



# GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering

Level: UG

Branch: Manufacturing / Production

Subject Code: BE05000591

Subject Name: Advance Material Processing

w. e. f. Academic Year:	2024-25
Semester:	5
Category of the Course:	Professional Core Course

<b>Prerequisite:</b>	Basic Knowledge of Manufacturing Processes, Basic Knowledge of Materials and Material Science
<b>Rationale:</b>	Advance Material Processing course provides a comprehensive understanding of advanced and unconventional manufacturing processes essential for modern engineering applications. It equips students with knowledge of mechanical, electrical, chemical, and thermal energy-based machining processes used for precision manufacturing of complex and hard-to-machine materials. The inclusion of laser materials processing highlights emerging industrial applications in high-technology sectors. Ceramic, glass, and powder processing modules introduce students to material synthesis, shaping, and sintering techniques critical for advanced material engineering. Additionally, the study of composite materials and their manufacturing methods prepares learners for lightweight, high-strength structural applications widely used in aerospace, automotive, and biomedical industries. Overall, this subject bridges the gap between traditional manufacturing and advanced technologies, enhancing students' ability to select appropriate processes, optimize performance parameters, and meet industry demands for high-quality, efficient, and sustainable production systems.

## Course Outcomes:

Sr. No.	CO statement	Marks% weightage
CO-1	Analyze the influence of process parameters on Material Removal Rate (MRR), surface finish, and tool wear in processes such as EDM, ECM, AJM, USM, LBM, and PAM.	10
CO-2	Evaluate different laser material processing techniques and their industrial applications in metals, non-metals, photovoltaic, and biomedical fields.	35
CO-3	Explain the processing of advanced materials including ceramics, powders, and glass, covering synthesis, shaping techniques, sintering, and property evaluation.	25
CO-4	Assess various manufacturing methods of composite materials and relate them to their mechanical properties such as stiffness and strength.	20
CO-5	Select appropriate advanced machining or material processing technique for a given engineering application considering material properties, accuracy, cost, and performance.	10



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## Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits	Assessment Pattern and Marks					Total Marks
L	T	P	PBL	Total no of hours per semester		Theory		Tutorial / Practical			
						ESE (E)	PA / CA (M)	PA/C A (I)	PBL (I)	ESE (V)	
45	0	30	45	120	4	70	30	20	30	50	200

*\* Problem-Based Learning (PBL) aims to accommodate learning beyond syllabus as per clause 9.4 of NBA manual.*

### Content:

Sr. No.	Content	Total Hrs
<b>1</b>	<p><b>Unconventional Machining Processes:</b></p> <p><b>Mechanical Energy Based Processes</b> Abrasive Jet Machining (AJM), Water Jet Machining (WJM), Abrasive Water Jet Machining (AWJM), Ultrasonic Machining (USM). Working Principles, equipment used, Process parameters, MRR- Applications.</p> <p><b>Electrical Energy Based Processes</b> Electric Discharge Machining (EDM): Working Principle, equipment used, Process Parameters, Surface Finish and MRR, electrode/Tool, Power and control Circuits, Tool Wear, Dielectric, Flushing, Wire cut EDM, Applications.</p> <p><b>Chemical and Electro-Chemical Energy Based Processes</b> Chemical machining and Electro - Chemical machining (CHM and ECM): Etchants, Maskant, Techniques of applying maskants, Process Parameters, Surface finish and MRR, Applications. Principles of ECM, equipment, Surface Roughness and MRR Electrical circuit, Process Parameters, ECG and ECH Applications.</p> <p><b>Thermal Energy Based Processes</b> Laser Beam machining and drilling (LBM), Plasma Arc machining (PAM) and Electron Beam Machining (EBM). Principles, Equipment, Types, Beam control techniques, Applications.</p>	<b>18</b>
<b>2</b>	<p><b>Laser Materials Processing</b> Fundamentals of industrial lasers. Laser materials interaction theories. Laser processing for various industries such as metals, non-metals, photovoltaic, biomedical applications.</p>	<b>05</b>
<b>3</b>	<p><b>Ceramic Processing / Powder Processing</b> Synthesis of common ceramic powders such as Al<sub>2</sub>O<sub>3</sub>, ZrO<sub>2</sub>, Si<sub>3</sub>N<sub>4</sub>, and SiC, Powder characterization, Binders, Lubricants, Deflocculants and flocculants as processing aids, shaping techniques such as powder compaction, Extrusion, Injection mouldings, Slip casting, Solid state and liquid phase sintering</p>	<b>08</b>
<b>4</b>	<p><b>Glass Processing</b></p>	<b>06</b>



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	Glass and Glassy State, Glass Compositions and Properties, Raw Materials, Glass Melting, glass furnace and furnace types, Glass Forming Processes, Glass processing, Application of Glass.	
5	<b>Composite Materials</b> Introduction, Classification of composites, Manufacturing methods: Spray Lay-Up, Wet/Hand Lay-up, Vacuum Bagging, Filament Winding, Pultrusion, Resin Transfer Moulding (RTM), Resin Film Infusion (RFI), Mechanical Properties -Stiffness and Strength	08
<b>TOTAL</b>		<b>45</b>

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
15	15	25	20	15	10

**R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)**

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

The syllabus of Advance Material Processing directly contributes to

<b>SDG 3</b>	Good Health and Well-being
<b>SDG 4</b>	Skill development in modern digital manufacturing
<b>SDG 7</b>	Affordable and Clean Energy
<b>SDG 9</b>	Industry, Innovation and Infrastructure
<b>SDG 11</b>	Sustainable Cities and Communities
<b>SDG 12</b>	Responsible Consumption and Production
<b>SDG 13</b>	Climate Action

## Reference Books:

1. Unconventional Machining process, Dr. Senthil, A R S Publishers
2. Modern Machining Processes, P. C. Pandey, H. S. Shan, Tata McGraw-Hill
3. Design for Advanced Manufacturing: Technologies and Processes, LaRoux K. Gillespie, McGraw-Hill Education
4. Advanced Machining Processes / Non-Traditional and Hybrid Machining Processes, Hassan El-Hofy, McGraw-Hill
5. The Handbook of Glass Manufacture, F. Tooley, Tooley, New York : Books for Industry, [1974]
6. Mechanics of composite materials. Robert M. Jones, Taylor and Francis
7. Fundamentals of Ceramic Powder Processing and Synthesis ,Terry A. Ring, Academic Press.
8. Principles of Laser Materials Processing, Elijah Kannatey-Asibu Jr.Wiley

## Standards and Act:

w.e.f. 2025-26

<https://syllabus.gtu.ac.in/>

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1. BIS: IS 3073,
2. IS 3683,
3. IS 10816,
4. IS 1528,
5. IS 1529,
6. IS 6905,
7. IS 2553,
8. IS 2835,
9. IS 14900
10. IS 14443,
11. IS 10192,
12. IS 13360

## List of Experiments:

1. Case Studies/ Brain storming for selection criteria for different manufacturing processes.
2. Case studies for cost estimation of various advanced manufacturing processes.
3. MRR and Surface finish measurement of unconventional manufacturing processes.
4. Study and demonstration of Abrasive Jet Machining (AJM): Identify components, working principle, and process parameters.
5. Experiment on Water Jet Machining (WJM) / Abrasive Water Jet Machining (AWJM): Analyze effect of pressure and abrasive flow rate on material removal.
6. Ultrasonic Machining (USM) experiment: Study tool vibration, slurry concentration, and its effect on MRR.
7. Electric Discharge Machining (EDM) operation: Measure MRR and tool wear for different current and pulse settings.
8. Wire Cut EDM (WEDM) demonstration: Study profile cutting and machining accuracy
9. Chemical Machining (CHM) experiment: Masking techniques and etching rate analysis.
10. Electrochemical Machining (ECM) study: Effect of voltage, electrolyte, and feed rate on MRR and surface finish
11. Laser Beam Machining (LBM) / Laser drilling demonstration: Study laser parameters and material interaction.
12. Plasma Arc Machining (PAM) demonstration: Observe cutting characteristics and surface quality
13. Powder metallurgy experiment: Powder compaction and sintering; evaluate density and strength.
14. Ceramic processing practical: Preparation of ceramic sample (e.g.,  $Al_2O_3$ ) and sintering study.
15. Composite manufacturing practical (Hand lay-up method): Fabrication of fiber-reinforced composite and testing basic properties.

## Major Equipment:

Abrasive Jet Machining (AJM), Water Jet Machining (WJM), Abrasive Water Jet Machining (AWJM), Ultrasonic Machining (USM). Electric Discharge Machining (EDM), Chemical machining and Electro - Chemical machining (CHM and ECM), Laser Beam machining (LBM), Plasma Arc machining (PAM) and Electron Beam Machining (EBM)

## List of Open Source Software:



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1. <http://nptel.ac.in>

## List of suggested activities for Problem-based Learning (PBL):

Sr. No	PBL category	Name of the activity	No. of hours	Evaluation Criteria
1.	Complex Problem-Solving targeting relevant SDGs / Mini Project	Mini Project	15h (need to be changed as per total PBL hours)	Based on the novelty of project, technical understanding, report quality and presentation
2.	Case Study Analysis / Seminar	Seminar	15h (need to be changed as per total PBL hours)	Based on the quality of report and presentation, technical understanding
3.	Micro project	Micro project	8h (need to be changed as per total PBL hours)	Based on the novelty of project, technical understanding, quality of report and demonstration
4.	Industry/Research laboratory visit	Industry/Research laboratory visit	Visit = 5h, Report preparation = 5h Total = 10h	Based on report submitted. Report should contain observations and calculations based on industry/ lab data.
5.	Video Based Learning	Technical video-based learning related to the subject	Duration of video = 5h Report preparation = 5h Total = 10h	Report /presentation based on the video learning outcomes.
6.	Assignment / Technical Writing / Research Writing	Assignment writing. Numerical based assignment is preferable.	5 assignments of 4 h each Total = 20h	Based on the correctness of submitted assignment
7.	Group Discussion / Quiz / Simulation	Problem solving/Coding using C, C++, MATLAB, Python, SCILAB, modeling and Analysis software or any other software	5 small coding-based assignment of 2h each Total = 10h	Based on the coding solution submitted.
8.	Video Based Learning	Self-learning online course	Minimum duration of the course should be 10h	Examination based assessment at the end of course. Based on the certificate produced.
9.	Complex Problem-	Identification and solution of Complex problem	Maximum 2 problems. Study of the problem and	Based on the depth of the solution submitted.



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	Solving targeting relevant SDGs / Mini Project		solution finding, Total = 10h	
10.	Video Based Learning	Videos on Industrial safety/Disaster Management aspects based on subject	Duration of video = 5h Report preparation = 5h Total = 10h	Based on quiz/report submitted
11.	Research Paper Review / Analysis	Technical paper reading and summarization of research papers based on relevant subject	5 research papers = 20h	Summarize research paper and evaluation critical parameters
12.	Poster / Chart / PowerPoint presentation	Poster/chart/power point preparation on technical topics	Duration = 6h	Based on poster/chart preparation and presentation skills
13.	Industry/Research laboratory visit	Industrial exposure for 2-3 days to observe and provide tentative solutions on society/environment/health /sustainability/any other issue	Duration = 15h for industrial exposure  Problem identification and tentative solution = 10h Total = 20h	Based on evaluation of critical problems and solutions
14.	Group Discussion / Quiz / Simulation	Group Discussion on emerging/trending technical topics based on subject	Duration = 1h – 3h per topic	Based on performance in group discussion, technical depth, knowledge etc.
15.	Case Study Analysis / Seminar	Real world case studies-based learning	Duration of data collection/study = 5h Report preparation = 5h Total = 10h	Based on in-depth study, technical depth, data collected, fact finding, etc.
16.	Group Discussion / Quiz / Simulation	Application/Software development	Duration = 10h	Depending on the complexity of the Application/Software
17.	Assignment / Technical Writing / Research Writing	Research paper publication	Duration = 10h	Based on submission of proof of publication
18.	Micro project	Upgradation/Reverse engineering studies of existing equipment of the laboratory	Duration 10h	Based on the performance of the equipment
19.	Industry/Research laboratory	Expert lecture/session	Duration 3h For attending the	Based on the proof of attendance



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	visit		lecture/session– 2h and for report writing 1h	and report submitted
20.	Video Based Learning	Annotated Video Explanation of Concept/Problem	10h (Preparation + Recording + Submission)	Based on accuracy of explanation, clarity, and presentation style.
21.	Assignment / Technical Writing / Research Writing	Patent Search and Innovation Gap Identification	10h (Search + Report)	Based on number of relevant patents analyzed and identification of innovation scope.
22.	Assignment / Technical Writing / Research Writing	Preparation of a report on Indian Standard(s)	10h (study of Indian Standard(s) + report	Based on report quality and understanding of the relevant Indian Standard(s).

Note:

1. In alignment with Outcome-Based Education (OBE) and NBA accreditation requirements, the subject **Advance Material Processing compulsorily incorporates Mini projects and Seminar as PBL activities.**

These activities are incorporated as integral Project-Based Learning (PBL) components. These activities are designed to foster experiential learning, encourage innovation, and strengthen problem-solving skills by engaging students in practical applications. The inclusion of PBL ensures that learners develop higher-order cognitive abilities mapped to Bloom's taxonomy, while simultaneously enhancing teamwork, communication, and research competencies essential for professional engineering practice.

2. The hours allocated to specific activities should be proportionate to the total no. of PBL hours and marks.
3. All the suggested activity should be related to the subject.
4. The number of hours is suggestive. Faculty can sub-divide the number of hours based on the activity. However, total number of hours is fixed.
5. Rubrics for the evaluation can be prepared by the faculty.
6. Subject teacher can add the relevant activities other than those listed above, with the consent of head of the department and DQAC.

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