, Manufacturing Science, East West Publisher, 2nd Ed., 2010
2. W F Hosford & R M Caddell, Metal Forming, Mechanics and Metallurgy, Cambridge University Press, 4th Ed., 2011
3. David Rees, Basic Engineering Plasticity: An Introduction with Engineering and Manufacturing Applications, Butterworth-Heinemann, 1st Ed., 2006
4. J. Chakrabarty, Theory of Plasticity, McGrawHill Book Co., International Edition, 1987.

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Precision and Micro Manufacturing

Course Code	MMT 537	**Course Category**	CE		**L**	**T**	**P**	**C**
					3	0	1	4
Pre-Requisite Course(s)	Manufacturing Processes	**Co-Requisite Course(s)**	Manufacturing Processes	**Progressive Course(s)**				
Course Offering Department	Mechanical Engineering	**Professional / Licensing Standards**						

Course Objectives / Course Learning Rationales (CLRs)

1. Understand the Principles of Precision and Micromanufacturing
2. Analyse and Apply Micromanufacturing Techniques
3. Integrate Advanced Metrology and Quality Control
4. Innovate and Optimize Manufacturing Processes

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	**Bloom's Level**	**Expected Proficiency Percentage**	**Expected Attainment Percentage**
Outcome 1	Explain the fundamentals of Precision and Micromanufacturing Techniques	3	80%	75%
Outcome 2	Practically use Micromanufacturing Processes	3	70%	65%
Outcome 3	Apply Metrology and Quality Control	3	70%	70%
Outcome 4	Innovate and Optimize Manufacturing Systems	2	70%	65%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	**Program Learning Outcomes (PLO)**												
	Engineering Knowledge	**Design / Development of Solutions**	**Conduct Investigations of Complex Problems**	**Modern Tools and ICT Usage**	**The Engineer and Society**	**Environment and Sustainability**	**Ethics**	**Individual and Teamwork Skills**	**Communication Skills**	**Life-long Learning**	**PSO 1**	**PSO 2**	**PSO 3**
Outcome 1	3	2	3	2				2		3	3	2	3
Outcome 2	3	3	3	3				2		3	3	3	2
Outcome 3	3	3	2	3				3		2	2	3	3
Outcome 4	3	3	3	3				2		3	3	3	3
Average	3	3	3	3				2		3	3	2	3

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Introduction to precision and Micromanufacturing	3	1	1,2
	Basic definition, Size scales, Scaling analysis, Technology change, Lithographic Processes	2	1	1,2
	Sources of Error, Machine Tool Variables- accuracy, stiffness, spindle vibration, flatness, straightness and smoothness of motion, Feedback Variables	2	1	1,2
	Cutting Tool Variables, Workpiece Variables, Environment Effects and Thermal Errors	2	1	1,2,3
Unit No. 2	Introduction to machining analysis	2	1,2	1,2,3
	Geometry of Cutting Edge, Energy Models, Comparison with Micro-scale Machining	2	1,2	1,2,3
	Diamond Micromachining	2	1,2	1,2,3
	Diamond as a Tool Material, Compatible Materials	1	1,2	1,2,3
Unit No. 3	Micro-mechanical Applications, Ductile Regime Grinding	2	3	1,2,3
	Focused ion beam-based Micro-/Nano-fabrication; Micro-ECM, Micro-EDM, Parameter dependencies	3	3	1,2,3,4
	Micro-milling: Process and applications	2	3	1,2,3
	micro-mechanically milled X-ray masks, Mask Absorption Quantification, Exposure Quantification.	3	3	1,2,3
Unit No. 4	Micro-drilling and Macro-drilling Techniques	3	1	1,2,3
	laser Optics, Laser Ablation, Heat Affected Zone and Laser Polymerisation. LIGA, S-LIGA	3	3	1,2,3
	Micro Welding: Micro welding in similar and dissimilar materials	2	4	1,2,3
	Micro Casting: Casting processes like vacuum, Semi-solid state	2	4	1,2,3,4
Unit No. 5	Processing of Integrated Circuits, Clean rooms, crystal growing and shaping of wafers, Etching, Photo and other lithography techniques, CVD, Metallisation etc.	3	2,4	1,2,3
	Micro Forming: Bulk Forming, Forming of Micro-sheet Metal Components.	2	2,4	1,2,3
	Micro Assembly: Mechanical Assembly, Self-assembly of Micro-parts; Handling for Micro-manufacturing.	2	4	1,2,3
	Robotics in Micro-manufacturing and Micro-robotics; and Measurement, Testing, and Diagnosis for Micro-manufacturing Systems.	3	2,4	1,2,3,4
	Total Contact Hours	**45**		

Lab Unitization Plan

S. No.	Description of experiments	Required Contact Hours	CLOs Addressed	References Used
1	Micro Milling and Micro Drilling	3	1	3
2	Micro Electrical Discharge Machining (Micro EDM).	3	2	3,4
3	Micro Injection Molding	3	2	3,4
4	Microforming	3	3	3
5	Laser Micromachining	3	4	3
6	Photolithography and Etching	3	3	3,4
7	Assembly of Micro Components	3	3,4	3
8	Metrology and Surface Characterization	3	3	3
9	Micro Electroforming	3	4	3
10	Finite Element Analysis (FEA) in Micromanufacturing	3	4	3
	Total Contact Hours	**30**		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								End Semester Exam (50%)	
		CLA-1 (10%)		CLA-2 (10%)		CLA-3 (15%)		Mid Term (15%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
	Understand	30%	30%	30%	30%	20%	30%	30%	30%	30%	30%
Level 2	Apply	10%	20%	30%	30%	20%	20%	30%	20%	20%	20%
	Analyse	40%	30%	20%	20%	40%	30%	20%	30%	30%	30%
Level 3	Evaluate										
	Create										
Total		**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Recommended Resources

1. V.K. Jain, Micromanufacturing Processes, CRC Press, 2012.
2. Yi Qin, Micromanufacturing Engineering and Technology, Elsevier, 2000.
3. Hongdi Zhang, Precision Micromanufacturing Process, Web Tutorial, 2023
4. Muammer Koc, Tugrul Ozel, Micro-Manufacturing: Design and Manufacturing of Micro-Products, Wiley, 2011.

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Quality Engineering

Course Code	MMT 538	Course Category	CE			L	T	P	C
						3	0	1	4
Pre-Requisite Course(s)		Co-Requisite Course(s)	Manufacturing Processes	Progressive Course(s)					
Course Offering Department	Mechanical Engineering	Professional / Licensing Standards							

Course Objectives / Course Learning Rationales (CLRs)

1. Understand the Principles of Quality Engineering.
2. Apply Statistical Methods for Quality Control.
3. Implement Quality Management Systems (QMS).
4. Conduct Failure Analysis and Root Cause Investigations

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Define and explain the fundamental concepts and principles of quality engineering	1	80%	75%
Outcome 2	Develop proficiency in using statistical tools and techniques for quality control	2	70%	75%
Outcome 3	Explore and understand the principles of Quality Management Systems, including international standards such as ISO 9001	3	80%	70%
Outcome 4	Develop skills in conducting failure analysis and root cause investigations to identify the reasons behind product or process failures	2	80%	75%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)												
	Engineering Knowledge	Design / Development of Solutions	Conduct Investigations of Complex Problems	Modern Tools and ICT Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Teamwork Skills	Communication Skills	Life-long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	3	1	3	2		1		1		2	3	2	3
Outcome 2	3	2	3	2		1		1		3	2	3	3
Outcome 3	3	3	3	3		2		3		3	3	2	3
Outcome 4	3	2	3	2		2		1		2	3	3	3
Average	3	2	3	2		2		2		2	3	2	3

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Basic concepts in Quality Engineering: definitions, approaches and relevance to organizational excellence.	3	1	**1,2**
	Quality and Competitiveness	2	1,2	**1,2**
	Product quality control: Acceptance sampling methods, Statistical Process Control: Process evaluation and control by control charts: x-bar.	2	1	**1,2**
	Single, multiple and sequential sampling plans, Recent developments in inspection methods	1	1	**1**
Unit No. 2	R-bar charts, Moving Average and Moving Range Charts	3	1,2	**1,2,3**
	Charts for Individuals	2	1,2	**1,2,3**
	Median and Range Charts, Control Charts for Attributes - Non-conforming.	2	2	**1,2,3**
	Non-conformities (defects).	1	2	**1,2,3**
Unit No. 3	Process capability studies: Various indices and approaches;.,	3	3	**1,2,3**
	Use of Nomographs, Discussions on capabilities of Process.	2	3	**1,2,3**
	Quality costs-Quality measurement, Total Quality Management perspective	2	3	**1,2,3**
	Methodologies, and procedures, Roadmap to TQM, ISO 9000, KAIZEN, Quality Circles.	3	3	**1,2,3**
Unit No. 4	Models for organizational excellence	3	1	**1,2,3**
	Quality Function Deployment	3	3,4	**1,2,3**
	Quality Cost Systems and Quality Policy Deployment	2	4	**1,2,3**
	Implementation of TQM and the management of change	2	4	**1,2,3**
Unit No. 5	Process evaluation and control by designs of experiment, Various basic designs; Special methods such as EVOP and ROBUST design (Taguchi Methods)	3	2,4	**1,2,3**
	Six Sigma Management: Concepts, Steps and Tools; Benchmarking and Balanced Score Cards	2	2,4	**1,2,3**
	TPM, FMECA, Fault Tree Analysis, Quality, and reliability perspectives of JIT	2	4	**1,2,3**
	Training for Quality. Application of Software tools and Case Studies	2	2,4	**1,2,3**
	Total Contact Hours	**45**		

S. No.	Description of experiments	Required Contact Hours	CLOs Addressed	References Used
1	To understand key quality concepts (QC, QA, TQM)	3	1	3
2	Case study analysis of quality failures and successes.	3	1	3
3	Lab exercise on creating and interpreting control charts	5	1	3
4	Lab setup for conducting experiments.	5	1	3
5	Data collection and analysis using statistical software.	5	2	3
6	calibration demonstration of measurement instruments	4	3	3
7	Interactive session on identifying potential failure mode	5	4	3
	Total Contact Hours	**30**		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								End Semester Exam (50%)	
		CLA-1 (10%)		CLA-2 (10%)		CLA-3 (15%)		Mid Term (15%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
	Understand	30%	30%	30%	30%	20%	30%	30%	30%	30%	30%
Level 2	Apply	10%	20%	30%	30%	20%	20%	30%	20%	20%	20%
	Analyse	40%	30%	20%	20%	40%	30%	20%	30%	30%	30%
Level 3	Evaluate										
	Create										
Total		**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Recommended Resources

1. Douglas C. Montgomery, "Design and Analysis of Experiments", Seventh Edition, Wiley,2010.
2. Juran J.M., "Quality Control by Design", The Free Press, 1992.
3. D. C. Montgomery, "Introduction to Statistical Quality Control," 7th ed. Hoboken, NJ, USA: Wiley, 2012.

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Finite element methods for Manufacturing

Course Code	MMT 539	**Course Category**	CE		**L**	**T**	**P**	**C**
					3	0	1	4
Pre-Requisite Course(s)		**Co-Requisite Course(s)**		**Progressive Course(s)**				
Course Offering Department	Mechanical Engineering	**Professional / Licensing Standards**						

Course Objectives / Course Learning Rationales (CLRs)

1. Understand the Fundamentals of Finite Element Analysis (FEA)
2. Develop Proficiency in Preprocessing for FEA
3. Conduct Finite Element Analysis and Interpret Results
4. Optimize Structural Designs Using FEA

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	**Bloom's Level**	**Expected Proficiency Percentage**	**Expected Attainment Percentage**
Outcome 1	Define and explain the basic principles of finite element analysis	3	80%	75%
Outcome 2	Gain proficiency in preprocessing tasks for FEA	2	80%	75%
Outcome 3	Acquire skills in setting up and solving finite element models using FEA software.	3	80%	70%
Outcome 4	Explore techniques for structural optimization using finite element methods to improve the efficiency and performance of engineering designs	2	80%	75%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	**Program Learning Outcomes (PLO)**												
	Engineering Knowledge	**Design / Development of Solutions**	**Conduct Investigations of Complex Problems**	**Modern Tools and ICT Usage**	**The Engineer and Society**	**Environment and Sustainability**	**Ethics**	**Individual and Teamwork Skills**	**Communication Skills**	**Life-long Learning**	**PSO 1**	**PSO 2**	**PSO 3**
Outcome 1	3	1	3	2				1		3	3	2	2
Outcome 2	3	1	3	3				1		2	3	3	2
Outcome 3	3	2	3	3				3		3	2	2	3
Outcome 4	3	3	3	3				3		3	3	3	3
Average	**3**	**2**	**3**	**2**				**2**		**3**	**3**	**2**	**3**

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Fundamentals of governing equations in Solid Mechanics and Heat Transfer.	2	1	1,2
	Strong form	2	1	1,2,3
	Weak form	2	1	1,3
	Variational formulation, weighted residual method - Galerkin formulation	3	1,2	1,2
Unit No. 2	Formulation of the finite element equations	2	2	1,2,3
	Element types	2	2	1,2,3
	Basic and higher order elements-	2	2	1
	Coordinate systems.	3	2	1,2,3
Unit No. 3	Finite elements in Solid Mechanics: analysis of trusses, beams and frames	2	2,4	1,2,3
	Planes tress, plane strain and axisymmetric elements, Plate and shell elements. - Isoperimetric formulation.	2	2,4	1,2,3
	Finite elements in Heat Transfer	2	2,4	1,2,3
	Formulations and solution procedures in one-dimensional and two-dimensional problems.	3	2,4	1,2,3
Unit No. 4	Structural dynamics: Formulation - Evaluation of Eigen values and Eigen vectors	3	1,4	1,2,3
	Element mass matrices	2	1,4	1,2,3
	Natural frequencies and mode shapes	2	1,4	1,2,3
	Numerical time integration	2	2,4	1,2,3
Unit No. 5	Computer implementation of the Finite element method: pre-processing	3	2,3	3
	Element calculation, Equation assembly, Solving	2	2,3	1,2,3
	Post processing – primary and secondary variables	2	2,3	1,2,3
	Introduction to computational packages.	2	3	1,2,3
	Total Contact Hours	**45**		

Lab Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Introduction to Finite Element Methods (FEM) in Manufacturing	2	1	1
	Basics of Finite Element Analysis (FEA)	1	1	1
	Key Concepts	2	1	1
	Finite Element Modeling	1	1	1
Unit No. 2	Boundary Conditions	2	1	1
	Structural Analysis in Manufacturing	2	1,2	1,2,3
	Introduction to Static Analysis	1	1,2	1,2,3
	Basic principles, Types of loads and constraints	1	1,2	1,2,3
Unit No. 3	Stress analysis in manufacturing components	1	1,2	1,2,3
	Failure prediction	2	1,2	1,2,3
	Thermal Analysis in Manufacturing	1	1,2	1,2,3
	Steady-State Thermal Analysis	2	1,2	1,2,3
Unit No. 4	Manufacturing Case Studies	1	1,2,3,4	2,3
	Applications in Manufacturing	1	1,2,3,4	2,3
	Advanced Topics in FEM for Manufacturing	2	2,3	2,3
	Optimization in Manufacturing	2	3,4	2,3
Unit No. 5	Transient Thermal Analysis	1	3,4	2,3
	Structural optimization in manufacturing	1	3,4	2,3
	Thermal optimization in manufacturing	2	3,4	2,3
	Nonlinear behavior in manufacturing processes	2	3,4	2,3
	Total Contact Hours	**30**		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								End Semester Exam (50%)	
		CLA-1 (10%)		CLA-2 (10%)		CLA-3 (15%)		Mid Term (15%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
	Understand	30%	30%	30%	30%	20%	30%	30%	30%	30%	30%
Level 2	Apply	10%	20%	30%	30%	20%	20%	30%	20%	20%	20%
	Analyse	40%	30%	20%	20%	40%	30%	20%	30%	30%	30%
Level 3	Evaluate										
	Create										
Total		**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Recommended Resources

1. Rao, S. S., "The Finite Element Method in Engineering", Fifth Edition, Elsevier, 2011.
2. Daryl L. Logan, "A First Course in the Finite Element Method", Fifth Edition, Cengage Learning, 2012.
3. David V. Hutton, "Fundamentals of Finite Element Analysis", McGraw Hill, 2005.

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Inspection and Testing Manufacturing

Course Code	MMT 540	Course Category	CE			L	T	P	C
						3	0	1	4
Pre-Requisite Course(s)	Basic mathematics	Co-Requisite Course(s)		Progressive Course(s)					
Course Offering Department	Mechanical Engineering	Professional / Licensing Standards							

Course Objectives / Course Learning Rationales (CLRs)

1. Understanding of how design principles and manufacturing processes are integrated to create functional and manufacturable products.
2. Develop Skills in Advanced Inspection Techniques
3. Analyze and Interpret Inspection Data
4. Implement Quality Control Processes

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Explain Proficiently Inspection Methods	2	80%	75%
Outcome 2	Perform Accurate Measurements.	3	70%	65%
Outcome 3	Comply Data Analysis and Reporting.	3	75%	70%
Outcome 4	Apply Quality Control Standards.	3	80%	75%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)												
	Engineering Knowledge	Design / Development of Solutions	Conduct Investigations of Complex Problems	Modern Tools and ICT Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Teamwork Skills	Communication Skills	Life-long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	3	1	3	1				2		3	3	2	3
Outcome 2	3	2	3	2				2		3	3	3	3
Outcome 3	3	3	2	2				3		2	2	3	3
Outcome 4	3	2	3	2				2		3	2	3	3
Average	3	2	3	2				2		3	3	2	3

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Types and purposes of testing of manufactured components.	1	1	1,2
	Precautions in inspections, Accuracy of measurement and important terms.	2	1	1,2
	Suitability and purpose; Review of Mechanical testing methods; Tensile Testing (TT); Compression test, Charpy Impact test, Hardness Testing (HT) - Micro and Nano-hardness test, Stress Rupture Testing (SRT); Toughness, Fatigue and Fracture toughness test, Bend test, Creep test, Chemical tests,	4	1,3	1,2
	Macrographs study; ASTM standard test methods : Tensile test, Charpy Impact test.	2	1	1,4
Unit No. 2	Micro-hardness evaluation, Fracture toughness test, Crack growth rate study, Flexural strength of beam	2	1,2	1,2,3
	Introduction to NDT, Visual Optical methods, Dye penetrant testing, Methods of application	2	1,2	1,2,3
	Magnetic particle testing, Magnetization methods, Field indicators, Particle application, Inspection; Eddy current testing, Faraday's law, Inductance,	2	1,2	1,2,3
	Lenz's law, Self and Mutual Inductance, Impedance plane, Inspection system	2	1,2	1,2,3
Unit No. 3	Ultrasonic testing: Basics of ultrasonic waves, Pulse and beam shapes, Ultrasonic transducers, Distance and Area calibration, Weld inspection by UT	2	3	1,2,3
	Acoustic emission testing: Sources of acoustic emission	2	1,3	1,2,3,4
	Source parameters, Kaiser-Felicity theory	2	3	1,2,3
	Equipment and Data analysis	3	3	1,2,3
Unit No. 4	X-rays and their properties,	3	1,2,3	1,2,3
	X-ray generation, X-ray absorption	3	3,4	1,2,3
	atomic scattering; Image formation, Image quality	2	4	1,2,3
	Digital Radiography, Image interpretation, Radiation Shielding	3	4	1,2,3,4
Unit No. 5	ASTM standard test method for NTD tests, like Radiographic	2	2,4	1,2,3
	Electromagnetic (eddy current),X-ray, Acoustic.	2	2,3	1,2,3
	Tomographic techniques;	2	4	1,2,3
	Comparison and selection NDT methods	2	4	1,2,3,4
	Total Contact Hours	**45**		

Lab Unitization Plan

S. No.	Description of experiments	Required Contact Hours	CLOs Addressed	References Used
1	Visual Inspection Techniques	3	1	3
2	Dimensional Measurement with Calipers and Micrometers	3	1	3,4
3	Coordinate Measuring Machine (CMM) Operation	3	1	3
4	Surface Roughness Measurement	3	1,2	3
5	Non-Destructive Testing (NDT) – Ultrasonic Testing	3	3,4	3,4
6	Radiographic Testing (X-Ray Inspection)	3	3	3
7	Hardness Testing	3	3	3
8	Tensile Testing	3	3	3,4
9	Magnetic Particle Inspection (MPI)	3	4	3
10	Eddy Current Testing	3	4	2,3
	Total Contact Hours	**30**		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								End Semester Exam (50%)	
		CLA-1 (10%)		CLA-2 (10%)		CLA-3 (15%)		Mid Term (15%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
	Understand	30%	30%	30%	30%	20%	30%	30%	30%	30%	30%
Level 2	Apply	10%	20%	30%	30%	20%	20%	30%	20%	20%	20%
	Analyse	40%	30%	20%	20%	40%	30%	20%	30%	30%	30%
Level 3	Evaluate										
	Create										
Total		**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Recommended Resources

1. Foster, P. Field, The Mechanical Testing of Metals and Alloys, Cousens Press , 2007.
2. Nondestructive Evaluation and Quality Control, ASM Handbook, Vol. 17. 2008.
3. J Prasad, Non-Destructive Test and Evaluation of Materials, McGraw Hill, 2017.
4. Welding Inspection, American Welding Society,3rdEd.,2000.

Flexible Manufacturing System

Course Code	MMT 541	Course Category	CE	L	T	P	C
				3	0	1	4
Pre-Requisite Course(s)		Co-Requisite Course(s)		Progressive Course(s)			
Course Offering Department	Mechanical Engineering	Professional / Licensing Standards					

Course Objectives / Course Learning Rationales (CLRs)

1. **To deconstruct the anatomy of Flexible Manufacturing Systems**
2. **To craft agile production lines**
3. **To optimize the pulse of production**
4. **To navigate the crossroads of flexibility and feasibility**

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Unpack the core components, types, and operational principles of FMS	**3**	**70%**	**75%**
Outcome 2	Design and implementation of FMS	**2**	**80%**	**75%**
Outcome 3	Master the art of measuring and maximizing FMS performance metrics, navigate the FMS software	**3**	**80%**	**70%**
Outcome 4	Analyze the economic viability of FMS, navigating the risks and rewards, and emerging with the critical thinking skills to make informed decisions that shape the future of manufacturing.	**3**	**80%**	**75%**

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)														
	Engineering Knowledge	Problem Analysis	Design and Development	Analysis, Design and Research	Modern Tool and ICT Usage	Society and Multicultural Skills	Environment and Sustainability	Moral, and Ethical Awareness	Individual and Teamwork Skills	Communication Skills	Project Management and Finance	Self-Directed and Life Long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	2	2	1	2	2				1			3	3	2	3
Outcome 2	3	3	3	3	3				1			3	2	3	2
Outcome 3	3	3	3	2	3				3			3	3	3	3
Outcome 4	3	3	3	3	3				3			3	3	3	2
Course Average	**3**	**3**	**3**	**3**	**2**				**2**			**3**	**3**	**3**	**3**

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used

Unit No. 1	Types of production system, comparison, plant layout, Functions in manufacturing, manufacturing support system	**2**	**1**	**1,2**
	Automation in the production system,	**2**	**1**	**1,2,3**
	Production quantity and product variety, production concepts and mathematical model, tutorial on production rate, production, capacity, utilization, availability, manufacturing lead time for all types of production	**2**	**1**	**1,3**
	Tutorial on manufacturing lead time, work in progress for all types of production, single product scheduling	**2**	**1**	**1,2**
Unit No. 2	Introduction to GT	**1**	**1**	**1,2,3**
	Formation of part families, part classification and coding system, production flow analysis, machine cell design, clustering algorithm, GT benefits	**2**	**1,2**	**1,2,3**
	Introduction and evolution of FMS	**1**	**1**	**1**
	FMS need and economic justification, components and classification of fms	**2**	**4**	**1,2,3**
Unit No. 3	Physical planning for FMS, objective, guideline.	**2**	**3**	**1,2,3**
	User-supplier responsibilities in planning, user-supplier role in site preparation, machine tool selection and layout, computer control system, datafiles, types of reports, system description and sizing, factors affecting it.	**2**	**3**	**1,2,3**
	Human resources for FMS, objective, staffing, supervisor role.	**2**	**3**	**1,2,3**
	Quantitative analysis methods for fms, bottle neck and extended bottle neck model, tutorial, FMS benefits and limitations.	**2**	**3**	**1,2,3**
Unit No. 4	Introduction to manufacturing cells, Cell description and classifications, Unattended machining, Requirement and features	**2**	**1,2**	**1,2,3**
	Cellular versus FMS, System simulation, Hardware configuration	**3**	**1,2,3**	**1,2,3**
	PLC and computer controllers, Communication networks	**2**	**1,2**	**1,2,3**
	Lean production and agile manufacturing	**3**	**1,2**	**1,2,3**
Unit No. 5	Introduction to FMS software, General structure and requirements	**3**	**3,4**	**3**
	Functional descriptions, Operational overview, FMS installation	**3**	**3,4**	**1,2,3**
	Acceptance testing, Performance goals, FMS application in machining, Sheet metal fabrication	**3**	**3,4**	**1,2,3**
	Prismatic component production, FMS development towards factories of the future	**4**	**3,4**	**1,2,3**
	Total Contact Hours	**45**		

Unitization Plan - Lab

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Hands-on training to students on CNC programming and robotics	**6**	**1**	**2**
Unit No. 2	Case study on FMS in various industries	**6**	**1**	**2**
Unit No. 3	FMS prototype making	**6**	**1,2**	**1,2,3**
Unit No. 4	Routine maintenance and calibration of CNC machines and robots	**6**	**1,2,3,4**	**2,3**
Unit No. 5	3D scanning and printing of components	**6**	**3,4**	**2**
	Total Contact Hours	**30**		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								End Semester Exam (50%)	
		CLA-1 (10%)		CLA-2 (10%)		CLA-3 (15%)		Mid Term (15%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
	Understand	30%	30%	30%	30%	20%	30%	30%	30%	30%	30%
Level 2	Apply	10%	20%	30%	30%	20%	20%	30%	20%	20%	20%
	Analyse	40%	30%	20%	20%	40%	30%	20%	30%	30%	30%
Level 3	Evaluate										
	Create										
Total		**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Recommended Resources

1. William W. Luggen, "Flexible Manufacturing Cells and Systems", Prentice Hall, New Jersey, 1991.
2. Mikell P. Groover, "Automation Production Systems & Computer Integrated manufacturing", Prentice, 2007.
3. Jha.N.K, "Handbook of Flexible Manufacturing Systems", Academic Press Inc.,1991.

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Product Design and Manufacturing

Course Code	MMT 542	Course Category	CE		L	T	P	C
					3	0	1	4
Pre-Requisite Course(s)	Basic mathematics	Co-Requisite Course(s)	Manufacturing Processes	Progressive Course(s)				
Course Offering Department	Mechanical Engineering	Professional / Licensing Standards						

Course Objectives / Course Learning Rationales (CLRs)

1. Understanding of how design principles and manufacturing processes are integrated to create functional and manufacturable products.
2. Develop Skills in Manufacturing Processes
3. Integrate Design and Manufacturing for Optimization
4. Apply Project Management and Collaboration Techniques

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Design Product, Tools and Techniques	3	80%	75%
Outcome 2	Explain various Manufacturing Processes	3	70%	65%
Outcome 3	Design for Manufacturability	3	80%	70%
Outcome 4	Manage the Project and Team Collaboration	3	80%	75%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)												
	Engineering Knowledge	Design / Development of Solutions	Conduct Investigations of Complex Problems	Modern Tools and ICT Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Teamwork Skills	Communication Skills	Life-long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	3	3	3	3				2		3	3	2	3
Outcome 2	3	1	3	1				3		3	3	2	3
Outcome 3	3	3	2	3				3		2	2	3	3
Outcome 4	3	2	3	3				3		3	2	3	3
Average	3	2	3	2				2		3	3	2	3

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Introduction to product design and manufacturing.	3	1	1,2
	Design methodology	2	1	1,2
	Design philosophy- types of designs, design models, concurrent engineering	2	1	1,2
	Design Teams – Organizations & product Planning.	1	1	1
Unit No. 2	Need Analysis & Scope – mission statement, customer study, Kano diagram.	3	1,2	1,2,3
	Establishing Product Function- functional decomposition, FAST and SOP, function structure.	2	1,2	1,2,3
	Product Tear down- reverse engineering.	2	1,2	1,2,3
	Product Specifications- QFD	1	1,2	1,2,3
Unit No. 3	Generation and evaluation of concepts – TRIZ, Decision matrix.	3	2,3,4	1,2,3
	Embodiment Design- product architecture, configuration, parametric design.	2	3	1,2,3
	Systems approach and other considerations of embodiment design.	2	3	1,2,3
	Equipment and Data analysis	3	3	1,2,3
Unit No. 4	Industrial Design – aesthetics and ergonomic aspects of product design.	3	1,3	1,2,3
	Value Engineering. Failure mode and effects analysis.	3	3,4	1,2,3
	Manufacturability assessments of given design	2	4	1,2,3
	Product Costing and Bill of Materials	2	4	1,2,3
Unit No. 5	Process planning for components and assembly.	3	2	1,2,3
	Component specifications	2	4	1,2,3
	Product Simulations and rapid prototyping	2	1,4	1,2,3
	Product manufacturing and Testing.	2	4	1,2,3
	Total Contact Hours	**45**		

Lab Unitization Plan

S. No.	Description of experiments	Required Contact Hours	CLOs Addressed	References Used
1	Conceptual Design and Prototyping	3	1	2,3
2	Computer-Aided Design (CAD)	3	1	3
3	Finite Element Analysis (FEA) of product.	3	1,3	3
4	Design for Manufacturability (DFM)	3	1	1,3
5	Computer Aided Engineering(CAE)	3	2,4	3
6	Rapid prototyping through 3D printing	3	3	3
7	Material Selection and Testing	3	3	3
8	Rapid Prototyping and Iteration	3	3	3
9	Assembly and Testing	3	4	1
10	Quality Control and Inspection	3	4	3
	Total Contact Hours	**30**		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								End Semester Exam (50%)	
		CLA-1 (10%)		CLA-2 (10%)		CLA-3 (15%)		Mid Term (15%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
	Understand	30%	30%	30%	30%	20%	30%	30%	30%	30%	30%
Level 2	Apply	10%	20%	30%	30%	20%	20%	30%	20%	20%	20%
	Analyse	40%	30%	20%	20%	40%	30%	20%	30%	30%	30%
Level 3	Evaluate										
	Create										
Total		**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Recommended Resources

1. Kevin Otto and Kristin Wood, " Product design"- Pearson, 2004.
2. David G. Ullman, "The Mechanical Design Process" – McGraw Hill, 2003.
3. George E. Dieter, " Engineering Design" – McGraw Hill, 2000.

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Biomaterials Processing and Applications

Course Code	MMT 543	Course Category	CE			L	T	P	C
						3	0	1	4
Pre-Requisite Course(s)		Co-Requisite Course(s)		Progressive Course(s)					
Course Offering Department	Mechanical Engineering	Professional / Licensing Standards							

Course Objectives / Course Learning Rationales (CLRs)

1. Understand the fundamentals of 3D bioprinting, biomaterials, as well as processing techniques relevant to biomaterials manufacturing.
2. To evaluate and select appropriate biomaterials for specific medical applications
3. To process biomaterials, 3D tissue/organ design and print.
4. Understand 4D bioprinting, biofabrication-based strategies from bench-to-bed to address specific clinical problems, applications and analyze future direction.

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Apply concepts of 3D printing in biofabrication and engineering components.	2	80%	75%
Outcome 2	Highlight the challenges in translating 3D printing to biofabrication, evaluate and select appropriate biomaterials for specific medical applications	3	80%	75%
Outcome 3	Process biomaterials, 3D tissue/organ design and print	3	70%	65%
Outcome 4	Explain the applications of biofabrication from research to clinical use	3	80%	75%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)												
	Engineering Knowledge	Design / Development of Solutions	Conduct Investigations of Complex	Modern Tools and ICT Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Teamwork Skills	Communication Skills	Life-long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	3	2	3	3				2		3	3	3	2
Outcome 2	3	3	3	2				2		3	3	3	3
Outcome 3	3	2	3	3				3		3	3	3	3
Outcome 4	3	3	3	3				3		3	3	2	3
Average	3	2	3	3				2		3	3	3	3

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Introduction to 3D printing, Importance of 3D printing in Product Development,	2	1	1
	Classification of 3D printing processes, CAD Modelling for 3D printing: 3D Scanning and digitization,	2	1	1
	Introduction to Bioprinting; different types of bioprinting techniques and their advantages and disadvantages	2	2	1,3,4
	Surface chemistry and physics of selected metals, polymers, and ceramics,	2	2	1,3,4
Unit No. 2	surface characterization methodology, modification of biomaterials' surfaces,	2	1,2	1,3,4
	biosensors and microarrays, bulk properties of implants, acute and chronic responses to implanted biomaterials,	2	1,2	1,2,4
	drug delivery and tissue engineering; Property requirement of biomaterials; Concept of biocompatibility;	3	2,3	1,3,4
	Cell-material interactions and foreign body response; Assessment of biocompatibility of biomaterials, important bio-metallic alloys; Ti-based, stainless steels,	2	1,2	2,3,4
Unit No. 3	Co-Cr-Mo alloys; Bio-inert, bio-active and bioresorbable ceramics; Processing and properties of different bio-ceramic materials with emphasize on hydroxyapatite;	3	1,2	2,3,4
	Synthesis of biocompatible coatings on structural implant materials;	2	1,2	2,3,4
	Microstructure and properties of glass ceramics; Biodegradable polymers;	1	1,2	2,3,4
	Design concept of developing new materials for bio-implant applications.	2	1,2	2,3,4
Unit No. 4	3D tissue designing and 3D tissue/organ printing	3	1,2	2,3
	Biomaterials used for bioink development with their merits and demerits	2	1,2	2,3,4
	Modulation of bioink properties to control different processing conditions	2	2,3	2,3,4
	3D bioprinted in vitro, in vivo, and ex vivo research models and techniques	3	3,4	2,3
Unit No. 5	In situ bioprinting and 4D bioprinting with examples from recent literature	3	3,4	2,3
	Biofabrication-based strategies from bench-to-bed to address specific clinical problems	3	3,4	2,3
	Next step in bioprinting (challenges and future direction)	2	3,4	2,3
	Ethical issues related to bioprinting	3	3,4	2,3
	Total Contact Hours	**45**		

Lab Unitization Plan

S. No.	Description of experiments	Required Contact Hours	CLOs Addressed	References Used
1	Introduction to Biomaterials	3	1	1,2,3
2	Synthesis of Biodegradable Polymers	3	1,4	1,2,3
3	Surface Modification Techniques	3	2	1,2,3
4	Biomaterial Scaffold Fabrication for Tissue Engineering	3	2,4	1,2,3
5	Biomaterial Characterization: Mechanical Properties	3	2	1,2,3
6	Drug Delivery Systems Using Biomaterials	3	3,4	1,2,3,4
7	Biocompatibility Testing and Cell Culture Techniques	3	3	1,2,3,4
8	In Vitro Degradation and Bioactivity Assessment	3	2,4	1,2,3
9	Imaging Techniques for Biomaterials	3	4	1,2,3
10	Case Studies and Emerging Trends in Biomaterials	3	4	1,4
	Total Contact Hours	30		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								End Semester Exam (50%)	
		CLA-1 (10%)		CLA-2 (10%)		CLA-3 (15%)		Mid Term (15%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
	Understand	30%	30%	30%	30%	20%	30%	30%	30%	30%	30%
Level 2	Apply	10%	20%	30%	30%	20%	20%	30%	20%	20%	20%
	Analyse	40%	30%	20%	20%	40%	30%	20%	30%	30%	30%
Level 3	Evaluate										
	Create										
Total		**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Recommended Resources

1. Chua, C.K., Leong K.F. and Lim C.S., "Rapid prototyping: Principles and applications", second edition, World Scientific Publishers, 2010.
2. Jeremy M. Crook, "3D Bioprinting Principles and Protocols", Springer, 2020.
3. Maika G. Mitchell, "Bioprinting Techniques and Risks for Regenerative Medicine", Elsevier, 2017.
4. TeohSwee Hin Engineering Materials For Biomedical Applications (Biomaterials Engineering and Processing Series, 2022

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Powder Materials and Processing

Course Code	MMT 544	Course Category	CE	L	T	P	C
				3	0	1	4
Pre-Requisite Course(s)		Co-Requisite Course(s)		Progressive Course(s)			
Course Offering Department	Mechanical Engineering	Professional / Licensing Standards					

Course Objectives / Course Learning Rationales (CLRs)

1. Understand the powder materials, their properties, production methods, and applications in various industries
2. To process the powder materials into finished component.
3. To optimize the factors influencing the process and product characteristics.
4. To use appropriate powder materials and processing techniques for specific manufacturing applications, demonstrating an understanding of their advantages and limitations.

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Explain the fundamental of powder materials.	1	80%	75%
Outcome 2	Process the powder materials into finished components	2	75%	75%
Outcome 3	To optimize the process and product characteristics	2	80%	70%
Outcome 4	To identify advantages and limitations, applications of powder materials	3	80%	75%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)												
	Engineering Knowledge	Design / Development of Solutions	Conduct Investigations of Complex Problems	Modern Tools and ICT Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Teamwork Skills	Communication Skills	Life-long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	3	2	3	2				2		3	3	2	3
Outcome 2	3	3	3	2				2		3	3	3	3
Outcome 3	3	3	2	2				3		3	3	3	3
Outcome 4	3	3	3	3				3		3	2	3	3
Average	3	2	3	2				2		3	3	2	3

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Introduction of powder materials	3	1	1,2
	Development of powder metallurgy	2	1	1,2
	Scope of powder metallurgy	2	1	1,2
	Characterization of metal powders,	1	1,2	1,2
Unit No. 2	Physical properties-particle size and shape determination,	2	1,2	1,2,3
	Technological properties apparent density, flow rate etc. and chemical properties	2	1,2	1,2,3
	Particle interaction and control	2	1,2	1,2,3
	Powder manufacturing: Powder mixing and blending	2	1,2	1,2,3
Unit No. 3	Dry and colloidal processing	3	3	1,2,3
	Reduction, electrolysis, and atomization processes	2	2,3	1,2,3
	Shaping techniques such as compacting	2	3,4	1,2,3
	Injection moulding; Compaction and sintering	3	3	1,2,3
Unit No. 4	Die compaction and other consolidation techniques	3	1,3	1,2,3
	Sintering, sintering with liquid phase	3	3,4	1,2,3
	Powder metallurgy products:	2	4	1,2,3
	Bearing, filters, friction parts,	2	4	1,2,3
Unit No. 5	Hard metals, refractory metals,	3	4	1,2,3
	Contact materials, magnetic materials,	2	2	1,2,3
	Structural parts,	2	4	1,2,3
	Dispersion strengthened materials	2	4	1,2,3
	Total Contact Hours	**45**		

Lab Unitization Plan

S. No.	Description of experiments	Required Contact Hours	CLOs Addressed	References Used
1	Introduction to Powder Characterization	3	1	1,2,3
2	Particle Morphology and Surface Area Analysis	3	1	1,2,3
3	Powder Mixing and Blending	3	2	1,2,3
4	Powder Compaction and Green Density Measurement	3	1	1,2,3
5	Sintering and Densification	3	2	1,2,3
6	Powder Metallurgy Techniques	3	3	1,2,3
7	Chemical Analysis of Powders	3	3	1,2,3
8	Spray Drying and Granulation	3	3	1,2,3
9	Additive Manufacturing with Powders	3	4	1,2,3
10	Safety and Environmental Considerations in Powder Handling	3	4	1,2,3
	Total Contact Hours	30		

Learning assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								End Semester Exam (50%)	
		CLA-1 (10%)		CLA-2 (10%)		CLA-3 (15%)		Mid Term (15%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
	Understand	30%	30%	30%	30%	20%	30%	30%	30%	30%	30%
Level 2	Apply	10%	20%	30%	30%	20%	20%	30%	20%	20%	20%
	Analyse	40%	30%	20%	20%	40%	30%	20%	30%	30%	30%
Level 3	Evaluate										
	Create										
Total		**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Recommended Resources

1. Glaus G. Goetzel, Treatise on Powder Metallurgy in three volumes, Interscience, 2022
2. Volume 1: Technology of Metal Powders and Their Products
3. Volume II: Applied and Physical Powder Metallurgy
4. Volume III: Classified and Annotated Bibliography.

SRM University *AP*, Andhra Pradesh

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Design and Analysis of Experiments

Course Code	MMT 545	Course Category	CE	L	T	P	C
				3	0	1	4
Pre-Requisite Course(s)		Co-Requisite Course(s)		Progressive Course(s)			
Course Offering Department	Mechanical Engineering	Professional / Licensing Standards					

Course Objectives / Course Learning Rationales (CLRs)

1. Understand the Fundamentals of Finite Element Analysis (FEA).
2. Develop Proficiency in Preprocessing for FEA.
3. Conduct Finite Element Analysis and Interpret Results.
4. Optimize Structural Designs Using FEA

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Define and explain the basic principles of finite element analysis, including the concept of discretization, element types, and the formulation of mathematical models for engineering structures	2	80 %	75 %
Outcome 2	Gain proficiency in preprocessing tasks for FEA, including geometry modeling, mesh generation, and material property assignment	2	70 %	65 %
Outcome 3	Acquire skills in setting up and solving finite element models using FEA software.	3	80 %	70 %
Outcome 4	Explore techniques for structural optimization using finite element methods to improve the efficiency and performance of engineering designs	2	70 %	65 %

Course Articulation Matrix (CLO) to Program Learning Outcomes (PL

CLOs	Program Learning Outcomes (PLO)												
	Engineering Knowledge	Design / Development of Solutions	Conduct Investigations of Complex Problems	Modern Tools and ICT Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Teamwork Skills	Communication Skills	Life-long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	3	2	2	3				3		3	3	2	3
Outcome 2	3	2	3	3				3		3	3	2	3
Outcome 3	3	2	3	3				3		3	3	2	3
Outcome 4	3	3	3	3				3		3	3	3	3
Average	3	3	3	3				3		3	3	2	3

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Introduction to Research	2	1	1,3
	Review of linear estimation, basic designs and Design Principles	2	1	1,2,3
	Completely Randomized Designs	1	1	1,2,3
	Treatment Comparisons, Diagnostics and Remedial Measures	1	1	1,2,3
	Experiments to Study Variances, Random Effects Models	1	1	1,2,3
	Factorial Designs	2	1	1,2,3
Unit No. 2	General factorial experiments	2	1,2	1,2,3
	Factorial effects	1	1,2	1,2,3
	Best estimates and testing the significance of factorial effects	1	1,2	1,2,3
	Study of 2^{nd} and 3^{rd} factorial experiments in randomized blocks	2	1,2	1,2,3
	Complete and partial confounding, construction of symmetrical confounded factorial experiments	1	1,2	1,2,3
	Fractional replications for symmetrical factorials	1	1,2	1,2,3
	Split plot and strip-plot experiments	1	1,2	1,2,3
Unit No. 3	Complete Block Designs: Balanced incomplete block designs	2	1,2	1,2
	Simple lattice designs	2	1,2	1,2
	Two-associate partially balanced incomplete block designs: association scheme and intra block analysis, group divisible design.	1	1,2	1,2
	Analysis of Covariance including a Measured Covariate Split-Plot Designs	3	1,2	1,2
	Repeated Measures Designs, missing plot technique: - General theory and applications	1	1,2	1,2
Unit No. 4	Analysis of Co-variance for CRD and RBD	4	1,2	1,2,3
	Application areas: Response surface experiments	4	1,2	1,2,3
Unit No. 5	First order designs, and orthogonal designs;	2	3,4	4,5
	Clinical trials	2	3,4	4,5
	Treatment-control designs	2	3,4	4,5
	Model variation and use of transformation	2	3,4	4,5
	Tukey's test for additivity	2	3,4	4,5
	Total Contact Hours	**45**		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)				End Semester Exam (50%)
		CLA-1 (10%)	Mid-1 (15%)	CLA-2 (10%)	Mid-2 (15%)	
		Th	Th	Th	Th	Th
Level 1	Remember	40%	50%	30%	20%	30%
	Understand					
Level 2	Apply	60%	50%	70%	80%	70%
	Analyse					
Level 3	Evaluate					
	Create					
Total		**100%**	**100%**	**100%**	**100%**	**100%**

Recommended Resources

1. Douglas C. Montgomery, "Design and Analysis of Experiments", Seventh Edition, Wiley,2010.
2. Jiju Antony, "Design of Experiments for Engineers and Scientists", Elsevier, 2003.
3. Larry B. Barrentine, "An Introduction to Design of Experiments: A Simplified Approach's Quality Press, 1999.
4. Paul G Mathews, "Design of Experiments with MINITAB", ASQ Quality Press, 2003.
5. Mark J. Anderson, Patrick J. Whitcomb, "DOE Simplified: Practical Tools for Effective Experimentation", Second Edition, Productivity Press,2007.

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Robotics and AI/ML for Manufacturing

Course Code	MMT 546	Course Category	CE	L	T	P	C
				3	0	1	4
Pre-Requisite Course(s)		Co-Requisite Course(s)		Progressive Course(s)			
Course Offering Department	Mechanical Engineering	Professional / Licensing Standards					

Course Objectives / Course Learning Rationales (CLRs)

1. Understand the fundamental principles of robotics, artificial intelligence (AI), and machine learning (ML) as applied to manufacturing processes
2. To design and implement robotic systems.
3. To deploy and configure robotic systems.
4. To integrate AI/ML solutions, and solving real-world manufacturing challenges.

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Utilize the robots for manufacturing processes	3	80%	75%
Outcome 2	Use AI/ML algorithms for process optimization, quality control, and predictive maintenance	3	75%	75%
Outcome 3	Deploy and configure robotic systems	2	80%	70%
Outcome 4	Integrate AI/ML solutions, and solving real-world manufacturing challenges	3	80%	75%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)												
	Engineering Knowledge	Design / Development of Solutions	Conduct Investigations of Complex Problems	Modern Tools and ICT Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Teamwork Skills	Communication Skills	Life-long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	3	3	3	2				2		3	3	2	3
Outcome 2	3	3	2	2				2		3	3	3	3
Outcome 3	3	2	3	2				3		3	3	3	3
Outcome 4	3	3	3	3				3		3	3	3	3
Average	3	3	3	2				2		3	3	3	3

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Introduction to robots	3	1	1,2
	Applications of robot and sensors	1	1	1,2,4
	Internal and external sensors;	2	1	1,2,4
	Hydraulic actuators	2	1,2	1,2,4
Unit No. 2	Pneumatic and electric actuators	2	1,2	1,2,3,4
	Programming of robots	2	1,2	1,2,3
	Homogeneous transformations	2	1,2	1,2,3
	D-H parameter notation	2	1,2,3	1,2,3
Unit No. 3	Direct kinematics of manipulators	3	2,3	1,2,3
	Inverse kinematics of manipulators	2	2,3	1,2,3
	Examples of kinematics of some common manipulator configurations	2	3,4	1,2,3
	Jacobian	3	3	1,2,3
Unit No. 4	Dynamics of manipulators	3	1,3	1,2,3
	Trajectory planning;	3	3,4	1,2,3
	Introduction to Automation	2	4	1,2,3
	Types of automation	2	1,4	1,2,3
Unit No. 5	Analysis of automated assembly systems	3	2,4	1,2,3
	Line balancing problems	2	1,2	1,2,3
	Analysis of automated material handling systems	2	4	1,2,3
	Automated storage and retrieval system	3	4	1,2,3
	Total Contact Hours	**45**		

Lab Unitization Plan

S. No.	Description of experiments	Required Contact Hours	CLOs Addressed	References Used
1	Introduction to Robotics and Automation	3	1	1,2,3
2	Robot Kinematics and Control	3	1	1,2,3
3	Machine Vision and Image Processing	3	2	1,2,3
4	Introduction to Machine Learning in Manufacturing	3	2	1,2,3
5	Predictive Maintenance with ML	3	2	1,2,3
6	Reinforcement Learning for Robotics	3	3,4	1,2,3,4
7	Collaborative Robots (Cobots) in Manufacturing	3	3	1,2,3,4
8	AI-Based Quality Control	3	2,4	1,2,3
9	Process Optimization Using AI/ML	3	4	1,2,3
10	Ethical and Safety Considerations in Robotics and AI	3	4	1,4
	Total Contact Hours	30		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								End Semester Exam (50%)	
		CLA-1 (10%)		CLA-2 (10%)		CLA-3 (15%)		Mid Term (15%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
	Understand	30%	30%	30%	30%	20%	30%	30%	30%	30%	30%
Level 2	Apply	10%	20%	30%	30%	20%	20%	30%	20%	20%	20%
	Analyse	40%	30%	20%	20%	40%	30%	20%	30%	30%	30%
Level 3	Evaluate										
	Create										
Total		**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Recommended Resources

1. Robotics: Fundamental concepts and analysis By A. Ghosal, Oxford university press, 2006.
2. M P Groover, Industrial Robotics, Pearson Edu, 2008.
3. K Fu, R Gonzalez, and C S G Lee, Robotics: Control, sensing, vision and intelligence, McGraw Hill, 1987.
4. M P Groover, Automation, Production systems and Computer Intigrated Manufacturing, Prentice Hall India, 1987.

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Manufacturing Automation and Industry 4.0

Course Code	MMT 547	**Course Category**		**L**	**T**	**P**	**C**
				3	0	1	4
Pre-Requisite Course(s)		**Co-Requisite Course(s)**		**Progressive Course(s)**			
Course Offering Department	Mechanical Engineering	**Professional / Licensing Standards**					

Course Objectives / Course Learning Rationales (CLRs)

1. Understand the principles and concepts of manufacturing automation and Industry 4.0
2. To apply automation technologies in manufacturing processes
3. To design, program, and implement automation solutions for diverse manufacturing applications
4. To integrate and leverage Industry 4.0 technologies to enhance data-driven decision-making

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Expalin smart manufacturing systems, cyber-physical systems, and the Industrial Internet of Things (IIoT).	3	80%	75%
Outcome 2	Apply automation technologies, such as programmable logic controllers (PLCs), robotic systems, and sensor networks, in manufacturing processes.	3	75%	75%
Outcome 3	Design, and implement automation solutions for improving efficiency and flexibility	2	80%	70%
Outcome 4	Integrate and leverage Industry 4.0 technologies	3	80%	75%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)												
	Engineering Knowledge	Design / Development of Solutions	Conduct Investigations of Complex Problems	Modern Tools and ICT Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Teamwork Skills	Communication Skills	Life-long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	3	3	3	2				2		3	3	2	3
Outcome 2	3	2	2	2				2		3	3	2	3
Outcome 3	3	2	2	2				3		3	2	3	3
Outcome 4	3	3	3	3				3		3	3	3	3
Average	3	3	3	2				2		3	3	3	3

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Introduction: Concept and scope of industrial automation	3	1	1,2
	Socio-economic considerations, Types of automation	1	1	1,2,4
	Automation strategies, Automation Technologies	2	1	1,2,4
	Fluid Power Control: Fluid Power Control elements and standard graphical symbols for them	2	1,2	1,2,3,4
Unit No. 2	Construction and performance of fluid power generators,	2	1,2	1,2,3,4
	Hydraulic & pneumatic cylinders -construction, design and mounting	2	1,2	1,2,3,4
	Hydraulic & pneumatic valves for pressure	2	1,2	1,2,3
	Flow & direction control, Simple hydraulic and pneumatic circuits;	2	1,2,3	1,2,3
Unit No. 3	Pneumatics: Pneumatic Logic Circuits:	3	2,3	1,2,3
	Boolean Algebra, Truth tables	2	2,3	1,2,3
	Un-complementation algorithm and Karnaugh Maps,	2	3,4	1,2,3
	Design of pneumatic logic circuits for a given time displacement diagram or sequence of operation;	3	3	1,2,3
Unit No. 4	High Volume Production Systems: Transfer devices	3	1,2,3	1,2,3
	Vibratory bowl feeders, Non-vibratory feeders	3	3,4	1,2,3,4
	Part orienting, feed track, Part placing and part escapement systems; Automation strategies,	2	4	1,2,3
	Analysis of flow lines, Automated assembly systems	2	1,4	1,2,3
Unit No. 5	Mechatronics: Mechanical system interfacing	3	2,4	1,2,3
	Simple mechatronic devices: Stepping motors	2	1,2	1,2,3
	DC motors, Analog / digital conversion and Programmable automation	2	4	1,2,3
	CNC, industrial robotics; Flexible manufacturing systems.	2	4	1,2,3
	Total Contact Hours	**45**		

Lab Unitization Plan

S. No.	Description of experiments	Required Contact Hours	CLOs Addressed	References Used
1	Introduction to Industry 4.0 and Smart Manufacturing	3	1	1,2,3
2	PLC Programming and Automation Basics	3	1	1,2,3
3	Human-Machine Interface (HMI) Design	3	2	1,2,3
4	IoT in Manufacturing	3	2	1,2,3
5	Data Analytics and Machine Learning in Manufacturing	3	2	1,2,3
6	Robotics Integration in Manufacturing	3	3,4	1,2,3,4
7	Cybersecurity in Smart Manufacturing	3	3	1,2,3,4
8	Augmented Reality (AR) and Virtual Reality (VR) in Manufacturing	3	2,4	1,2,3
9	Advanced Manufacturing Technologies (3D Printing, CNC)	3	4	1,2,3
10	Digital Transformation and Smart Factory Design	3	4	1,4
	Total Contact Hours	**30**		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								End Semester Exam (50%)	
		CLA-1 (10%)		CLA-2 (10%)		CLA-3 (15%)		Mid Term (15%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
	Understand	30%	30%	30%	30%	20%	30%	30%	30%	30%	30%
Level 2	Apply	10%	20%	30%	30%	20%	20%	30%	20%	20%	20%
	Analyse	40%	30%	20%	20%	40%	30%	20%	30%	30%	30%
Level 3	Evaluate										
	Create										
Total		**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Recommended Resources

1. A. Esposito, Fluid Power with Applications, Prentice Hal of India, New Delhi, 2008.
2. S.R. Majumdar, Pneumatic Systems, McGraw Hill, 2017
3. Geoffrey Boothroyd, Assembly Automation and Product Design, CRC press, 2005
4. M. P. Groover, Automation, Production System and Computer Integrated Manufacturing, Prentice Hal of India, New Delhi, 2017.