Department of Mechanical Engineering

M.Tech. Materials and Manufacturing Technology
Curriculum and Syllabus

(Applicable to the students admitted during AY: 2022-23)

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)												
	POs										PSOs		
PEOs	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

<table>
<tr><th colspan="4">Category Wise Credit Distribution</th></tr>
<tr><th>Course Sub-Category</th><th>Sub-Category Credits</th><th>Category Credits</th><th>Learning Hours</th></tr>
<tr><td colspan="2">Ability Enhancement Courses (AEC)</td><td>1</td><td rowspan="3">30</td></tr>
<tr><td>University AEC</td><td>0</td><td></td></tr>
<tr><td>School AEC</td><td>1</td><td></td></tr>
<tr><td colspan="2">Value Added Courses (VAC)</td><td>0</td><td rowspan="3">0</td></tr>
<tr><td>University VAC</td><td>0</td><td></td></tr>
<tr><td>School VAC</td><td>0</td><td></td></tr>
<tr><td colspan="2">Skill Enhancement Courses (SEC)</td><td>0</td><td rowspan="4">0</td></tr>
<tr><td>School SEC</td><td>0</td><td></td></tr>
<tr><td>Department SEC</td><td>0</td><td></td></tr>
<tr><td>SEC Elective</td><td>0</td><td></td></tr>
<tr><td colspan="2">Foundation / Interdisciplinary courses (FIC)</td><td>0</td><td rowspan="3">0</td></tr>
<tr><td>School FIC</td><td>0</td><td></td></tr>
<tr><td>Department FIC</td><td>0</td><td></td></tr>
<tr><td colspan="2">Core + Core Elective including Specialization (CC)</td><td>38</td><td rowspan="3">1140</td></tr>
<tr><td>Core</td><td>28</td><td></td></tr>
<tr><td>Core Elective (Inc Specialization)</td><td>10</td><td></td></tr>
<tr><td>Minor (MC) + Open Elective (OE)</td><td>6</td><td>6</td><td>180</td></tr>
<tr><td colspan="2">Research / Design / Internship/ Project (RDIP)</td><td>27</td><td rowspan="3">810</td></tr>
<tr><td>Internship / Design Project / Startup / NGO</td><td>12</td><td></td></tr>
<tr><td>Internship / Research / Thesis</td><td>15</td><td></td></tr>
<tr><td colspan="2">Total</td><td>72</td><td>2160</td></tr>
</table>

Semester wise Course Credit Distribution Under Various Categories						
Category	**Semester**					
	I	**II**	**III**	**IV**	**Total**	**%**
Ability Enhancement Courses - AEC	1	0	0	0	1	**1**
Value Added Courses - VAC	0	0	0	0	0	**0**
Skill Enhancement Courses - SEC	0	0	0	0	0	**0**
Foundation / Interdisciplinary Courses - FIC	0	0	0	0	0	**0**
CC / SE / CE / TE / DE / HSS	21	17	0	0	38	**53**
Minor / Open Elective - OE	0	0	6	0	6	**8**
(Research / Design / Industrial Practice / Project / Thesis / Internship) - RDIP	0	3	9	15	27	**38**
Grand Total	**22**	**20**	**15**	**15**	**72**	**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	AEC	S AEC	EGL 501	English for Research Paper Writing	1	0	0	1
2	Core	CC	MMT 561	Mechanics of Composite Materials	3	0	0	3
3	Core	CC	MMT 552	Surface Engineering	3	0	0	3
4	Core	CC	MMT 581	Numerical Methods	3	0	0	3
5	Core	CC	MMT 581L	Numerical Methods Lab	0	0	1	1
6	Core	CC	MMT 554	Advanced Manufacturing Methods	3	0	0	3
7	Core	CC	MMT 554 L	Advanced Manufacturing Methods Lab	0	0	1	1
9	Elective	CE	CE	Core Elective	3	0	0	3
10	Core	CC	MMT 562	Mechanical Behavior of Materials	3	0	0	3
11	Core	CC	MMT 570	Seminar	1	0	0	1
				Semester Total	**20**	**0**	**2**	**22**

SEMESTER - II								
S. No	**Category**	**Sub-Category**	**Course Code**	**Course Title**	**L**	**T/D**	**P/Pr**	**C**
1	Core	CC	MMT 556	Materials processing	3	0	0	3
2	Core	CC	MMT 557	Fracture mechanics	3	0	0	3
3	Core	CC	MMT 559	Material characterization	3	0	0	3
4	Core	CC	MMT 559L	Material characterization lab	0	0	2	1
5	Elective	CE	CE	Core Elective	3	0	0	3
6	Elective	CE	CE	Core Elective	3	0	0	3
7	Elective	CE	CE	Core Elective Lab	0	0	1	1
8	RDIP	RDIP	MMT 571	Seminar	1	0	0	1
9	RDIP	RDIP	RM 101	Research methodology and IPR	2	0	0	2
				Semester Total	**18**	**0**	**3**	**20**

SEMESTER - III								
S. No	**Category**	**Sub-Category**	**Course Code**	**Course Title**	**L**	**T/D**	**P/Pr**	**C**
1	RDIP	RDIP	MMT 575	Project Phase - I	0	0	9	9
2	Elective	OE		Open Elective / Minor	3	0	0	3
3	Elective	OE		Open Elective / Minor	3	0	0	3
				Semester Total	**6**	**0**	**9**	**15**

SEMESTER - IV								
S. No	**Category**	**Sub-Category**	**Course Code**	**Course Title**	**L**	**T/D**	**P/Pr**	**C**
1	RDIP	RDIP	MMT576	Project Phase - II	0	0	15	15
				Semester Total	**0**	**0**	**15**	**15**

Core Electives								
S. No	Category	Sub-Category	Course Code	Course Title	L	T/D	P/Pr	C
1	Elective	TE	MMT 558	Additive manufacturing	3	0	0	3
2	Elective	TE	MMT 558L	Additive manufacturing lab	0	0	1	1
3	Elective	TE	MMT 559	Mechanical behavior of materials	3	0	0	3
4	Elective	TE	MMT 560	Smart materials and structures	3	0	0	3
5	Elective	TE	MMT 561	Design of experiments	3	0	0	3
6	Elective	TE	MMT 553	Analysis of machining processes	3	0	0	3
7	Elective	TE	MMT 563	Lean manufacturing	3	0	0	3
8	Elective	TE	MMT 564	Finite element methods	3	0	0	3
9	Elective	TE	MMT 565	Processing of composite materials	3	0	0	3
10	Elective	TE	MMT 566	Reliability engineering	3	0	0	3
11	Elective	TE	MMT 567	Quality engineering	3	0	0	3
12	Elective	TE	MMT 568	Fracture mechanics	3	0	0	3
13	Elective	TE	MMT 569	Production and operation management	3	0	0	3
14	Elective	TE	MMT 570	Logistics and supply chain management	3	0	0	3
15	Elective	TE	MMT 571	Tool design	3	0	0	3
16	Elective	TE	MMT 572	Nanotechnology	3	0	0	3
17	Elective	TE	MMT 573	Biomaterials	3	0	0	3
18	Elective	TE	MMT 574	Rubber technology	3	0	0	3
19	Elective	TE	MMT 575	Computational material science	3	0	0	3
20	Elective	TE	MMT 576	Fundamentals of polymer science	3	0	0	3
21	Elective	TE	MMT 577	Multibody dynamics	3	0	0	3

English for Research Paper Writing

Course Code	EGL 501	Course Category	AEC		L	T	P	C
					1	0	0	1
Pre-Requisite Course(s)		**Co-Requisite Course(s)**		**Progressive Course(s)**				
Course Offering Department	English	**Professional / Licensing Standards**						

Course Objectives / Course Learning Rationales (CLRs)

1. Understand the Structure of a Research Paper
2. Familiarize students with the different types of research & methodologies.
3. Develop fundamental proofreading skills to identify and correct common grammatical errors.
4. Guide students in creating clear thesis statements and research questions to shape their papers.

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 and recall the key components of a research paper, including abstracts, introductions, methods, results, discussions, and conclusions.	1,2	75%	75%
Outcome 2	Interpret the structure and organization of research papers, recognizing the role each section plays in conveying information.	2	75%	75%
Outcome 3	Analyze the effectiveness of thesis statements and research questions in guiding the development of a research paper.	3	75%	75%
Outcome 4	Generate clear and concise sentences, paragraphs, and sections that conform to academic writing standards.	3	75%	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		1				3	3	3	3				
Outcome 2		1				3	3	3	3				
Outcome 3		1				3	3	3	3				
Outcome 4		1				3	3	3	3				
Average		1				3	3	3	3				

Course Unitization Plan

Unit No.	Unit Name	Required Contact Hours	CLOs Addressed	References Used
Unit 1	**Planning & Preparation**	**3**		
	What is research & the need for research	1	1,2	1,2
	Planning a manuscript	2	1,2	1,2
			1	1,2
Unit 2	**The Key to Good Writing**	**3**		
	Structuring a paragraph	2	1,2	1,2
	Sequencing a paragraph	1	1,2	1,2
Unit 3	**Being Concise**	**3**	1,2	1,2
	The steps to being concise	2	1,2	1,2
	Redundancy Vs Conciseness	1	1,2	1,2
Unit 4	**The Basic Components**	**3**		
	Abstract & Introduction	2	3	1,2
	Basic Formats	1	1,2	1,2
			1,3	1,2
Unit 5	**Practical Implementation**	**3**		
	Presentation of a paper	3	1,2,3,4	1,2
Total Contact Hours		**15**		

Learning Assessment

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

Recommended Resources

1. Wallwork Adrian. (2016). English for Writing Research Papers. New York: Springer.
2. Dudley Evans, T. (1998). Developments in English for Specific Purposes: A multidisciplinary approach. U.K: Cambridge University Press

Other Resources

1. Hutchinson, T., & Waters, A. (1987). English for Specific Purposes: A learner-centered approach. U.K: Cambridge University Press
2. Raman, Meenakshi, and Sangeetha Sharma. (2008). Technical Communication: English Skills for Engineers. New Delhi: Oxford University Press
3. Trimble, Louis. English for Science and Technology - A Discourse Approach. (1985). Cambridge: Cambridge University Press
4. Williams, Phil. Advanced Writing Skills for Students of English. (2018). Brighton: Rumian Publishing.
5. Wilson, Paige and Teresa Ferster Glazier. (2013). The Least You Should Know About English: Writing Skills, Form C (11th Edition). Boston: Cengage Learning.

Course Designers

1. Dr. Srabani Basu

Mechanics of Composite Materials

Course Code	MMT 561	**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 learn the fundamental concept of composite materials starting from manufacturing methods, micromechanics to macromechanics
2. To understand the concepts of structural analysis, failure analysis of the structure made up of composite materials

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 effect of the constituent of composites and their mechanical properties	2	80%	75%
Outcome 2	Compute the elastic modulus and strength of unidirectional laminates	3	70%	65%
Outcome 3	Apply manufacturing methods and the concepts of the mechanics of composites to given materials	3	80%	70%
Outcome 4	Demonstrate coupling effects in laminated composite beams/plates, Apply the failure criteria in design of composite materials	3	85%	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		2					1	2			
Outcome 2		2		3					1		1		
Outcome 3	3	3		3								3	
Outcome 4	2	2		3					1		3	2	
Average	2			2					1	1			

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1 Introduction to composites	Definition & General Characteristics, Application	1	1	1
	fibre Glass, Carbon, Ceramic and Aramid fibres	3	1	1
	Matrices – Polymer, Metal, Ceramic & Graphite	3	1	1
	Characterizing of fibres and matrices	2	1	1
Unit No. 2 Mechanics & Performance	Characteristics of fibre reinforced Lamina & laminates	4	2,3	1,2,3
	Inter-laminar stresses & Static Mechanical Properties	3	2,3	1,2,3
	Environmental effects, fracture behaviour & damage tolerance	3	2,3	1,2,3
	Fatigue & Impact properties	2	2,3	1,2,3
Unit No. 3 Manufacturing	Fabrication of fibre reinforced Polymer matrix composites, Thermo-plastic and Thermosetting polymers matrix preparation – Matrix preforms/precursor preparation	2	3	1,2,3,4
	Hand layup techniques, Bag moulding, Compression moulding, Pultrusion, filament winding techniques	2	3	1,2,3,4
	Fabrication of Metal matrix composites	1	3	1,2,3,4
	Fabrication of Ceramic matrix composites	1	3	1,2,3,4
Unit No. 4 Analysis	Analysis of Orthotropic lamina, Hooke's Law	3	4,5	1,2,3,4
	Stiffness and Compliance matrices	3	4,5	1,2,3,4
	Strengths of orthotropic lamina	3	4,5	1,2,3,4
	Stress analysis of laminated composite Beams, Plates, Shells	2	4,5	1,2,3,4
Unit No. 5 Design	Failure predictions in composites	2	4,5	1,3
	Laminated design consideration	2	4,5	1,3
	Bolted joints and Bonded joints	1	4,5	1,3
	Design examples	1	4,5	1,3

Learning Assessment

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

Recommended Resources

1. P.K. Mallick, "Fibre Reinforced Composite: Materials, Manufacturing & Design", Marcel Dekker Inc., 1993
2. J. C. Halpin, "Primer on Composite Materials, Analysis", Technomic Publishing Co., 1984
3. B. D. Agarwal and L. J. Broutman, "Ananlysis and Performance of Fiber Composites", John Wiley and Sons, Newyork, 1990

4. -P. K. Mallick and S. Newman (eds), "Composite Materials Technology", Hansen Publisher, Munich, 1990

Surface Engineering

Course Code	MMT 552	**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 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	1	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	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			3	3	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	3	3	3	3	3	3
Average	3	3	2	3			3	3	3	3	3	2	3

Course Unitization Plan (Theory)

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**

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%		30%		40%		50%		40%	
	Understand										
Level 2	Apply	70%		70%		60%		50%		60%	
	Analyse										
Level 3	Evaluate										
	Create										
Total		100%		100%		100%		100%		100%	

Recommended Resources

1. Peter Martin, Introduction to Surface Engineering and Functionally Engineered Materials, Wiley, 2011
2. W. Batchelor, L. N. Lam and M. Chandrasekaran, Materials degradation and its control by surface engineering, , Imperial college press,2007
3. Pradeep L. Menezes, Tribology for Scientists and Engineers , "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, 2005

Course Designers

Numerical methods

Course Code	MMT 581	**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. Predict and derive the solution methodologies.
2. Identify advantages and disadvantages of various methods to solve a particular problem.
3. Apply the knowledge of the methods to engineering applications.
4. Study 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	70%	65%
Outcome 3	Solve given engineering problems using numerical techniques and Python programming	3	70%	65%
Outcome 4	Demonstrate index notation methods for given equations using Python	3	60%	55%

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	2	3	3	2
Outcome 2	3		3	2					3	2	3	3	3
Outcome 3	3		3	2					3	2	3	3	3
Outcome 4	3		3	3					3	3	3	3	3
Average	3		3	3					3	2	3	3	3

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Numerical methods	0.5	1	1, 3
	Algorithms	1	1	1, 3
	Scientific notation, Precision effects, Error's	1	1	1, 3
	Syntax	0.5	1	1, 3
Unit No. 2	Linear algebraic systems	1	2	1, 2
	Gauss elimination method	1	2	1, 2,3
	LU decomposition, Tri diagonal Matrices, Thomas algorithm	3	2	1, 2
	Iterative solvers (Jacobi, Gauss-Siedel)	2	2	1, 2
	Convergence acceleration and stability using relaxation	2	2	1, 2
	Nonlinear equations solution using Bisection and Newton Raphson Nonlinear systems	3	2	1, 2, 4
Unit No. 3	Interpolation, extrapolation	1	2	1, 2, 3
	Linear, quadratic, and cubic interpolation -- Direct methods	1	2	1, 2
	Newton divided differences interpolation	2	2	1, 2
	Lagrange interpolation	1	2	1, 2
	Curve fitting and its applications	1	2	1, 2
	Regression analysis, error definitions	1	2	1, 2
	Linear least squares regression single variable, multi variable	1	2	1, 2
	Polynomial regression	2	2,4	1,2
Unit No. 4	Ordinary differential equations integration using Euler and Runge Kutta methods	2	2,4	1,2, 3
	Ordinary differential equations Predictor corrector methods, boundary, and initial value problems	3	2,4	1,2
	Discretisation, grid and boundaries	2	2,4	1,2
	Finite differences (forward, backward, and central) formulas up to 6th order derivations	3	2,4	1, 2
	Order of accuracy	2	2,4	1, 2
	Classification of partial differential equations (PDE)	1	2,4	1, 2
	Solution of elliptic, hyperbolic, and parabolic PDE using finite differences	3	2,4	1, 2
	Steady and transient problems	0.5	3	4
	Grid transformation	1	4	1
	Application of linear and nonlinear system solutions to various engineering problems	1	4	1, 2, 3
	Application of Curve fitting and interpolation in Mechanical engineering	1	4	1, 2
	ODE and PDE applications specific to mechanical engineering	2	4	1, 2

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (55%)			End Semester Exam (45%)
		CLA-1 (20%)	Mid-1 (15%)	CLA-2 (20%)	
		Th	Th	Th	Th
Level 1	Remember	30%	35%	40%	40%
	Understand				
Level 2	Apply	70%	65%	60%	60%
	Analyse				
Level 3	Evaluate				
	Create				
Total		100%	100%	100%	100%

Recommended Resources

1. Steven C. Chapra and Raymond P. Canalem, Numerical methods for engineers, McGrawhill, 2007
2. Chris H. Woodford and Christopher Phillips, Numerical Methods with worked examples, , Springer,2005
3. John Kiusalaas, Numerical Methods in Engineering with Python, 2007.

Other Resources

1. John H Mathews, Numerical Methods using Matlab,
2. Matlab Workspace online

Course Designers

Numerical Methods Lab

Course Code	MMT 581 L	**Course Category**	CC		**L** 0	**T** 0	**P** 1	**C** 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. Predict and derive the solution methodologies.
2. Identify advantages and disadvantages of various methods to solve a particular problem.
3. Apply the knowledge of the methods to engineering applications.
4. Study 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	70%	65%
Outcome 3	Solve given engineering problems using numerical techniques and Python programming	3	70%	65%
Outcome 4	Demonstrate index notation methods for given equations using Python	3	60%	55%

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					3	2	3	3	2
Outcome 2	3	2	3	2					3	2	3	3	3
Outcome 3	3	3	3	2					3	2	3	3	3
Outcome 4	3	3	3	3					3	3	3	3	3
Average	3	3	3	3					3	2	3	3	3

Course Unitization Plan—Lab

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

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)	End Semester Exam (50%)
		Experiments and performance (50%)	
Level 1	Remember	40%	40%
	Understand		
Level 2	Apply	60%	60%
	Analyse		
Level 3	Evaluate		
	Create		
Total		**100%**	**100%**

Recommended Resources

1. Numerical methods for engineers by Steven C. Chapra and Raymond P. Canalem McGrawhill Publications
2. Numerical Methods with worked examples, Chris H. Woodford and Christopher Phillips, Springer
3. Numerical Methods in Engineering with Python, John Kiusalaas
4. Numerical Methods using Matlab, John H Mathews

Course Designers

Advanced Manufacturing Methods

Course Code	MMT 554	**Course Category**	CC		L	T	P	C
					3	0	0	3
Pre-Requisite Course(s)	Manufacturing Science	**Co-Requisite Course(s)**		**Progressive Course(s)**				
Course Offering Department	Mechanical Engineering	**Professional / Licensing Standards**						

Course Objectives / Course Learning Rationales (CLRs)

1. Understand the basic principle of advanced machining processes
2. Understand the several techniques of the advanced welding processes.
3. Understand the metal casting processes with their applications.
4. Understand the metal forming processes with their applications.

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	Distinguish various metal removing processes based on surface finish.	1	80%	75%
Outcome 2	Distinguish various metal joining processes based on principle of working.	2	75%	70%
Outcome 3	Distinguish various metal casting processes based on principle of working.	3	80%	70%
Outcome 4	Distinguish various metal forming processes 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	2	3	2				2		3	3	2	3
Outcome 2	3	2	2	2				2		3	3	2	3
Outcome 3	3	3	3	3				3		3	3	2	3
Outcome 4	3	2	2	2				1		3	3	3	3
Average	3	2	2	2				3		3	3	2	3

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Non-conventional machining, imitation of conventional manufacturing process, Difference between conventional and non-conventional process, need of NCM	3	1	1,2
	Classification of NCM, advantages and disadvantages of NC, Hybrid processes. Parametric analysis and applications of processes such as ultrasonic machining (USM),	2	1	1,2
	Abrasive jet maching (AJM), Water jet machining (WJM), Abrasive water jet machining (AWJM), Electrochemical machining (ECM),	2	1	1,2
	Electro discharge machining (EDM), Electron beam machining (EBM), Laser beam machining (LBM) processes, Plasma arc machining (pam)	2	1	1
Unit No. 2	Introduction to laser beam welding, Laser surfacing, laser hardening and cladding	2	2	1,2,3
	Electron beam welding, process, ultrasonic welding,	2	2	1,2,3
	plasma arc welding, explosive welding,	2	2	1,2,3
	cladding process, under water welding	2	2	1,2,3
Unit No. 3	Process parameters, advantages, limitations and application of Metal mould casting,	2	3	1,2,3
	Continuous casting, Squeeze casting	2	3	1,2,3
	Vacuum mould casting, Evaporative pattern casting	2	3	1,2,3
	Ceramic shell casting, Stir casting process, Centrifugal casting	3	3	1,2,3
Unit No. 4	Introduction forming processes, advantages, limitations and applications, Vacuum forming	3	4	1,2,3
	Explosive forming, and hydro forming, advantages and applications	3	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	2	4	1,2,3
Unit No. 5	Photolithography, Thin Film Deposition, Thermal Oxidation of Silicon	3	4	1,2,3
	Wet Etching, Silicon Anisotropic Etching	2	2,4	1,2,3
	Plasma Etching and Reactive Ion Etching	2	2,4	1,2,3
		3	2,4	1,2,3

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%	-	10%	-	10%	-	10%	-	10%	-
	Understand	30%	-	30%	-	10%	-	30%	-	30%	-
Level 2	Apply	10%	-	30%	-	10%	-	20%	-	20%	-
	Analyse	40%	-	20%	-	40%	-	20%	-	30%	-
Level 3	Evaluate	-	-	10%	-	20%	-	20%	-	10%	-
	Create	-	-	-	-	10%	-	-	-	-	-
Total		**100%**		**100%**		**100%**		**100%**		**100%**	

Recommended Resources

1. P. N. Rao, "Manufacturing Technology", Mc Grawhill, 2020.
2. V. K. Jain, "Advanced machining processes", Allied Publications, 2022.
3. A. Ghosh, and A. K. Mallik, "Manufacturing Science", East-West Press Pvt. Ltd, 2017.

Course Designers

SRM University *AP*, Andhra Pradesh

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

Advanced Manufacturing Methods Lab

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">MMT 554 L</td><td rowspan="2">Course Category</td><td rowspan="2" colspan="2">CC</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>1</td></tr>
<tr><td>Pre-Requisite Course(s)</td><td>Manufacturing Science</td><td>Co-Requisite Course(s)</td><td></td><td>Progressive Course(s)</td><td colspan="4"></td></tr>
<tr><td>Course Offering Department</td><td>Mechanical Engineering</td><td>Professional / Licensing Standards</td><td colspan="6"></td></tr>
</table>

Course Objectives / Course Learning Rationales (CLRs)

1. Understand the basic principle of advanced machining processes
2. Understand the several techniques of the advanced welding processes.
3. Understand the metal casting processes with their applications.
4. Understand the metal forming 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	Distinguish various metal removing processes based on surface finish.	2	80%	75%
Outcome 2	Distinguish various metal joining processes based on principle of working.	1	70%	65%
Outcome 3	Distinguish various metal casting processes based on principle of working.	3	70%	65%
Outcome 4	Distinguish various metal forming and laser texturing machining processes based on principle of working.	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	2	3	2				2		3	3	2	3
Outcome 3	3	2	3	3				3		3	3	2	3
Outcome 4	3	3	3	2				2		3	3	3	3
Average	3	2	3	2				2		3	3	2	3

Course Unitization Plan – Lab

S. No.	Description of experiments	Required Contact Hours	CLOs Addressed	References Used
1	To do the experimental study on electric discharge machining (EDM).	3	1	1
2	To do the experimental study on electrochemical machining (ECM).	3	1	1
3	To do the experimental study on Ultrasonic machining (USM).	3	1	1
4	To do the experimental study on laser beam welding (LBW).	3	1	1
5	To do the experimental study on ultrasonic welding (USW).	3	2	1
6	To do the experimental study on squeeze casting.	3	3	1
7	To do the experimental study on centrifugal casting.	3	3	1
8	To do the experimental study on evaporative pattern casting.	3	3	1
9	To do the experimental study on vacuum forming process.	3	4	1
10	To do the experimental study on hydraulic forming.	3	4	1

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%	-	10%	-	10%	-	10%	-	10%
	Understand	-	30%	-	30%	-	10%	-	30%	-	30%
Level 2	Apply	-	10%	-	30%	-	10%	-	20%	-	20%
	Analyse	-	40%	-	20%	-	40%	-	20%	-	30%
Level 3	Evaluate	-	-	-	10%	-	20%	-	20%	-	10%
	Create	-	-	-	-	-	10%	-	-	-	-
Total			**100%**		**100%**		**100%**		**100%**		**100%**

Recommended Resources

1. Advanced Manufacturing Methods Laboratory Manuals, SRM university, Andhra Pradesh.

Course Designers

Mechanical Behaviour of Materials

Course Code	MMT 562	**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 familiarize with the structure-property relationship, elasticity, plasticity
2. To learn about viscoelasticity, elastic-plastic, deformation mechanisms, heat treatment, strain hardening
3. To gain knowledge of fracture mechanics, creep, fatigue, residual stresses
4. To explore the microstructural changes and their effects on mechanical properties during deformation and failure.

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 elasticity, plasticity, viscoelasticity	1	85%	75%
Outcome 2	Describe about the heat treatment, strain hardening effects	2	85%	75%
Outcome 3	Describe about various deformation mechanisms	3	85%	70%
Outcome 4	Tell about the fracture mechanics, creep, microstructural change, and fatigue	3	85%	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	3	3	1		1		1		2	3	2	3
Outcome 3	3	2	3	2		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	Elasticity, plasticity, structure-property relations	6	1	1
	Viscoelasticity. Elastic-Plastic Deformation. Mechanical testing.	6	1	1
Unit No. 2	Heat Treatment. Strain Hardening. Strain Rate and Temperature Effects on Deformation	3	2	1
	Slip, Dislocations, Twinning, and Hardening	3	2	1
Unit No. 3	Introduction to Fracture	3	3	1
	Ductile and Brittle Fracture. Fracture Mechanics	4	3	1
Unit No. 4	Introduction to Creep, Introduction to Fatigue	3	1	1
	Stages of Creep, Mechanisms of Creep, Creep Deformation and Fracture	4	3,4	1
	Mechanisms of Fatigue, Fatigue Failure and Fracture	3	4	1
	Cumulative Fatigue Damage. Wear processes.	4	4	1
Unit No. 5	Residual Stresses, Ceramics, Glasses, Polymers, Composites, Mechanical Working, and	3	4	1
	Micromechanics and deformations	3	4	1

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%	-	10%	-	10%	-	10%	-	10%	-
	Understand	30%	-	30%	-	10%	-	30%	-	30%	-
Level 2	Apply	10%	-	30%	-	10%	-	20%	-	20%	-
	Analyse	40%	-	20%	-	40%	-	20%	-	30%	-
Level 3	Evaluate	-	-	10%	-	20%	-	20%	-	10%	-
	Create	-	-	-	-	10%	-	-	-	-	-
	Total	**100%**		**100%**		**100%**		**100%**		**100%**	

Recommended Resources

1. F. A. Mayor and K. K. Chawla, Mechanical Behavior of Materials, 2nd edition, Cambridge University Press, 2009

Course Designers

Seminar

					L	T	P	C
Course Code	MMT 570	**Course Category**	CC		1	0	0	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	Analyze the research paper structure	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	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**
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)

Other Resources

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

Course Designers

Materials Processing

Course Code	MMT 556	Course Category	CC		L 3	T 0	P 0	C 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 learn the principle and methodology of the metal casting and solidification processes.
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 learn the powder production process and characterization

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 principle and methods to produce material by casting and powder processing.	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	Execute powder production process and characterization	3	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	2	3				3	3	3	3	2	3
Average	3	3	1	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 metal casting processes, Pattern making, moulding methods (sand), material, and processes with special references to patterns, sands, and binders. Design of gating etc	**3**	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.	**2**	1	1
	Heat treatment of cast alloys. Casting defects and remedies, comparison of casting methods.	1	1	1
Unit No. 2	Solidification: Thermodynamics of homogeneous and heterogeneous nucleation and kinetics of growth. Interface morphologies.	3	1	2
	Iron-making and steel-making process. Phase diagram, Solidification of eutectic and isomorphous system	3	1	2
	Role of thermal gradient and growth rate., Derivation of non-equilibrium freezing equation. heat flow for different mold materials (insulating and non-insulating)	3	1	2
	Plane front and cellular solidification.	1	1	2
Unit No. 3	Introduction to metal joining processes: Principles to Soldering, Brazing and Welding.	**1**	2	**3**
	Types of fusion welding processes, gas welding, solid state welding,	**2**	2	**3**
	Special welding processes, such as friction stir welding, electron beam welding and ultrasonic welding.	**2**	2	**3**
	Metallurgical principles involved in welding of carbon, alloy steels and important nonferrous alloys such as aluminium and magnesium-based alloys.	**2**	2	**3**
	Welding defects and their remedies: microstructural features of Heat Affected Zone (HAZ) and their effect on mechanical properties.	**2**	2	3
Unit No. 4	Hot deformation processes, Microstructural evolution, Recovery, Recrystallization, Dynamic recrystallization,	**2**	3	**4**
	SPD-based thermo-mechanical processes, Friction stir Processing, Equal Channel Angular Processing, High-pressure torsion case study.	**2**	3	**4**
	Flow curves as a function of strain rate and temperature, Stress, strain, strain rate sensitivity	**2**	3	**4**
	Thermo-chemical surface treatments	**2**	3	**4**
Unit No. 5	Production of metal powders, recent developments in powder production, mechanical alloying.	**1**	**1**	**5**
	Development of nanostructures and composite materials via powder processing route.	**2**	**1**	**5**
	Characteristics of powders,	**1**	**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.	**3**	**1**	**5**

Learning Assessment

<table>
<tr><th colspan="2" rowspan="3">Bloom's Level of Cognitive Task</th><th colspan="8">Continuous Learning Assessments</th><th colspan="2" rowspan="2">End Semester Exam (50%)</th></tr>
<tr><th colspan="2">CLA-1 (15%)</th><th colspan="2">CLA-2 (10%)</th><th colspan="2">CLA-3 (10%)</th><th colspan="2">Mid Term (15%)</th></tr>
<tr><th>Th</th><th>Prac</th><th>Th</th><th>Prac</th><th>Th</th><th>Prac</th><th>Th</th><th>Prac</th><th>Th</th><th>Prac</th></tr>
<tr><td rowspan="2">Level 1</td><td>Remember</td><td>30%</td><td></td><td>40%</td><td></td><td>40%</td><td></td><td>50%</td><td></td><td>40%</td><td></td></tr>
<tr><td>Understand</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Level 2</td><td>Apply</td><td>70%</td><td></td><td>60%</td><td></td><td>60%</td><td></td><td>50%</td><td></td><td>60%</td><td></td></tr>
<tr><td>Analyse</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Level 3</td><td>Evaluate</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Create</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Total</td><td>100%</td><td></td><td>100%</td><td></td><td>100%</td><td></td><td>100%</td><td></td><td>100%</td><td></td></tr>
</table>

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. Fundamentals of Solidification, W. Kurz and D.J. Fisher, CRC Press, 1998.
3. A textbook of Welding Technology by O P Khanna, Dhanpat Rai Publications
4. Thermomechanical processing of metallic Materials, Elsevier publisher, Edited by Robert W. Cahn
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

Course Designers

Fracture Mechanics

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">MMT 557</td><td rowspan="2">Course Category</td><td rowspan="2" colspan="2">CC</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td>Pre-Requisite Course(s)</td><td></td><td>Co-Requisite Course(s)</td><td></td><td>Progressive Course(s)</td><td colspan="4"></td></tr>
<tr><td>Course Offering Department</td><td>Mechanical Engineering</td><td>Professional / Licensing Standards</td><td colspan="6"></td></tr>
</table>

Course Objectives / Course Learning Rationales (CLRs)

1. To understand the fundamentals of fracture mechanics
2. To analyse crack propagation and Critical conditions
3. To apply fracture mechanics principles to real world problems
4. To interpret experimental data and conduct fracture analysis

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 key concepts in fracture mechanics, such as stress intensity factor, fracture toughness, and critical crack size.	1	80%	75%
Outcome 2	Develop skills in predicting and analyzing crack propagation under various loading conditions.	2	75%	70%
Outcome 3	Demonstrate the ability to apply fracture mechanics concepts to practical engineering problems.	3	80%	70%
Outcome 4	Evaluate and recommend strategies for preventing or mitigating fractures in engineering components.	4	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	2		3	3	3	2	3	3	3
Outcome 2	3	2	3	2	1		3	3	3	2	3	3	3
Outcome 3	3	2	3	2	2		3	3	3	2	3	3	3
Outcome 4	3	3	3	3	2		3	3	3	3	3	3	3
Average	3	2	3	3	2		3	3	3	2	3	3	3

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Basic principles	2	1	1
	Griffith energy balance approach	2	1	1,2
	Fracture mechanics approach to design	2	1	1,2
	Airy stress function, effect of finite crack size.	2	1	1,2
Unit No. 2	Plasticity effects	2	1	1
	Dugdales approach	2	1,2	1,2,3
	Plastic zone for plain stress and plain strain approach	2	1,2	1,2,3
	Stress intensity factors, fracture toughness.	2	1,2	1,2,3
Unit No. 3	Energy release rate	3	3	3
	Criteria for crack growth,	3	3	3
	Crack resistance, compliance.	3	3	3
Unit No. 4	Fracture beyond general yield	3	3,4	3
	Crack tip opening displacement, use of CTOD criteria	3	3,4	3
	Experimental determination of CTOD	2	3,4	3
	Parameters affecting critical CTOD	2	3,4	2
Unit No. 5	Use of J integral, limitation of J integral,	3	3,4	2
	Experimental determination of J integral,	3	3,4	3
	Parameters affecting J Integral.	4	3,4	3

Learning Assessment

<table>
<tr><th colspan="2" rowspan="2">Bloom's Level of Cognitive Task</th><th colspan="4">Continuous Learning Assessments (50%)</th><th rowspan="2">End Semester Exam (50%)</th></tr>
<tr><th>CLA-1 (15%)</th><th>CLA-2 (10%)</th><th>CLA-3 (10%)</th><th>Midterm-1 (15%)</th></tr>
<tr><td rowspan="2">Level 1</td><td>Remember</td><td rowspan="2">50%</td><td rowspan="2">40%</td><td rowspan="2">50%</td><td rowspan="2">45%</td><td rowspan="2">30%</td></tr>
<tr><td>Understand</td></tr>
<tr><td rowspan="2">Level 2</td><td>Apply</td><td rowspan="2">50%</td><td rowspan="2">60%</td><td rowspan="2">50%</td><td rowspan="2">55%</td><td rowspan="2">70%</td></tr>
<tr><td>Analyse</td></tr>
<tr><td rowspan="2">Level 3</td><td>Evaluate</td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td>Create</td></tr>
<tr><td colspan="2">Total</td><td>100%</td><td>100%</td><td>100%</td><td>100%</td><td>100%</td></tr>
</table>

Recommended Resources

1. Elements of Fracture Mechanics by Prasant Kumar, Mc Graw Hill Education, 2009 Edition.
2. Anderson, "Fracture Mechanics-Fundamental and application", T.L CRC press1998.
3. David Broek, "Elementary Engineering Fracture Mechanics", Springer Netherlands,2011.

Course Designers

Materials Characterisation

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">MMT 559</td><td rowspan="2">Course Category</td><td rowspan="2" colspan="2">CC</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td>Pre-Requisite Course(s)</td><td></td><td>Co-Requisite Course(s)</td><td></td><td>Progressive Course(s)</td><td colspan="4"></td></tr>
<tr><td>Course Offering Department</td><td>Mechanical Engineering</td><td>Professional / Licensing Standards</td><td colspan="6"></td></tr>
</table>

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 thermal 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

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										
Level 2	Apply	60%		50%		70%			60%	50%	
	Analyse										
Level 3	Evaluate										
	Create										
	Total	**100%**		**100%**		**100%**		**100%**		**100%**	

Recommended Resources

1. Editors C. Richard Brundle, Charles A. Evans, Jr., Shaun Wilson, Butterworth-Heinemann, Encyclopedia of Materials Characterization, Surfaces, Interfaces, Thin Films, Boston, US, 1995
2. B D Cullity, Element of X-ray diffraction, , Addison Wesley Publishing Company Inc., 2007
3. D.B. Williams and C. Barry Carter, Transmission electron microscopy", volumes, Springer, 1996. USA
4. W. W. Wendlandt, Thermal Methods of Analysis, John Wiley, 1974.

Course Designers

Materials Characterization Lab

Course Code	MMT 559L	Course Category	CC		L 0	T 0	P 2	C 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 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	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 (Laboratory)

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 (a) micro-etching techniques for ferrous and non-ferrous alloys, dark/bright field imaging, differential interference contrast technique, phase contrast technique. (a) 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**	**1-4**	**1**
2	X-ray Diffraction- Phase analysis of ferrous and non-ferrous materials, crystallite size calculation, residual stress calculation	**3**	**1-4**	**2**
3	Differential Scanning Calorimetry (DSC) (a) Determining glass transition temperature of polymeric materials (b) sample preparation, determination of thermodynamic parameters, measurements on precipitation-hardened Al alloys	**3**	**1-4**	**4**
4	Measurement of Coefficient of Thermal Expansion	**2**	**1-4**	**4**
4	Scanning electron microscopy: sample preparation techniques, secondary electron and backscattered electron imaging, point, line, and area mapping, X-ray mapping	**4**	**1-4**	**1**
5	Study micrographs of differently heat-treated materials and compare them	**4**	**1-4**	**1**
6	Transmission electron microscopy: sample preparation, bright/dark field imaging, Selected area diffraction and indexing	**3**	**1-4**	**3**
7	The spectroscopic method for the analysis of a sample	**3**	**1-4**	**1**

Learning Assessment

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

Recommended Resources

1. Editors C. Richard Brundle, Charles A. Evans, Jr., Shaun Wilson, Butterworth-Heinemann, Encyclopedia of Materials Characterization, Surfaces, Interfaces, Thin Films, Boston, US, 1995
2. B D Cullity, Element of X-ray diffraction, , Addison Wesley Publishing Company Inc., 2007
3. D.B. Williams and C. Barry Carter, Transmission electron microscopy", volumes, Springer, 1996. USA
4. W. W. Wendlandt, Thermal Methods of Analysis, John Wiley, 1974.

Course Designers

Seminar

Course Code	MMT 571	Course Category	RDIP		L	T	P	C
					1	0	0	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	Analyze research paper structure	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	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**
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).

Other Resources

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

Course Designers

Research Methodology and IPR

Course Code	RM 101	Course Category	RDIP		L	T	P	C
					2	0	0	2
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. Developing Research Skills
2. Understanding Intellectual Property Rights (IPR)
3. Enhancing Ethical Research Practices
4. Promoting Effective Communication of Research Results

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 research problem formulation	2	80%	75%
Outcome 2	Analyse research-related information and understand research ethics	2	70%	65%
Outcome 3	Understanding that when IPR would take such an important place in the growth of individuals & nations.	3	80%	70%
Outcome 4	Understand that IPR protection provides an incentive to inventors for further research work and investment in R&D.	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	1	2	2				1		3	2	2	3
Outcome 2	3	2	3	3				2		3	3	2	3
Outcome 3	3	3	3	2				1		3	2	2	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

Session	Description of Topic	Contact hours	CLOs Addressed	Reference
1	**Unit I**	**6**		
2	Meaning of research problem, Sources of research problem	2	1	1,3
3	Criteria Characteristics of a good research problem,	2	1	1,2,3
4	Errors in selecting a research problem, scope, and objectives of research problem.	2	1	1,2,3
5	**Unit II**	**6**		
6	Approaches of investigation of solutions for research problem, data collection,	2	1,2	1,2,3
7	Analysis, interpretation, Necessary instrumentations.	2	1,2	1,2,3
8	Effective literature studies approaches, analysis Plagiarism, Research ethics.	2	1,2	1,2,3
9	**Unit III**	**6**		
10	Effective technical writing,	2	1,2	1,2
11	how to write report, Paper Developing a Research Proposal,	2	1,2	1,2
12	Format of research proposal, a presentation and assessment by a review committee.	2	1,2	1,2
13	**Unit IV**	**6**		
14	Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research,	2	1,2	1,2,3
15	innovation, patenting, development. International Scenario: International cooperation on Intellectual Property.	2	1,2	1,2,3
16	Procedure for grants of patents, Patenting under PCT.\	1	1,2	1,2,3
17	Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.	1	1,2	1,2,3
18	**Unit V**	**6**		
19	New Developments in IPR: Administration of Patent System.	2	3,4	4,5
20	New developments in IPR; IPR of Biological Systems,	2	3,4	4,5
21	Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.	2	3,4	4,5
22				
	Total Contact Hours	**30**		

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. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students' "Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
2. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step-by-Step Guide for beginners" Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
3. Mayall, "Industrial Design", McGraw Hill, 1992.
4. Niebel, "Product Design", McGraw Hill, 1974.
5. Asimov, "Introduction to Design", Prentice Hall, 1962.

Other Resources

1. Enter Data

Course Designers

1. Dr. Manjesh Kumar, Department of Mechanical Engineering, SRM University-AP, Andhra Pradesh.
2. Dr. Manas Das, Department of Mechanical Engineering, IIT Guwahati

Project Phase 1

Course Code	MMT 575	Course Category	RDIP		L	T	P	C
					0	0	9	9
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. 2	**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	**50**	**1**	**1**
Unit No. 2	Methods: Application of various methods and approaches to ensure the successful execution of the Project	**50**	**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	**50**	**3**	**3**
Unit No. 4	Poster Presentation: Making a scientific presentation of the results obtained with appropriate reasoning.	**50**	**3**	**3**
Unit No. 5	Writing of manuscript or thesis. Obtained results are summarized in the form thesis/manuscript/report	**70**	**4**	**4,5**

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										
	Understand		70%		60%		50%		50%		50%
Level 2	Apply										
	Analyse		30%		40%		50%		30%		30%
Level 3	Evaluate										
	Create								20%		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

Course Designers

Project Phase -II

Course Code	MMT 576	**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. 2	**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	**90**	**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	**90**	**3**	**3**
Unit No. 4	Poster Presentation: Making a scientific presentation of the results obtained with appropriate reasoning.	**90**	**3**	**3**
Unit No. 5	Writing of manuscript or thesis. Obtained results are summarized in the form thesis/manuscript/report	**90**	**4**	**4**

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%		50 %				50 %		40 %
Level 2	Apply										
	Analyse		20%		30 %				20 %		40 %
Level 3	Evaluate										
	Create		10 %		20 %				30 %		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

Course Designers

Additive Manufacturing

Course Code	MMT 558	**Course Category**	TE		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 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	70%	75%
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 of rapid 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
	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
	Hierarchical Structure of Additive Manufacturing Processes, Integration of Additive Manufacturing in the Product Development Process,	2	1	1,2
	Advantages and limitations of AM, Applications	1	1	1
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
	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
Unit No. 3	CAD model preparation, Data interfacing for rapid prototyping Part orientation and support generation	3	3	1,2,3
	Model slicing and contour data organization	2	3	1,2,3
	Direct and adaptive slicing, A selective hatching strategy for AM,	2	3	1,2,3
	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
	EOS DirectTool™ Process, Direct Metal Tooling using 3Dp™. Applications of Rapid Tooling Technology	2	4	1,2,3
Unit No. 5	Reverse Engineering (PPT), Design Methodology in reverse engineering, 3D scanning	3	2,4	1,2,3
	3D Scanners and photogrammetry, Data Acquisition, Processing of Cloud Points,	2	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	3	2,4	1,2,3

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (__%)								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%	-	10%	-	10%	-	10%	-	10%	-
	Understand	30%	-	30%	-	10%	-	30%	-	30%	-
Level 2	Apply	10%	-	30%	-	10%	-	20%	-	20%	-
	Analyse	40%	-	20%	-	40%	-	20%	-	30%	-
Level 3	Evaluate	-	-	10%	-	20%	-	20%	-	10%	-
	Create	-	-	-	-	10%	-	-	-	-	-
	Total	**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. Liou, L.W. and Liou, F.W., "Rapid Prototyping and Engineering applications : A tool box for prototype development", CRC Press, 2011.

Other Resources

Course Designers

Additive Manufacturing Lab

Course Code	MMT 558L	**Course Category**	TE		L	T	P	C
					0	0	2	1
Pre-Requisite Course(s)		**Co-Requisite Course(s)**		**Progressive Course(s)**				
Course Offering Department	Mechanical Engineering	**Professional / Licensing Standards**						

<u>Course Objectives / Course Learning Rationales (CLRs)</u>

1. To introduce concepts of CAD and its usefulness in CAM.
2. To be familiar with the characteristics of the different materials those are used in additive manufacturing.
3. To be familiar with the tessellation process, stl files and repair of stl file using mesh repair algorithms.
4. To gain knowledge of the potential implications of AM technologies on product development and gain the hand on experience on various 3D printers.

<u>Course Outcomes / Course Learning Outcomes (CLOs)</u>

	At the end of the course the learner will be able to	**Bloom's Level**	**Expected Proficiency Percentage**	**Expected Attainment Percentage**
Outcome 1	Define CAD modelling and assemblies for 3D printing.	2	80%	75%
Outcome 2	Describe 3D printing techniques for product developments	1	70%	65%
Outcome 3	Demonstrate the materials and technologies used in 3D printing	3	70%	65%
Outcome 4	Illustrate the repair algorithms for damaged triangles in stl files and Printing of components	3	80%	75%

<u>Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)</u>

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**	**Communication Skills**	**Life-long Learning**	**PSO 1**	**PSO 2**	**PSO 3**
Outcome 1	3	2	3	2		1		1		3	3	2	3
Outcome 2	3	2	3	2		1		1		3	3	2	3
Outcome 3	3	2	3	3		2		3		3	3	2	3
Outcome 4	3	3	3	2		2		1		3	3	3	3
Average	**3**	**2**	**3**	**2**		**2**		**2**		**3**	**3**	**2**	**3**

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

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (__%)								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%	-	10%	-	10%	-	10%	-	10%
	Understand	-	30%	-	30%	-	10%	-	30%	-	30%
Level 2	Apply	-	10%	-	30%	-	10%	-	20%	-	20%
	Analyse	-	40%	-	20%	-	40%	-	20%	-	30%
Level 3	Evaluate	-	-	-	10%	-	20%	-	20%	-	10%
	Create	-	-	-	-	-	10%	-	-	-	-
Total			**100%**		**100%**		**100%**		**100%**		**100%**

Recommended Resources

1. P N Rao, "CAD/CAM: Principles and Applications", Mc Graw Hill, 2017
2. Ian Gibson, David W Rosen, Brent Stucker., "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 2010
3. Chua Chee Kai, Leong Kah Fai, "Rapid Prototyping: Principles & Applications", World Scientific, 2003
4. Lab Manual, 2022

Other Resources

Course Designers

Mechanical Behavior of Materials

Course Code	MMT 559	Course Category	TE		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 familiarize with the structure-property relationship, elasticity, plasticity
2. To learn about viscoelasticity, elastic-plastic, deformation mechanisms, heat treatment, strain hardening
3. To gain knowledge of fracture mechanics, creep, fatigue, residual stresses
4. To explore the microstructural changes and their effects on mechanical properties during deformation and failure.

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 elasticity, plasticity, viscoelasticity	1	85%	75%
Outcome 2	Describe about the heat treatment, strain hardening effects	2	85%	75%
Outcome 3	Describe about various deformation mechanisms	3	85%	70%
Outcome 4	Tell about the fracture mechanics, creep, microstructural change, and fatigue	3	85%	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 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 Lifelong Learning	PSO 1	PSO 2	PSO 3
Outcome 1	3	3	1	3	2		1		1			2	3	2	3
Outcome 2	3	3	3	3	1		1		1			2	3	2	3
Outcome 3	3	3	2	3	2		2		3			2	3	2	3
Outcome 4	3	3	2	3	2		2		1			2	3	3	3
Average	**3**	**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	Elasticity, plasticity, structure-property relations	**6**	**1**	**1**
	Viscoelasticity. Elastic-Plastic Deformation. Mechanical testing.	**6**	**1**	**1**
Unit No. 2	Heat Treatment. Strain Hardening. Strain Rate and Temperature Effects on Deformation	**3**	**2**	**1**
	Slip, Dislocations, Twinning, and Hardening	**3**	**2**	**1**
Unit No. 3	Introduction to Fracture	**3**	**3**	**1**
	Ductile and Brittle Fracture. Fracture Mechanics	**4**	**3**	**1**
Unit No. 4	Introduction to Creep, Introduction to Fatigue	**3**	**1**	**1**
	Stages of Creep, Mechanisms of Creep, Creep Deformation and Fracture	**4**	**3,4**	**1**
	Mechanisms of Fatigue, Fatigue Failure and Fracture	**3**	**4**	**1**
	Cumulative Fatigue Damage. Wear processes.	**4**	**4**	**1**
Unit No. 5	Residual Stresses, Ceramics, Glasses, Polymers, Composites, Mechanical Working, and	**3**	**4**	**1**
	Micromechanics and deformations	**3**	**4**	**1**

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%	-	10%	-	10%	-	10%	-	10%	-
	Understand	30%	-	30%	-	10%	-	30%	-	30%	-
Level 2	Apply	10%	-	30%	-	10%	-	20%	-	20%	-
	Analyse	40%	-	20%	-	40%	-	20%	-	30%	-
Level 3	Evaluate	-	-	10%	-	20%	-	20%	-	10%	-
	Create	-	-	-	-	10%	-	-	-	-	-
Total		**100%**		**100%**		**100%**		**100%**		**100%**	

Recommended Resources

1. **F. A. Mayor and K. K. Chawla, Mechanical Behavior of Materials, 2nd edition, Cambridge University Press, 2009**

Other Resources

Course Designers

Smart Materials and Structures

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">MMT 560</td><td rowspan="2">Course Category</td><td rowspan="2" colspan="2">TE</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td>Pre-Requisite Course(s)</td><td></td><td>Co-Requisite Course(s)</td><td></td><td>Progressive Course(s)</td><td colspan="4"></td></tr>
<tr><td>Course Offering Department</td><td>Mechanical Engineering</td><td>Professional / Licensing Standards</td><td colspan="6"></td></tr>
</table>

Course Objectives / Course Learning Rationales (CLRs)

1. To familiarize with the functioning and applications of shape memory alloys
2. To learn about the MEMS devices and their applications
3. To understand how to design and develop smart structures
4. To explore the integration of sensors and actuators in smart materials for real-time monitoring and adaptive response

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 shape memory alloys, their functions, and applications	4	85%	75%
Outcome 2	Describe how ER/MR fluids work and their applications	2	85%	75%
Outcome 3	Describe the working of MEMS devices and their applications	3	85%	70%
Outcome 4	Describe how to develop smart structures	3	85%	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	3		1		2			2	3	2
Outcome 2	3	2	3	3		1		2			2	3	2
Outcome 3	3	3	3	3		2		2			2	3	2
Outcome 4	3	2	3	2		2		2			2	3	3
Average	3	2	3	3		2		2			2	3	2

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Shape memory alloys	1	1	1
	Experimental phenomenology, shape memory effect, Tanaka constitutive model	3	1,2	1
	Testing of SMA wires, multiplexing, vibration control through SMA	2	1	1
Unit No. 2	ER and MR Fluid	1	1,2	1
	Mechanisms and properties	4	1,2	1
	Bingham plastic model	2	1,2	1
	Post-yield flow applications in clutches/dampers	2	1,2	1
Unit No. 3	MEMS, Mechanical Properties of MEMS Materials	2	3	1
	Scaling of Mechanical Systems	2	3	1
	Fundamentals of Theory, The Intrinsic Characteristics of MEMS	2	3	1
	Miniaturization, Microelectronics Integration.	2	3,4	1
Unit No. 4	MEMS devices, Sensors and Actuators, Conductivity of Semiconductors	3	1	1
	Crystal Planes and Orientation, (Stress and Strain Relations, Flexural Beam Bending Analysis Under Simple Loading Conditions), Polymers in MEMS	3	3,4	1
	MEMS Applications. Vibration Absorbers: series and Parallel, Damped Vibrations (Overview), Active, Vibration Absorbers, Fiber Optics, Physical Phenomena, Characteristics, Sensors, Fiber Optics in Crack Detection, applications	3	4	1
	Control of Structures: Modelling, Control Strategies and Limitations, Active Structures in Practice	3	4	1
Unit No. 5	Smart Structures: Types of Smart Structures, Feasibility of Smart Structures, Piezoelectric materials, Properties, piezoelectric	2	4	1
	Key of Smart Structures, Applications of Smart Structures	2	4	1
	Constitutive Relations, Depoling, and Coercive, Field, field strain relation	2	2,4	1
	Inchworm Linear Motor. Beam Modelling: Beam Modelling with induced strain Rate effects, Inchworm Linear Motor Beam Modelling with induced strain, Actuation-single Actuators, dual Actuators, Pure Extension, Pure Bending harmonic excitation, Bernoulli- Euler beam Model, problems, Piezoelectrical Applications	4	4	1

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%	-	10%	-	10%	-	10%	-	10%	-
	Understand	30%	-	30%	-	10%	-	30%	-	30%	-
Level 2	Apply	10%	-	30%	-	10%	-	20%	-	20%	-
	Analyse	40%	-	20%	-	40%	-	20%	-	30%	-
Level 3	Evaluate	-	-	10%	-	20%	-	20%	-	10%	-
	Create	-	-	-	-	10%	-	-	-	-	-
Total		**100%**		**100%**		**100%**		**100%**		**100%**	

Recommended Resources

1. M. V. Gandhi and B. S. Thompson, Smart Materials and Structures, Chapman & Hall, 1992

Course Designers

Design of Experiments

Course Code	MMT 561	Course Category	TE		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. 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 (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	3	2	2	2	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	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

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 Understand	40%	50%	30%	20%	30%
Level 2	Apply Analyse	60%	50%	70%	80%	70%
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.

Course Designers

Analysis of Machining processes

					L	T	P	C
Course Code	MMT 553	**Course Category**	TE		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. 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

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	3	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.	3	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

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%	-	10%	-	10%	-	10%	-	10%	-
	Understand	30%	-	30%	-	10%	-	30%	-	30%	-
Level 2	Apply	10%	-	30%	-	10%	-	20%	-	20%	-
	Analyse	40%	-	20%	-	40%	-	20%	-	30%	-
Level 3	Evaluate	-	-	10%	-	20%	-	20%	-	10%	-
	Create	-	-	-	-	10%	-	-	-	-	-
	Total	**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.

Course Designers

Lean Manufacturing

Course Code	MMT 563	**Course Category**	TE		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. 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

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (__%)								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%	-	10%	-	10%	-	10%	-	10%	-
	Understand	30%	-	30%	-	10%	-	30%	-	30%	-
Level 2	Apply	10%	-	30%	-	10%	-	20%	-	20%	-
	Analyse	40%	-	20%	-	40%	-	20%	-	30%	-
Level 3	Evaluate	-	-	10%	-	20%	-	20%	-	10%	-
	Create	-	-	-	-	10%	-	-	-	-	-
Total		**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.

Course Designers

Finite Element Methods

					L	T	P	C
Course Code	MMT 564	**Course Category**	TE		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. 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	75%	70%
Outcome 2	Gain proficiency in preprocessing tasks for FEA	2	90%	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

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (__%)								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%	-	10%	-	10%	-	10%	-	10%	-
	Understand	30%	-	30%	-	10%	-	30%	-	30%	-
Level 2	Apply	10%	-	30%	-	10%	-	20%	-	20%	-
	Analyse	40%	-	20%	-	40%	-	20%	-	30%	-
Level 3	Evaluate	-	-	10%	-	20%	-	20%	-	10%	-
	Create	-	-	-	-	10%	-	-	-	-	-
Total		**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.

Course Designers

Processing of Composite Materials

Course Code	MMT 565	**Course Category**	TE		**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. Understand the composite material fundamentals including types of reinforcements and matrices.
2. To explore composite manufacturing techniques
3. To characterize mechanical and thermal properties
4. To analyze processing challenges and Quality Control

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 reinforcements (fibers, particles) and matrices (polymeric, metallic, ceramic) to enhance material properties	2	80%	75%
Outcome 2	Highlight various composite manufacturing techniques, specific applications and limitations of each method	3	80%	75%
Outcome 3	Characterize the mechanical (strength, stiffness) and thermal properties (conductivity, expansion) of composite materials	3	70%	65%
Outcome 4	Analyze common processing challenges, non-destructive testing (NDT) and inspection methods	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	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	Types and forms of reinforcement and their properties. Prefabricated forms.	2	1	1
	Selection of matrices: physical and mechanical properties. Bonding mechanisms.	2	1	1,2
	Types of reinforcement distributions: uniform, gradient and surface.	2	1,2	1,3
	Factors in composite design. Structure-property relationships.	2	2	1,3
Unit No. 2	Models of various materials properties of composites	2	1,2	1,3
	Density, modulus, strength, specific heat, coefficient of thermal expansion,	2	1,2	1,2
	Thermal conductivity and diffusivity,	3	2,3	1,3
	Electrical conductivity and dielectric constant. Isotropic and anisotropic properties.	2	1,2	2,3
Unit No. 3	Fabrication techniques: infiltration,	3	1,2	2,3
	Casting, reaction sintering, electro-deposition,	2	1,2	2,3
	Diffusion bonding,	1	1,2	2,3
	Thermal and plasma spray forming,	2	1,2	2,3
Unit No. 4	Laser method, powder forming,	3	1,2	2,3
	Additive processes, crystal growth and physical vapour deposition.	2	1,2	2,3
	Testing and inspection methods.	2	2,3	2,3
	Laminated Composites, Sample level lamination, case studies.	3	2,3,4	2,3
Unit No. 5	Experimental techniques, compositional analyses (introduction) and qualification of composites.	3	3,4	2,3
	Instrumental characterization and introduction to advanced characterization techniques (XRD, XRF, ITFR)	3	3,4	2,3
	SEM, TEM, TGA	2	2,3,4	2,3
	Non-Destructive Analyses of Composites.	2	3,4	2,3

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%	-	10%	-	10%	-	10%	-	-	10%
	Understand	30%	-	30%	-	10%	-	30%	-	-	30%
Level 2	Apply	10%	-	30%	-	10%	-	20%	-	-	20%
	Analyse	40%	-	20%	-	40%	-	20%	-	-	20%
Level 3	Evaluate	-	-	10%	-	20%	-	20%	-	-	10%
	Create	-	-	-	-	10%	-	-	-	-	10%
Total		**100%**		**100%**		**100%**		**100%**			**100%**

Recommended Resources

1. Clyne, T. W. and Withers, P. J., "An Introduction to Metal Matrix Composites", Cambridge University Press, 1993.
2. Matthews, F. L. and Rawlings, R. D., "Composite Materials: Engineering and Science", Chapman & Hall, London, 1994.
3. Suresh, S., Martensen, A., and Needleman, A., "Fundamentals of Metal Matrix Composites", Butterworth Heinemann, 1993.

Course Designers

Reliability Engineering

						L	T	P	C
Course Code	MMT 566	**Course Category**	TE			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. 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	90%	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	3	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

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%	-	10%	-	10%	-	10%	-	10%	-
	Understand	30%	-	30%	-	10%	-	30%	-	30%	-
Level 2	Apply	10%	-	30%	-	10%	-	20%	-	20%	-
	Analyse	40%	-	20%	-	40%	-	20%	-	30%	-
Level 3	Evaluate	-	-	10%	-	20%	-	20%	-	10%	-
	Create	-	-	-	-	10%	-	-	-	-	-
Total		**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.

Course Designers

Quality Engineering

						L	T	P	C
Course Code	MMT 567	**Course Category**	TE			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. 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	80%	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	3	2,4	1,2,3

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%	-	10%	-	10%	-	10%	-	10%	-
	Understand	30%	-	30%	-	10%	-	30%	-	30%	-
Level 2	Apply	10%	-	30%	-	10%	-	20%	-	20%	-
	Analyse	40%	-	20%	-	40%	-	20%	-	30%	-
Level 3	Evaluate	-	-	10%	-	20%	-	20%	-	10%	-
	Create	-	-	-	-	10%	-	-	-	-	-
Total		**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. Mitra A., "Fundamentals of Quality Control and Improvement", PHI, Second Edition,2005.

Course Designers

Fracture Mechanics

						L	T	P	C
Course Code	MMT 568	**Course Category**	TE			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 fracture mechanics
2. To analyse crack propagation and Critical conditions
3. To apply fracture mechanics principles to real world problems
4. To interpret experimental data and conduct fracture analysis

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 key concepts in fracture mechanics, such as stress intensity factor, fracture toughness, and critical crack size.	1	80%	75%
Outcome 2	Develop skills in predicting and analyzing crack propagation under various loading conditions.	2	75%	70%
Outcome 3	Demonstrate the ability to apply fracture mechanics concepts to practical engineering problems.	3	80%	70%
Outcome 4	Evaluate and recommend strategies for preventing or mitigating fractures in engineering components.	4	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 CT Usage	Society and Multicultural Skills	Environment and Sustainability	Moral, and Ethical Awareness	Individual and Teamwork Skills	Communication Skills	Project Management and	Self-Directed and Lifelong Learning	PSO 1	PSO 2	PSO 3
Outcome 1	3	3	1	3	2	2		3	3	3	3	2	3	3	3
Outcome 2	3	3	2	3	2	1		3	3	3	3	2	3	3	3
Outcome 3	3	3	2	3	2	2		3	3	3	3	2	3	3	3
Outcome 4	3	3	3	3	3	2		3	3	3	3	3	3	3	3
Average	**3**	**3**	**2**	**3**	**3**	**2**		**3**	**3**	**3**	**3**	**2**	**3**	**3**	**3**

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Basic principles	2	1	1
	Griffith energy balance approach	2	1	1,2
	Fracture mechanics approach to design	2	1	1,2
	Airy stress function, effect of finite crack size.	2	1	1,2
Unit No. 2	Plasticity effects	2	1	1
	Dugdales approach	2	1,2	1,2,3
	Plastic zone for plain stress and plain strain approach	2	1,2	1,2,3
	Stress intensity factors, fracture toughness.	2	1,2	1,2,3
Unit No. 3	Energy release rate	3	3	3
	Criteria for crack growth,	3	3	3
	Crack resistance, compliance.	3	3	3
Unit No. 4	Fracture beyond general yield	3	3,4	3
	Crack tip opening displacement, use of CTOD criteria	3	3,4	3
	Experimental determination of CTOD	2	3,4	3
	Parameters affecting critical CTOD	2	3,4	2
Unit No. 5	Use of J integral, limitation of J integral,	3	3,4	2
	Experimental determination of J integral,	3	3,4	3
	Parameters affecting J Integral.	4	3,4	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%)**	**Midterm-1 (15%)**	
Level 1	Remember	50%	40%	50%	45%	30%
	Understand					
Level 2	Apply	50%	60%	50%	55%	70%
	Analyse					
Level 3	Evaluate					
	Create					
Total		**100%**	**100%**	**100%**	**100%**	**100%**

Recommended Resources

1. Elements of Fracture Mechanics by Prasant Kumar, Mc Graw Hill Education, 2009 Edition.
2. Anderson, "Fracture Mechanics-Fundamental and application", T.L CRC press1998.

3. David Broek, "Elementary Engineering Fracture Mechanics", Springer Netherlands,2011

Other Resources

Course Designers

Production and operation management

Course Code	MMT 569	Course Category	TE		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	85%	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

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%	-	10%	-	10%	-	10%	-	10%	-
	Understand	30%	-	30%	-	10%	-	30%	-	30%	-
Level 2	Apply	10%	-	30%	-	10%	-	20%	-	20%	-
	Analyse	40%	-	20%	-	40%	-	20%	-	30%	-
Level 3	Evaluate	-	-	10%	-	20%	-	20%	-	10%	-
	Create	-	-	-	-	10%	-	-	-	-	-
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

Course Designers

Logistics and Supply Chain Management

Course Code	MMT 570	**Course Category**	TE		**L** 3	**T** 0	**P** 0	**C** 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 fundamental concepts and components of logistics and SCM
2. To analyze the strategic role of logistics and SCM in enhancing business performance
3. To design, manage, and optimize supply chain operations
4. To understand impact of technology and globalization on SCM practices

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 concepts and components of logistics and SCM	2	80%	75%
Outcome 2	Analyze the strategic role of logistics and SCM in enhancing business performance	3	80%	75%
Outcome 3	Optimize supply chain operations.	3	70%	65%
Outcome 4	Make strategies for managing risk, sustainability, and innovation in supply chains.	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	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 Supply Chain Networks	2	1	1
	Role of logistics in SCM	2	1	1
	Integration of supply chain activities	2	2	1,3
	Basic supply chain models and frameworks	2	2	1,3
Unit No. 2	Supply Chain Strategy and Competitive Advantage	2	1,2	1,3
	Demand Forecasting Techniques	2	1,2	1,2
	Inventory Management: Models and Practices	3	2,3	1,3
	Network Design and Optimization	2	1,2	2,3
Unit No. 3	Transportation Management Systems (TMS)	3	1,2	2,3
	Distribution Strategies and Network Design	2	1,2	2,3
	Warehousing and Inventory Control	1	1,2	2,3
	Logistics Service Providers and 3PL/4PL	2	1,2	2,3
Unit No. 4	Enterprise Resource Planning (ERP) Systems in SCM	3	1,2	2,3
	Role of IoT, AI, and Big Data Analytics in SCM	2	1,2	2,3
	Blockchain for Supply Chain Transparency	2	2,3	2,3
	Digital Transformation and E-commerce	3	3,4	2,3
Unit No. 5	Global Supply Chain Challenges and Solutions	3	3,4	2,3
	Sustainability and Corporate Social Responsibility (CSR) in SCM	3	3,4	2,3
	Risk Identification, Assessment, and Mitigation Strategies	2	3,4	2,3
	Future Trends: Resilience, Innovation, and Ethical SCM	2	3,4	2,3

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%	-	10%	-	10%	-	10%	-	-	10%
	Understand	30%	-	30%	-	10%	-	30%	-	-	30%
Level 2	Apply	10%	-	30%	-	10%	-	20%	-	-	20%
	Analyse	40%	-	20%	-	40%	-	20%	-	-	20%
Level 3	Evaluate	-	-	10%	-	20%	-	20%	-	-	10%
	Create	-	-	-	-	10%	-	-	-	-	10%
Total		**100%**		**100%**		**100%**		**100%**			**100%**

Recommended Resources

1. Sunil Chopra and Peter Meindl, "Supply Chain Management: Strategy, Planning, and Operation" Pearson, 2015
2. Martin Christopher, "Logistics & Supply Chain Management" Pearson, 2020
3. Alan Rushton, Phil Croucher, and Peter Baker, "The Handbook of Logistics and Distribution Management" Kogan Page, 2017.

Course Designers

Tool Design

						L	T	P	C
Course Code	MMT 571	**Course Category**	TE			3	0	0	3
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	80%	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.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 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 No. 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 No. 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 No. 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 No. 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

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%	-	10%	-	10%	-	10%	-	10%	-
	Understand	30%	-	30%	-	10%	-	30%	-	30%	-
Level 2	Apply	10%	-	30%	-	10%	-	20%	-	20%	-
	Analyse	40%	-	20%	-	40%	-	20%	-	30%	-
Level 3	Evaluate	-	-	10%	-	20%	-	20%	-	10%	-
	Create	-	-	-	-	10%	-	-	-	-	-
Total		**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.

Course Designers

Nanotechnology

						L	T	P	C
Course Code	MMT 572	**Course Category**	TE			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 introduce the fundamentals of nanotechnology
2. To learn various synthesis methods of nanomaterials
3. To introduce characterization techniques involved in nanotechnology.
4. To Familiarize with the potentialities of nanotechnology

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 nanomaterials based on dimensions and describe their properties.	2	80%	75%
Outcome 2	Describe the method of production of nanomaterials of different dimensions.	2	70%	65%
Outcome 3	Describe the basic characterization techniques of nanomaterials	3	80%	70%
Outcome 4	Produce nanomaterials for suitable applications.	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		2	3	3	3	2	3
Outcome 3	3	3	2	3		2		2	3	3	3	2	3
Outcome 4	3	3	3	3		2		2	3	3	3	3	3
Average	3	3	2	3		2		2	3	3	3	2	3

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Basics of Nanotechnology: Introduction to bulk and nanomaterials Importance of Nanotechnology and scientific revolution	**2**	**1**	**1**
	Dimensionality and size-dependent phenomena, Surface to volume ratio.	1	1	1
	Properties at the nanoscale – optical & mechanical, electronic and magnetic	**2**	1	**1**
	Hazards and risks of exposure to nanoparticles, Toxicity of nanoparticles	**2**	1	**1**
	Classification based on dimensionality- Quantum dots, wells and wires	**1**	1	**1**
Unit No. 2	Introduction to zero-dimensional nanostructures: (Quantum Dots) and Nanoparticles. Nanoparticles through homogeneous nucleation growth	**2**	**2**	**2**
	Kinetically confined synthesis of nanoparticles, Classification of nanoparticle synthesis techniques:	**2**	**2**	**2**
	solid-state synthesis of nanoparticles, Mechanical alloying and mechanical milling, Solution processing of nanoparticles: sol-gel processing, solution precipitation	**4**	**2**	**2**
	Vapor-phase synthesis of nanoparticles, inert gas condensation of nanoparticles, Plasma-based, flame-based synthesis of particles, Spray pyrolysis-based synthesis of nanoparticles	**4**	2	**2**
	Water–oil microemulsion (reverse micelle) method commercial production and use of nanoparticles	**1**	2	**2**
Unit No. 3	Introduction to One-Dimensional Nanostructures: Nanowires and Nanorods and their applications	**1**	2	**2**
	Fundamentals of evaporation (dissolution) condensation growth, Spontaneous growth - evaporation (dissolution) condensation Growth, Evaporation-condensation growth mechanism	**3**	2	**2**
	Dissolution-condensation growth, fundamental aspects of (vapor-liquid-solid) VLS and (solid-liquid-solid) SLS growth	3	2	**2**
	Stress-induced recrystallization. Template based synthesis	**1**	2	**2**
Unit No. 4	Introduction to two-Dimensional Nanostructures: Thin Films and Special nanomaterials, Fundamentals of film growth.	**2**	2	**2**
	Physical vapor deposition (PVD), Chemical vapours deposition (CVD) , Sol-Gel Films; spin coating and dip coating	**2**	2	**2**
	Atomic layer deposition (ALD), self-assembly, LB technique - electrochemical deposition	**2**	2	**2**
	Electrochemical deposition and electrophoretic deposition	**1**	2	**2**
	Micro and mesoporous material and core shell structure- Nanocomposites and nanograined materials	**2**	2	**2**
Unit No. 5	**Introduction to characterization techniques of nanomaterials.** X-ray diffraction (XRD), Field emission scanning electron microscopy (FESEM), Transmission electron microscope (TEM), UV-Vis Spectroscopy	4	3	3
	Applications in Nanotechnology: Solar Energy conversion and catalysis, Chemical and biosensors, Nanomedicine and nanobiotechnology, Nanorobotics	4	4	2

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	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. T. Pradeep, "A Textbook of Nanoscience and Nanotechnology", Tata McGraw Hill Education Pvt. Ltd.,2012
2. Guozhong Cao, "Nanostructures and Nanomaterials: Synthesis, properties, and applications" 2nd Edition - World Scientific Publishing Company 2011.
3. Douglas A. Skoog, James Holler, "Principles of Instrumental Analysis", Sauder's college publication, CBS publishers and distributors, 1998.

Course Designers

Biomaterials

						L	T	P	C
Course Code	MMT 573	**Course Category**	TE			3	0	0	3
Pre-Requisite Course(s)		**Co-Requisite Course(s)**		**Progressive Course(s)**					
Course Offering Department	Mechanical Engineering	**Professional / Licensing Standards**							

<u>Course Objectives / Course Learning Rationales (CLRs)</u>

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.

<u>Course Outcomes / Course Learning Outcomes (CLOs)</u>

	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%

<u>Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)</u>

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	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	2	3,4	2,3

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%	-	10%	-	10%	-	10%	-	-	10%
	Understand	30%	-	30%	-	10%	-	30%	-	-	30%
Level 2	Apply	10%	-	30%	-	10%	-	20%	-	-	20%
	Analyse	40%	-	20%	-	40%	-	20%	-	-	20%
Level 3	Evaluate	-	-	10%	-	20%	-	20%	-	-	10%
	Create	-	-	-	-	10%	-	-	-	-	10%
Total		**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.

Course Designers

Rubber Technology

Course Code	MMT 574	**Course Category**	TE		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. Understand the fundamental properties and classifications of rubber materials.
2. Explore the various processing techniques used in the rubber industry.
3. Study the compounding and vulcanization processes in rubber manufacturing.
4. Analyze the applications and performance characteristics of different types of rubber.

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 classify rubber materials	2	80%	75%
Outcome 2	Highlight various processing techniques used in the rubber industry	3	80%	75%
Outcome 3	Processes for rubber manufacturing including sustainability and environmental considerations	3	70%	65%
Outcome 4	Investigate the latest advancements and challenges in the rubber industry	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	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	Structure and composition of natural rubber	2	1	1
	Types of synthetic rubbers (e.g., SBR, EPDM, NBR)	2	1	1
	Physical, chemical, and mechanical properties of rubber	2	2	1,3
	Rubber elasticity and viscoelasticity	2	2	1,3
Unit No. 2	Types of fillers (carbon black, silica) and their effects	2	1,2	1,3
	Use of plasticizers, stabilizers, and antioxidants	2	1,2	1,2
	Rubber reinforcing agents and their impact on performance	3	2,3	1,3
	Designing compounds for specific applications (e.g., tires, seals)	2	1,2	2,3
Unit No. 3	Sulfur vulcanization and accelerators	3	1,2	2,3
	Peroxide and other non-sulfur vulcanization methods	2	1,2	2,3
	Curing kinetics and crosslink density	1	1,2	2,3
	Post-curing processes and their effects on rubber properties	2	1,2	2,3
Unit No. 4	Mixing and mastication processes	3	1,2	2,3
	Injection molding and compression molding	2	1,2	2,3
	Extrusion and calendaring processes	2	2,3	2,3
	Quality control in rubber processing	3	3,4	2,3
Unit No. 5	Applications in automotive, aerospace, medical, and consumer products	3	3,4	2,3
	Innovations in thermoplastic elastomers (TPEs) and nano-reinforced rubbers	3	3,4	2,3
	Recycling and reclaiming rubber	2	3,4	2,3
	Environmental and sustainability challenges in rubber production	2	3,4	2,3

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%	-	10%	-	10%	-	10%	-	-	10%
	Understand	30%	-	30%	-	10%	-	30%	-	-	30%
Level 2	Apply	10%	-	30%	-	10%	-	20%	-	-	20%
	Analyse	40%	-	20%	-	40%	-	20%	-	-	20%
Level 3	Evaluate	-	-	10%	-	20%	-	20%	-	-	10%
	Create	-	-	-	-	10%	-	-	-	-	10%
	Total	**100%**		**100%**		**100%**		**100%**			**100%**

Recommended Resources

1. John S. Dick, "Rubber Technology: Compounding and Testing for Performance", Hanser Publications, 2009.
2. Maurice Morton, "Rubber Technology", 3rd Edition, Springer Science & Business Media, 2013.
3. M. S. Evans, "Rubber Compounding: Chemistry and Applications", 2nd Edition, CRC Press, 2015.

Course Designers

Computational Material Science

Course Code	MMT 575	**Course Category**	TE		**L** 3	**T** 0	**P** 0	**C** 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 fundamental principles of materials science
2. To gain proficiency in various computational techniques and tools used in materials science
3. To learn how to predict and analyze the physical, chemical, and mechanical properties of materials using computational models and simulations.
4. To enhance problem-solving skills by applying computational techniques to real-world materials science challenges 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 fundamental materials science principles and computational methods.	2	80%	75%
Outcome 2	Get proficiency in molecular dynamics, density functional theory, and finite element analysis.	3	80%	75%
Outcome 3	Predict and analyze material properties using simulations.	3	70%	65%
Outcome 4	Apply computational techniques to solve real-world materials science problems.	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	3				2		3	3	3	2
Outcome 2	3	3	3	2				2		3	2	3	3
Outcome 3	3	3	3	2				3		3	3	3	3
Outcome 4	3	3	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	Overview of materials science and engineering, atomic structure: atoms, ions, and bonding, periodic table and electronic configurations, types of bonding	2	1	1
	Miller indices and crystallographic planes, amorphous vs crystalline materials, defects in solids	2	1	1
	Stress-strain behavior and mechanical testing, Elasticity, plasticity, and hardness, fracture toughness and impact testing,	2	2	1,3,4
	Structure and properties of metals and alloys, ceramics: types, properties, and applications, polymers: classification, synthesis, and properties, composites	2	2	1,3,4
Unit No. 2	Role of computational methods in materials science, comparison of computational techniques, high-performance computing and parallel processing	2	1,2	1,3,4
	Introduction to molecular dynamics (MD , density functional theory (DFT), finite element analysis (FEA), computational thermodynamics and CALPHAD	2	1,2	1,2,4
	Monte carlo simulations, quantum mechanics and wavefunction methods, finite difference methods, root-finding algorithms monte carlo integration, optimization techniques	3	2,3	1,3,4
	Molecular dynamics software, density functional theory software, finite element analysis software, computational thermodynamics software,visualization tools	2	1,2	2,3,4
Unit No. 3	Classical mechanics and equations of motion, interatomic potentials, initial conditions and system equilibration, time integration algorithms	3	1,2	2,3,4
	Hohenberg-Kohn theorems and Kohn-Sham equations Exchange-correlation functionals, hybrid functionals, Pseudopotentials and basis sets	2	1,2	2,3,4
	Microstructure of glass ceramics; Biodegradable polymers;	1	1,2	2,3,4
	Basic principles of finite element method (FEM), Element types: 1D, 2D, 3D elements, meshing techniques: structured and unstructured meshes, boundary conditions and constraints, static analysis	2	1,2	2,3,4
Unit No. 4	Real-world applications, structure-property relationships, design of alloys and composites, multi-objective optimization	3	1,2	2,3
	Integration of computational methods in production processes, quality control and process optimization	2	1,2	2,3,4
	Computational tools for failure analysis, materials selection and performance prediction	2	2,3	2,3,4
	Case studies: designing lightweight alloys, optimizing catalysts, integration of computational and experimental methods, challenges and future directions in material design	3	3,4	2,3
Unit No. 5	Literature review and background research, Designing computational experiments, Data collection and analysis	3	3,4	2,3
	Machine learning algorithms for materials science, Neural networks and deep learning, high-throughput screening and data mining, multiscale modeling	3	3,4	2,3
	Advanced molecular dynamics: coarse-grained, reactive md, ab initio molecular dynamics, computational materials genomics	2	3,4	2,3
	Uncertainty quantification in simulations, future directions in computational materials science	2	3,4	2,3

Learning Assessment

<table>
<tr><th colspan="2" rowspan="2">Bloom's Level of Cognitive Task</th><th colspan="8">Continuous Learning Assessments (50%)</th><th colspan="2" rowspan="2">End Semester Exam (50%)</th></tr>
<tr><th colspan="2">CLA-1 (10%)</th><th colspan="2">CLA-2 (10%)</th><th colspan="2">CLA-3 (15%)</th><th colspan="2">Mid Term (15%)</th></tr>
<tr><th colspan="2"></th><th>Th</th><th>Prac</th><th>Th</th><th>Prac</th><th>Th</th><th>Prac</th><th>Th</th><th>Prac</th><th>Th</th><th>Prac</th></tr>
<tr><td rowspan="2">Level 1</td><td>Remember</td><td>20%</td><td>-</td><td>10%</td><td>-</td><td>10%</td><td>-</td><td>10%</td><td>-</td><td>-</td><td>10%</td></tr>
<tr><td>Understand</td><td>30%</td><td>-</td><td>30%</td><td>-</td><td>10%</td><td>-</td><td>30%</td><td>-</td><td>-</td><td>30%</td></tr>
<tr><td rowspan="2">Level 2</td><td>Apply</td><td>10%</td><td>-</td><td>30%</td><td>-</td><td>10%</td><td>-</td><td>20%</td><td>-</td><td>-</td><td>20%</td></tr>
<tr><td>Analyse</td><td>40%</td><td>-</td><td>20%</td><td>-</td><td>40%</td><td>-</td><td>20%</td><td>-</td><td>-</td><td>20%</td></tr>
<tr><td rowspan="2">Level 3</td><td>Evaluate</td><td>-</td><td>-</td><td>10%</td><td>-</td><td>20%</td><td>-</td><td>20%</td><td>-</td><td>-</td><td>10%</td></tr>
<tr><td>Create</td><td>-</td><td>-</td><td>-</td><td>-</td><td>10%</td><td>-</td><td>-</td><td>-</td><td>-</td><td>10%</td></tr>
<tr><td colspan="2">Total</td><td>100%</td><td></td><td>100%</td><td></td><td>100%</td><td></td><td>100%</td><td></td><td></td><td>100%</td></tr>
</table>

Recommended Resources

1. Richard M. Martin, "Electronic Structure: Basic Theory and Practical Methods", Cambridge University Press, 2004.
2. Andrew R. Leach, "Molecular Modelling: Principles and Applications", Pearson Education, 2001.
3. Gottfried J. Schmitz and Ulrich Prahl, "Handbook of Software Solutions for ICME", Wiley-VCH, 2017.
4. Jens Nørskov and Felix Studt, "Fundamental Concepts in Heterogeneous Catalysis", Wiley, 2014.

Course Designers

Fundamentals of Polymer Science

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">MMT 576</td><td rowspan="2">Course Category</td><td rowspan="2" colspan="2">TE</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td>Pre-Requisite Course(s)</td><td></td><td>Co-Requisite Course(s)</td><td></td><td>Progressive Course(s)</td><td colspan="4"></td></tr>
<tr><td>Course Offering Department</td><td>Mechanical Engineering</td><td>Professional / Licensing Standards</td><td colspan="6"></td></tr>
</table>

<u>Course Objectives / Course Learning Rationales (CLRs)</u>

1. Understand the basic concepts and classifications of polymers.
2. Learn about the chemical synthesis and mechanisms of polymerization.
3. Explore the physical and mechanical properties of polymers, polymer characterization techniques.
4. Understand the applications of polymers in different fields and industries.

<u>Course Outcomes / Course Learning Outcomes (CLOs)</u>

	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 concepts and importance of polymers, Comprehend basic polymer terminology.	2	80%	75%
Outcome 2	Identify different polymerization techniques and their mechanisms.	3	80%	75%
Outcome 3	Utilize different analytical techniques to characterize polymers.	3	70%	65%
Outcome 4	Identify the diverse applications of polymers in different sectors,environmental impact and sustainability issues.	3	80%	75%

<u>Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)</u>

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	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	Definition and types of polymers (natural and synthetic)	2	1	1
	Polymer structure: linear, branched, and crosslinked	2	1	1
	Molecular weight and distribution	2	1	1,3
	Introduction to polymer morphology	2	1	1,3
Unit No. 2	Addition (chain-growth) polymerization: free radical, cationic, anionic	2	1,2	1,2,3
	Condensation (step-growth) polymerization	2	1,2	1,2
	Ring-opening polymerization	3	1,2,3	1,3
	Copolymerization and block copolymers	2	1,2	2,3
Unit No. 3	Amorphous and crystalline polymers	3	1,2,3	2,3
	Glass transition temperature (Tg) and melting temperature (Tm)	2	1,2,3	2,3
	Mechanical testing: tensile, impact, hardness	1	1,2	2,3
	Thermal analysis: DSC, TGA, DMA	2	1,2,3	2,3
Unit No. 4	Spectroscopic methods: FTIR, NMR, UV-Vis	3	3	2,3
	Chromatographic techniques: GPC, SEC	2	3	2,3
	Microscopy: SEM, TEM, AFM	2	3	2,3
	Rheology and thermal analysis techniques	3	1,2,3	2,3
Unit No. 5	Polymers in packaging, automotive, electronics, and biomedical applications	3	1,3,4	2,3
	Conducting polymers, biodegradable polymers, and nanocomposites	3	4	2,3
	Recycling and environmental considerations in polymer use	2	4	2,3
	Emerging trends and future directions in polymer science	2	4	2,3

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%	-	10%	-	10%	-	10%	-	-	10%
	Understand	30%	-	30%	-	10%	-	30%	-	-	30%
Level 2	Apply	10%	-	30%	-	10%	-	20%	-	-	20%
	Analyse	40%	-	20%	-	40%	-	20%	-	-	20%
Level 3	Evaluate	-	-	10%	-	20%	-	20%	-	-	10%
	Create	-	-	-	-	10%	-	-	-	-	10%
Total		**100%**		**100%**		**100%**		**100%**			**100%**

Recommended Resources

1. Paul C. Painter and Michael M. Coleman, "Fundamentals of Polymer Science: An Introductory Text", CRC Press, 2008.
2. Robert J. Young and Peter A. Lovell, "Introduction to Polymers", 3rd Edition, CRC Press, 2011.
3. Fred W. Billmeyer Jr., "Textbook of Polymer Science", 3rd Edition, Wiley-Interscience, 1984.

Course Designers

Multibody Dynamics

Course Code	MMT 577	Course Category	TE		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 make the students gain the fundamentals required for analysing the Multibody system dynamics.
2. To give a brief overview of various approaches for formulating the kinematics of multibody system.
3. To give a brief overview of various approaches for formulating the dynamics of multibody system.
4. To train the students to perform the kinematic and dynamic analysis of a multibody systems.

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	Analyse multibody systems.	3	85%	75%
Outcome 2	Numerically compute multibody system kinematics.	2	85%	75%
Outcome 3	Numerically compute multibody system dynamics.	3	80%	70%
Outcome 4	Mathematically formulate and analyse multibody system kinematics and dynamics.	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	2	3	3				1		3	3	3	2
Outcome 3	3	2	3	3				3		3	3	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	What is MBD, Applications and scope of MBD, Objectives of MBD, Preliminaries of MBD: Kinematics-Position, velocity, acceleration	2	1,2	1,2
	Momentum, Angular momentum, Kinetics- Force, moment, torque, equations of motion	2	1,2	1,2,3
	Methods of formulations for MBD, Mathematical Background For MBD: Vectors, Scalars, Arrays, Matrix operations	2	1,2	1,3
	Differentiation of vectors, arrays and matrices, Differential equations	2	1,2	1,2
Unit No. 2	Kinematics of particles	1	2	1,2,3
	Kinematics of a rigid body- position, Velocity and acceleration of a rigid body	2	2	1,2,3
	Array of coordinates, degrees of freedom, Constraint equations	1	2	1
	Kinematics of joints, Numerical problems	2	2	1,2,3
Unit No. 3	Newton's laws of motion- Dynamics of particle and system of particles, Dynamics of rigid body- Centroidal equations of motion	2	3	1,2,3
	Numerical problems, Non centroidal equations of motion	2	3	1,2,3
	Force elements, Applied forces- Gravitational forces, point to point actuator, point to point spring, point to point damper,	2	3	1,2,3
	Combined elements, rotational elements, viscous friction, Reaction Force: Method of Lagrange multipliers, Coulomb friction, Numerical problems	2	3	1,2,3
Unit No. 4	General procedure, Formulation of kinematic joint constraints, Revolute,	2	1,2	1,2,3
	Translational, composite and rigid joints, Numerical examples,	3	1,2	1,2,3
	Velocity and acceleration of joint constraints	2	1	1,2,3
	Formation of system Jacobian, Numerical examples	3	1	1,2,3
Unit No. 5	Dynamics of system of un-constrained bodies	3	3,4	3
	Dynamics of two body system, Dynamics general unconstrained bodies	3	3,4	1,2,3
	Dynamics of System of constrained bodies, Numerical problems	3	3,4	1,2,3
	Analysis of MBD system	4	3,4	1,2,3

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (__%)								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%	-	10%	-	10%	-	10%	-	10%	-
	Understand	30%	-	30%	-	10%	-	30%	-	30%	-
Level 2	Apply	10%	-	30%	-	10%	-	20%	-	20%	-
	Analyse	40%	-	20%	-	40%	-	20%	-	30%	-
Level 3	Evaluate	-	-	10%	-	20%	-	20%	-	10%	-
	Create	-	-	-	-	10%	-	-	-	-	-
Total		**100%**		**100%**		**100%**		**100%**		**100%**	

Recommended Resources

1. Planar Multibody Dynamics: Formulation, programming and applications by Parviz E Nikravesh, CRC Press, 2007.
2. Fundamentals of Multibody Dynamics: Theory and Applications by Farid Amiroche, Springer Science & Business Media, 2007.
3. Ahmed A. Shabana, "Railroad Vehicle Dynamics: A Computational Approach", CRC Press, 2009.

Course Designers