Curriculum of Diploma Programme

in

Leather Technology

Department of Science, Technology and Technical

Education (DSTTE), Govt. of Bihar

State Board of Technical Education(SBTE), Bihar

Semester – Fourth
Teaching & Learning Scheme

Course Codes	Category of course	CourseTitles	Teaching & Learning Scheme (Hours/Week)					
			Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
			L	T				
2472401	PCC	Leather Processing Technique-II	3		4	2	9	6
2472402	PCC	Mechanics of Leather Machines	3		2	2	7	5
2472403	PCC	Thermodynamics	3			2	5	4
2472404	PCC	Environmental Management in the Leather Industry	3			2	5	4
2472405	PEC	(a) Costing, Marketing & Visual Merchandising (b) Leather & Fashion Design products Merchandising (c) Tannery Byproducts Utilization	4				4	4
2472406	PCC	Tannery Practice II			4	2	6	3
2472407	PS	Mini Project			2	2	4	2
2472408	PCC	Material Testing & Analysis			2	2	4	2
			16	00	16	14	44	30

- **Note: Prefix will be added to Course Code if applicable (T for Theory Paper, P for Practical Paper and S for Term Work)**
- **Legend:**
- CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)
- LI: Laboratory Instruction (Includes experiments/practical performances /problem-based experiences in laboratory, workshop, field or other locations using different instructional/Implementation strategies)
- Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.
- TW: Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)
- SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.
- C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)
- **Note:** TW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure

Semester – Fourth

Assessment Scheme

Course Codes	Category of course	Course Titles	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Assessment (TA)		Term work & Self Learning Assessment (TWA)		Lab Assessment(LA)		
			Progressive Theory Assessment (PTA)	End Theory Assessment	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment	
2472401	PCC	Leather Processing Technique-II	30	70	20	30	20	30	200
2472402	PCC	Mechanics of Leather Machines	30	70	20	30	20	30	200
2472403	PCC	Thermodynamics	30	70	20	30			150
2472404	PCC	Environmental Management in the Leather Industry	30	70	20	30			150
2472405	PEC (ANY ONE)	(a)Costing, Marketing & Visual Merchandising (b) Leather & Fashion Design products Merchandising (c)Tannery Byproducts Utilization	30	70					100
2472406	PCC	Tannery Practice II			20	30	20	30	100
2472407	PSI	Mini Project			10	15	10	15	50
2472408	PCC	Material Testing & Analysis			10	15	10	15	50
			150	350	120	180	80	120	1000

Note: Prefix will be added to Course Code if applicable (T for Theory Paper, P for Practical Paper and S for Term Work)

Legend:

PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)

PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)

TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.

Note: Separate passing is must for progressive and end semester assessment for both theory and practical.

- ETA & ELA are to be carried out at the end of the term/ semester.

Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done **internally (40%)** as well as **externally (60%)**. Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self-learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/ presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist

A) Course Code : 2472401(T2472401/P2472401/S2472401)
B) Course Title : Leather Processing Technique–II

C) Pre- requisite Course(s) : Leather Processing Technique–I

D) Rationale

Leather Processing Technique–II provides advanced knowledge of post-tanning, dyeing, fatliquoring, finishing, and specialty leather manufacturing processes. The course builds upon fundamental tanning concepts to develop skills for producing quality leathers with desired properties and aesthetics. It also emphasizes eco-friendly technologies and quality control practices essential for sustainable leather production.

E) Course Outcomes (COs): After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/ laboratory/ workshop/ field/ industry.

After completion of the course, the students will be able to-

CO1 Explain the principles and objectives of post-tanning and finishing operations in leather processing.
CO2: Explain the identification and selection of suitable chemicals and auxiliaries used in dyeing, fatliquoring, and finishing processes
CO3 Describe and analyze the impact of various process parameters on the physical, mechanical, and aesthetic properties
CO4: Describe the understanding of advanced and specialty techniques in leather manufacturing.
CO5 Explain and apply eco-friendly and sustainable methods for post-tanning and finishing to minimize environmental impact.

F) Suggested Course Articulation Matrix (CAM):

PSO-1: Apply knowledge of chemistry, biochemistry, and material science to analyze, process, and enhance the quality of hides and skins into value-added leather products.

PSO-2: Utilize modern analytical tools and sustainable processing techniques for innovation, quality improvement, and environmental compliance in leather and allied industries

Course Outcomes (COs)	PO-1Basic and Discipline Specific Knowledge	PO-2Problem Analysis	PO-3Design / Development of Solutions	PO-4Engineering Tools	PO-5Engineering Practices for Society, Sustainability and Environment	PO-6Project Management	PO-7Life Long Learning	PSO-1	PSO-2
CO-1	3	3	-	1	-	-	-	-	-
CO-2	3	3	-	1	-	1	1	-	-
CO-3	3	3	-	2	-	1	1	-	-
CO-4	3	3	3	3	-	1	2	-	-
CO-5	3	3	3	3	3	3	3	-	3

Legend: High (3), Medium (2), Low (1) and No ma1pping (-)

*PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Course Code	Course Title	Scheme of Studies (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (SW+SL)	Total Hours (CI+LI+SW+SL)	Total Credits(C)
		L	T				
2472401	Leather Processing Technique-II	03	-	04	02	09	06

Legend:

CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)

LI: Laboratory Instruction (Includes experiments/practical performances in laboratory, workshop, field or other locations using different instructional/Implementation strategies)

Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.

TW: Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

SL: Self Learning, MOOCs, spoken tutorials, open educational resources (OERs)

C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)

Note: TW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

H) Assessment Scheme:

Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
		Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	

2472401	Leather Processing Technique-II	30	70	20	30	20	30	200

Legend:

PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)

PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)

TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.

Note:

- ETA & ELA are to be carried out at the end of the term/ semester.
- Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done **internally (40%)** as well as **externally (60%)**. Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self-learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/ presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activities.

I) Course Curriculum Detailing: This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Term Work (TW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

J) Theory Session Outcomes (TSOs) and Units: T2472401

Major Theory Session Outcomes (TSOs)	Units (with Expanded Title and Subtopics)	Relevant CO(s)
TSO 1.1 Explain the objectives and significance of post-tanning operations for improving leather quality and performance. **TSO 1.2** Describe the chemical principles and mechanisms involved in neutralization and retanning processes. **TSO 1.3** Identify various retanning agents such as vegetable tannins, syntans, and resins, and explain their functional properties.	**Unit 1 – Post-Tanning Operations: Neutralization and Retanning** 1.1 Introduction and objectives of post-tanning 1.2 Role of post-tanning in improving handle, fullness, and feel of leather 1.3 Sequence of post-tanning operations and interrelationship with previous stages 1.4 Neutralization principles, reactions, and pH control 1.5 Chemistry of retanning and its influence on leather structure 1.6 Control parameters for achieving uniform retanning 1.7 Vegetable tannins and syntans: types and roles 1.8 Polymer and resin-based retanning agents 1.9 Comparison between vegetable and synthetic retanning systems	CO-1
TSO 2.1 Explain the purpose, principles, and process parameters of leather dyeing.	**Unit 2 – Leather Dyeing** 2.1 Importance of dyeing in post-tanning 2.2 Mechanisms of dye uptake and diffusion	CO-2

TSO 2.2 Classify different categories of dyes (acid, basic, direct, metal complex) used for various types of leather. **TSO 2.3** Determine factors influencing dyeing uniformity, penetration, and shade matching.	2.3 Influence of pH, temperature, and electrolyte on dyeing 2.4 Classification and characteristics of dyes 2.5 Selection criteria for dyes based on leather type 2.6 Matching of shade and tone during application 2.7 Factors affecting dye penetration and evenness 2.8 Troubleshooting of dyeing defects 2.9 Testing of color fastness and performance	
TSO 3.1 Explain the need and importance of fatliquoring in post-tanning to impart softness, flexibility, and feel to leather. **TSO 3.2** Describe the chemistry, composition, and preparation of natural and synthetic fatliquors. **TSO 3.3** Determine the factors affecting fatliquor stability, penetration, and performance in leather.	**Unit 3 – Fatliquoring** 3.1 Purpose and objectives of fatliquoring 3.2 Role of fatliquors in leather softness, flexibility, and tensile properties 3.3 Mechanisms of lubrication and internal oil distribution 3.4 Composition and chemistry of natural, synthetic, and semi-synthetic fatliquors 3.5 Methods of preparation and emulsification 3.6 Testing of stability and compatibility 3.7 Process control parameters affecting fatliquoring 3.8 Comparative study of different types of fatliquors 3.9 Quality evaluation of fatliquored leather	CO-3
TSO 4.1 Explain the principles, methods, and objectives of drying and conditioning of leather after wet operations. **TSO 4.2** Discuss the use and functions of mechanical operations such as setting, staking, buffing, and toggling. **TSO 4.3** Determine drying temperature, humidity, and process parameters affect leather texture and strength.	**Unit 4 – Drying, Conditioning and Mechanical Operations** 4.1 Importance of drying in post-tanning 4.2 Principles of water removal and fiber structure stabilization 4.3 Common drying methods (toggle, vacuum, paste, sammying) 4.4 Objectives and techniques of setting, staking, and stretching 4.5 Buffing and its influence on surface texture 4.6 Mechanical softening and conditioning 4.7 Control of drying parameters (temperature, air velocity, humidity) 4.8 Monitoring fiber relaxation and shrinkage 4.9 Quality assessment of conditioned leather	CO-4
TSO 5.1 Explain the objectives and fundamentals of leather finishing processes to enhance appearance and performance. **TSO 5.2** Identify finishing components such as binders, pigments, waxes, and lacquers and their functional properties. **TSO 5.3** Compare mechanical and spray finishing methods and their effects on durability, gloss, and touch.	**Unit 5 – Leather Finishing Techniques** 5.1 Purpose and classification of finishing 5.2 Physical and chemical aspects of film formation 5.3 Stages of finishing: base coat, intermediate coat, top coat 5.4 Composition of finishing formulations 5.5 Role of each component in adhesion, flexibility, and gloss 5.6 Preparation and application of finishes 5.7 Finishing equipment and application techniques (spray, roller, curtain coating) 5.8 Defects and remedies in finishing 5.9 Evaluation of finish quality and performance	CO-5

Note: One major TSO may require more than one Theory session/Period.

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2472401

Practical / Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment / Practical Titles	Relevant CO(s)
LSO 1.1 Demonstrate the process of neutralization and retanning of chrome-tanned leather and assess its impact on softness and fullness.	1	Practical exercise on neutralization and retanning of chrome-tanned leather.	CO-1
LSO 1.2 Identify and compare the performance of different retanning agents (vegetable tannins, syntans, and resins) through controlled experiments.	2	Study of different types of retanning agents and their effects on leather properties.	CO-1
LSO 2.1 Perform dyeing of crust leather using acid and metal-complex dyes and observe penetration, shade uniformity, and fastness properties.	3	Practical exercise on dyeing of leather using various classes of dyes.	CO-2
LSO 2.2 Evaluate the influence of pH, temperature, and time on the shade and color fastness of dyed leather.	4	Study of parameters affecting the dyeing process and shade development.	CO-2
LSO 3.1 Prepare and apply fatliquor formulations and evaluate softness, tensile strength, and handle of treated leather.	5	Practical exercise on fatliquoring process and performance evaluation of fatliquored leather.	CO-3
LSO 3.2 Compare the effects of natural and synthetic fatliquors on the physical properties and feel of leather.	6	Comparative study of natural vs. synthetic fatliquors in leather processing.	CO-3
LSO 4.1 Operate drying and conditioning equipment and analyze the impact of drying parameters on leather quality and dimensional stability.	7	Experiment on drying and conditioning of post-tanned leather.	CO-4
LSO 4.2 Perform mechanical operations like staking, buffing, and toggling to understand their role in enhancing the texture and grain of leather.	8	Demonstration of mechanical finishing operations on dried leather.	CO-4
LSO 5.1 Apply different finishing systems (aniline, semi-aniline, and pigmented) using spray and roller coating techniques and evaluate film properties.	9	Practical exercise on application of leather finishing systems using spray/roller methods.	CO-5
LSO 5.2 Assess the gloss, adhesion, and flexibility of finished leather under varying finishing conditions.	10	Evaluation of finishing film performance through standard tests.	CO-5

L) Suggested Term Work and Self-Learning: S2472401 Some sample suggested assignments, micro project and other activities are mentioned here for reference.

a. Assignments

S. No.	Assignment Topics	Purpose / Expected Learning	Relevant CO(s)
1	Explain the principles of post-tanning and finishing operations in leather processing.	Reinforce theoretical understanding through descriptive and analytical writing.	CO-1
2	Compare different dyeing methods used for leather coloring.	Develop the ability to evaluate alternative processing techniques.	CO-2
3	Write short notes on fatliquoring and its role in leather softness.	Enhance the conceptual clarity of functional finishing processes.	CO-3
4	Discuss eco-friendly approaches in post-tanning and finishing.	Promote understanding of sustainable practices in leather production	CO-4
5	Analyze the factors affecting the quality and performance of finished leather.	Improve analytical skills in assessing product performance characteristics.	CO-5

b. Micro Projects

S. No.	Micro Project Topics	Purpose / Expected Learning	Relevant CO(s)
1	Preparation of flowchart for post-tanning, dyeing, and finishing operations.	Develop analytical and visualization skills.	CO-2
2	Experimental study on effect of pH or time on dye uptake of leather.	Apply theoretical knowledge to practical experiments.	CO-2
3	Development of eco-friendly finishing formulation using bio-based materials.	Promote sustainable processing skills.	CO-4
4	Measurement and comparison of softness and tensile strength for differently treated leathers.	Evaluate and improve leather quality.	CO-4
5	Design a sustainable leather processing layout minimizing chemical waste.	Develop problem-solving and design skills.	CO-5

c. Other Activities

1. Seminar Topics:

S. No.	Seminar Topic	Purpose / Expected Learning	Relevant CO(s)
1	Innovations in bio-based leather chemicals.	Enhance research and presentation skills.	CO-3
2	Advances in enzyme-assisted leather processing.	Develop understanding of modern eco-efficient processing technologies.	CO-3
3	Sustainable leather production and waste minimization.	Promote awareness of sustainability practices in leather manufacturing	CO-4
4	Nanotechnology in leather finishing.	Explore advanced finishing technologies for improved performance.	CO-4
5	Circular economy approaches in leather industry.	Analyze strategies for resource recovery, reuse, and value creation.	CO-5

2. Surveys:

S. No.	Survey Topic	Purpose / Expected Learning	Relevant CO(s)
1	Industrial survey on adoption of eco-friendly tanning and finishing methods.	Promote industry–academia linkage.	CO-4
2	Comparative study of effluent treatment practices in tanneries.	Awareness of environmental sustainability.	CO-5
3	Market survey on consumer perception of sustainable leather products.	Understand market trends and sustainability acceptance.	CO-5

3. Visit:

S. No.	Visit Place / Activity	Purpose / Expected Learning	Relevant CO(s)
1	Visit to a leather tannery for observing post-tanning and finishing processes.	Provide real-world exposure to leather processing.	CO-3

2	Visit to a leather testing and quality assurance laboratory.	Learn testing methods and quality evaluation.	CO-3
3	Visit to an effluent treatment plant (ETP) for understanding waste management in leather industry.	Understand environmental compliance and sustainability.	CO-5

d. Self-Learning Topics

S. No.	Self-Learning Topic	Purpose / Expected Learning	Relevant CO(s)
1	Study of advanced post-tanning chemicals and their role in leather quality improvement.	Understand new chemicals and their effects on leather properties.	CO-2, CO-3
2	Exploration of eco-friendly dyes, fatliquors, and finishing agents.	Promote sustainable and green leather processing practices.	CO-4, CO-5
3	Analysis of leather defects and troubleshooting techniques in finishing.	Develop problem-solving skills for leather quality issues.	CO-3, CO-4
4	Comparative study of conventional vs. enzyme-assisted pretannage methods.	Learn advantages and limitations of biochemical processing.	CO-2, CO-5
5	Research on specialty leathers such as waterproof, patent, and metallic leathers.	Enhance understanding of specialty leather processing techniques.	CO-4
6	Review of leather industry standards, quality certifications, and compliance requirements.	Gain knowledge about quality assurance and regulatory practices.	CO-3, CO-5
7	Study on effluent treatment, waste minimization, and sustainable leather manufacturing processes.	Awareness of environmental sustainability in leather industry.	CO-5
8	Investigation of modern leather finishing	Improve knowledge of advanced finishing processes and performance enhancement.	

M) Suggested Course Evaluation Matrix: The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and sessional work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate **CO attainment**.

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Sessional Work Assessment (SWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Sessional Work & Self Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	15%	15%	20%	20%	33%	20%	20%
CO-2	20%	25%	20%	20%	33%	25%	20%
CO-3	25%	25%	20%	20%	34%	20%	20%
CO-4	25%	20%	20%	20%	--	20%	20%
CO-5	15%	15%	20%	20%	--	15%	20%
Total Marks	30	70	20	20	10	20	30
			50				

Legend:

***:** Other Activities include self- learning, seminar, visits, surveys, product development, software development etc.

******: Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

N) Suggested Specification Table for End Semester Theory Assessment: Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

Unit Title and Number	Total Classroom Instruction (CI) Hours	Relevant COs Number (s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit 1 – Post-Tanning Operations: Neutralization and Retanning	8	CO-1	11	4	4	3
Unit 2 – Leather Dyeing	12	CO-2	17	4	6	7
Unit 3 – Fatliquoring	10	CO-3	17	4	6	7
Unit 4 – Drying, Conditioning and Mechanical Operations	10	CO-4	14	4	6	4
Unit 5 – Leather Finishing Techniques	8	CO-5	11	4	3	4
Total Marks	48	-	70	20	25	25

Note: Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA (%)	PDA (%)	
1	Practical on neutralization and retanning of chrome-tanned leather.	CO-1	50	40	1
2	Study of different types of retanning agents and their effects on leather properties.	CO-1	50	40	2
3	Practical on dyeing of leather using various classes of dyes.	CO-2	50	40	3
4	Study of parameters affecting the dyeing process and shade development.	CO-2	45	45	4
5	Practical on fatliquoring process and performance evaluation of fatliquored leather.	CO-3	50	40	5
6	Comparative study of natural vs. synthetic fatliquors in leather processing.	CO-3	50	40	6
7	Experiment on drying and conditioning of post-tanned leather.	CO-4	50	40	7
8	Demonstration of mechanical finishing operations on dried leather.	CO-4	50	40	8
9	Practical on application of leather finishing systems using spray/roller methods.	CO-5	50	40	9
10	Evaluation of finishing film performance through standard tests.	CO-5	50	40	10

Legend:

PRA*: Process Assessment

PDA**: Product Assessment

Note: This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student performance.

P) Suggested Instructional/Implementation Strategies:

Q) List of Major Laboratory Equipment, Tools and Software:

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment / Practical Number
1	**Tanning Drum / Rotating Wooden Drum**	Wooden or stainless-steel drum with variable speed (5–20 rpm), capacity 10–25 L, for neutralization, retanning, and dyeing experiments.	1, 2, 3, 4
2	**pH Meter**	Digital bench-type pH meter with electrode accuracy ±0.01, suitable for aqueous leather solutions.	1, 3, 4, 12

3	**Analytical Balance**	Electronic balance with precision up to 0.001 g for weighing tanning agents, dyes, and chemicals.	All Practicals
4	**Hot Air Oven**	Temperature range: ambient to 250°C; used for drying leather samples and conditioning after treatment.	7, 8, 9
5	**Mechanical Staking Machine**	Used for softening and stretching of dried leather; adjustable pressure and stroke control.	8
6	**Buffing and Polishing Machine**	Equipped with abrasive rollers and dust collector; used for buffing grain and flesh sides.	8
7	**Spray Gun and Finishing Booth**	Air compressor-based spray gun with adjustable nozzle; spray booth with exhaust and filtration system for safe application of coatings.	9, 10
8	**Roller Coating Machine**	Roller diameter 100–150 mm, adjustable coating thickness and speed, used for uniform film formation.	9
9	**Gloss Meter**	Measures surface gloss (20°, 60°, 85° angles); digital readout for finish evaluation.	10
10	**Tensile Testing Machine (Leather Grade)**	Load capacity: 0–500 N; elongation up to 300 mm; conforming to ISO 3376 for tensile and tear strength testing.	11
11	**Tear Strength Tester**	Elmendorf or pendulum type; measures tear resistance as per ISO 3377-2 standard.	11
12	**Color Fastness Testing Apparatus**	For wet/dry rub fastness and light fastness testing (ISO 105-X12, ISO 105-B02).	11
13	**Water Absorption and Flex Tester**	Used to evaluate leather's flexing resistance and water permeability under dynamic load.	11
14	**Spectrophotometer (UV-Vis)**	Measures absorbance of dye solutions to analyze dye uptake and shade depth.	3, 4
15	**Effluent Analysis Kit**	Includes COD, BOD, TDS, pH, and chloride measurement modules for wastewater analysis.	12
16	**Glassware and Chemical Reagents Set**	Beakers, flasks, burettes, pipettes, indicators, and standard solutions for general laboratory experiments.	All Practicals
17	**Drying Frame / Toggle Machine**	Stainless steel frame with adjustable tension clamps; used for even drying and conditioning of leather sheets.	7, 8
18	**Computer System with Finishing Simulation Software (optional)**	Software for process simulation of leather finishing (color matching, coating analysis); compatible with Windows/Linux systems.	9, 10
19	**Leather Sample Cutting Tools and Molds**	Die cutters, scalpels, templates for preparing standard specimens (ISO dimensions).	1–11
20	**Personal Protective Equipment (PPE)**	Includes lab coats, gloves, goggles, masks, and fume extractor to ensure safety during handling of chemicals and spray finishes.	All Practicals

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1	Principles of Leather Manufacture	R. H. M. Wilson	Leather Industries Research Association, 5th Edition, ISBN: 978-085160-XXXX
2	Leather Science and Technology	A. J. S. Leather	Chapman & Hall, 3rd Edition, ISBN: 978-041234-XXXX
3	Chemistry of Leather Manufacture	R. R. Bhattacharya	Allied Publishers, 2nd Edition, ISBN: 978-817XXX-XXXX
4	Biochemistry for Leather Processing	P. K. Gupta	New Age International, 1st Edition, ISBN: 978-812240-XXXX
5	Sustainable Leather Processing	S. K. Rout	CRC Press, 1st Edition, ISBN: 978-0367XX-XXXX
6	Enzymes in Leather Manufacture	V. S. Sharma	Springer, 1st Edition, ISBN: 978-3030XX-XXXX
7	An Introduction to the Principles of Leather Manufacture	Prof. S. S. Dutta	Indian Leather Technologists' Association (ILTA), Kolkata
8	Analytical Chemistry of Leather Manufacture	Mr. P. K. Sarkar	Indian Leather Technologists' Association (ILTA), Kolkata

(b) Open Educational Resources (OER):

S. No.	Resource Type	Title / Description	Link / Reference	Relevant Practical / Module
1	**Learning Package**	*Guide to Leather Making – Part II* (Leather Naturally) – Comprehensive overview of modern leather processing, machinery, and eco-friendly techniques	https://www.leathernaturally.org/wp-content/uploads/2023/02/LN-Guide_to_leather_making_PART_TWO.pdf	All Practicals
2	**E-Book / PDF**	*Professional Education and Training in the Leather-Based Industries* – Covers advanced processing, training methods, and sustainability	https://leatherpanel.org/sites/default/files/publications-attachments/profesional_training_leather_lpm2010.pdf	Practicals 7, 11, 12, 16
3	**Research Paper / Review**	*Recycling of Chrome-Tanned Leather and Its Utilization in Polymeric Composites* – Modern sustainable approach for effluent reduction	https://www.mdpi.com/2073-4360/13/3/429	Practicals 11, 12, 15, 16

4	**Video Tutorial / Lecture**	*Leather Processing Operations and Beamhouse Chemistry* – FAO Leather and Leather Products Industry videos	https://www.fao.org/leather/	Practicals 1–6
5	**Case Study / Field Report**	*Traditional Leather Processing and Marketing in Ethiopia* – Comparative study of conventional vs eco-friendly methods	https://www.academia.edu/54504197/Traditional_Leather_Processing_Production_and_Marketing_in_Amhara_Regional_State_of_Ethiopia	Practicals 13–16
6	**Online Course / MOOC**	*Leather Technology and Sustainable Production* (edX / Coursera – open access modules on industrial biotechnology and materials science)	https://www.edx.org/	Practicals 2, 6, 7, 15
7	**Technical Bulletin**	*How to Conduct Environmental Impact Assessment for Leather Processing Industry* – Steps, effluent control, EIA methodology	https://corpbiz.io/learning/how-to-conduct-eia-for-leather-processing-industry/	Practicals 11, 12, 15, 16
8	**Laboratory Reference Manual**	*Guide to Leather Material Testing* – Standard test methods for physical and chemical evaluation	https://www.researchgate.net/publication/Leather_Material_Testing	Practicals 3, 4, 5
9	**Industrial Resource / Manufacturers' Data**	*Chemical and Enzyme Processing Manuals* – Open-access documents provided by enzyme/chemical companies (e.g., Novozymes, TFL, Stahl)	https://www.novozymes.com/	Practicals 2, 6, 7, 13
10	**Open Learning Repository**	*OER Commons – Leather Technology Resources* – General and advanced educational content for tanning, finishing, and testing	https://www.oercommons.org/	All Practicals

A) Course Code : **2472402(T2472402/P2472402/S2472402)**
B) Course Title : Mechanics of Leather Machines

C) Pre- requisite Course(s) : Engineering Mechanics and Basic Mechanical Engineering
D) Rationale:

The course provides students with a fundamental understanding of the mechanical principles and components underlying leather processing machines. It bridges theoretical mechanics with practical applications, enabling learners to analyze, operate, and maintain machines efficiently. This knowledge ensures optimized performance, durability, and safety in leather manufacturing processes.

E) Course Outcomes (COs): After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/ laboratory/ workshop/ field/ industry.

After completion of the course, the students will be able to-

CO1 Explain the fundamental mechanical principles, kinematics, and dynamics relevant to leather machines.
CO2 Explain the function of machine elements such as gears, shafts, bearings, and linkages used in leather processing equipment.
CO3 Apply knowledge of mechanics to assess, operate, and maintain leather machinery efficiently and safely.
CO4 Describe machine design and mechanical behavior to the specific requirements of leather processing operations.
CO5 Describe problem-solving skills for troubleshooting and optimizing the performance of leather machines.

F) Suggested Course Articulation Matrix (CAM):

PSO-1: Apply knowledge of chemistry, biochemistry, and material science to analyze, process, and enhance the quality of hides and skins into value-added leather products.

PSO-2: Utilize modern analytical tools and sustainable processing techniques for innovation, quality improvement, and environmental compliance in leather and allied industries

Course Outcomes (COs)	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design / Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2
CO-1	3	3	-	-	-	-	1	-	-
CO-2	3	3	2	2	-	1	2	-	-
CO-3	3	3	3	2	1	1	2	-	1
CO-4	2	3	3	2	-	-	2	-	-
CO-5	3	3	3	3	-	-	2	-	1

Legend: High (3), Medium (2), Low (1) and No ma1pping (-)

*PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Course Code	Course Title	Scheme of Studies (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (SW+ SL)	Total Hours (CI+LI+SW+SL)	Total Credits(C)
		L	T				
2472402	Mechanics of Leather Machines	03	-	02	02	07	05

Legend:

CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)

LI: Laboratory Instruction (Includes experiments/practical performances in laboratory, workshop, field or other locations using different instructional/Implementation strategies)

Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.

TW: Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

SL: Self Learning, MOOCs, spoken tutorials, open educational resources (OERs)

C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)

Note: TW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

H) Assessment Scheme:

Course Code		Assessment Scheme (Marks)			Total Marks (TA+TWA+LA)
		Theory Assessment (TA)	Term Work & Self-Learning Assessment (TWA)	Lab Assessment (LA)	

	Course Title	Progressive Theory Assessment (PTA)	End Theory Assessment	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2472402	Mechanics of Leather Machines	30	70	20	30	20	30	200

Legend:

PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)

PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)

TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.

Note:

- ETA & ELA are to be carried out at the end of the term/ semester.
- Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done **internally (40%)** as well as **externally (60%)**. Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self-learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/ presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activities.

I) Course Curriculum Detailing: This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Term Work (TW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

J) Theory Session Outcomes (TSOs) and Units: T2472402

Major Theory Session Outcomes (TSOs)	Units	Relevant CO(s)
TSO.1a Explain the basic principles of mechanics and kinematics relevant to leather machinery. **TSO.1b** Describe the types of kinematic pairs and mechanisms used in leather machines.	**Unit–1.0 Fundamentals of Mechanics for Leather Machines** 1.1 Basic concepts of mechanics and relevance to leather machinery 1.2 Force systems and equilibrium	CO-1

TSO.1c Explain velocity and acceleration analysis of simple mechanisms.	1.3 Friction, torque, and motion in machine components 1.4 Load transmission and stress analysis 1.5 Basic kinematics of mechanisms	
TSO.2a Identify various machine elements such as gears, shafts, pulleys, and bearings. **TSO.2b** Discuss design considerations for components under load and motion. **TSO.2c** Explain failure modes and maintenance requirements of machine elements.	**Unit–2.0 Machine Elements in Leather Machines** 2.1 Gears, gear trains, and belt drives 2.2 Shafts and couplings 2.3 Bearings and lubrication methods 2.4 Springs and fasteners 2.5 Power transmission components	CO-1, CO-2
TSO.3a Describe the operation principles and working of major leather processing machines (splitting, shaving, fleshing, and rolling). **TSO.3b** Determine the motion and force transmission in leather machines. **TSO.3c** Apply knowledge of mechanics to troubleshoot operational issues.	**Unit–3.0 Mechanics of Leather Processing Machines** 3.1 Working principles of splitting, shaving, and fleshing machines 3.2 Rollers, conveyors, and drums 3.3 Mechanical adjustment and control mechanisms 3.4 Power requirements and efficiency considerations	CO-2, CO-3
TSO.4a Explain finishing machine mechanics and surface treatment equipment. **TSO.4b** Identify common defects in finishing operations and corrective measures. **TSO.4c** Discuss eco-friendly and sustainable operation practices for leather machinery.	**Unit–4.0 Finishing and Surface Coating Machines** 4.1 Spray, roller, and curtain coating machines 4.2 Plating, embossing, and glazing mechanisms 4.3 Drying and curing equipment 4.4 Evaluation of machine performance and product quality	CO-3, CO-4
TSO.5a Correlate machine operation parameters with leather quality and productivity. **TSO.5b** Suggest improvements in machine design and operation for sustainable production.	**Unit–5.0 Sustainable and Advanced Leather Machinery** 5.1 Energy-efficient and automated machines 5.2 Waste minimization and recycling in machine operations 5.3 Integration of green technologies 5.4 Safety and ergonomics in leather machine operation	CO-4, CO-5

Note: One major TSO may require more than one Theory session/Period.

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2472402

Practical / Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment / Practical Titles	Relevant CO(s)
LSO 1.1 Students will be able to identify and measure forces, torques, and motion parameters in machine components.	1	Demonstration and measurement of forces and torque in basic machine elements.	CO-1
LSO 1.2 Students will be able to assemble and disassemble simple mechanisms to understand kinematic motion.	2	Assembly and disassembly of linkages and simple kinematic pairs.	CO-1
LSO 1.3 Students will be able to analyze velocity and acceleration of mechanisms using graphical or analytical methods.	3	Velocity and acceleration analysis of simple mechanisms (slider-crank, four-bar).	CO-1

LSO 2.1 Students will be able to study and measure gear ratios, belt drives, and power transmission efficiency.	4	Study of gear trains, belt drives, and measurement of speed and torque.	CO-2
LSO 2.2 Students will be able to investigate shaft and bearing performance under load and lubrication conditions.	5	Load testing and lubrication study of shafts and bearings.	CO-2
LSO 2.3 Students will be able to perform stress and deflection analysis on machine components.	6	Determination of stress and deflection in shafts and beams.	CO-2
LSO 3.1 Students will be able to operate leather processing machines and observe motion, force transmission, and machine adjustments.	7	Demonstration and operation of splitting, shaving, and fleshing machines.	CO-3
LSO 3.2 Students will be able to measure machine parameters affecting product quality, such as roller speed and pressure.	8	Measurement of operational parameters in leather machines (roller speed, pressure, tension).	CO-3
LSO 3.3 Students will be able to troubleshoot and suggest improvements in machine operation based on observed performance.	9	Troubleshooting of common issues in leather machine operation.	CO-3
LSO 4.1 Students will be able to operate finishing machines and evaluate surface quality of leather products.	10	Demonstration of leather finishing operations (spray, roller, embossing).	CO-4
LSO 4.2 Students will be able to identify defects in finishing and propose corrective measures.	11	Detection and correction of finishing defects in leather samples.	CO-4
LSO 5.1 Students will be able to apply sustainable and energy-efficient practices in machine operation.	12	Demonstration of eco-friendly machine operation and energy optimization.	CO-5
LSO 5.2 Students will be able to conduct comparative studies of conventional vs. optimized machine settings for efficiency and product quality.	13	Comparative study of conventional and optimized machine operation for efficiency and quality.	CO-5
LSO 5.3 Students will be able to document, analyze, and report machine performance and suggest improvements for sustainability.	14	Project experiment: Analysis and reporting of machine performance and sustainability measures.	CO-5

L) Suggested Term Work and Self-Learning: S2472402 Some sample suggested assignments, micro project and other activities are mentioned here for reference.

a. Assignments

S. No.	Assignment Topics	Purpose / Expected Learning	Relevant CO(s)
1	Explain the principles of motion, force transmission, and kinematics in leather machines.	Reinforce theoretical understanding of machine mechanics and motion analysis through descriptive and analytical writing.	CO-1
2	Compare different types of leather machine elements (gears, belts, pulleys, shafts) and their applications.	Develop analytical skills to evaluate machine components and their suitability for specific operations.	CO-2
3	Write short notes on power transmission efficiency and load analysis in leather machines.	Understand the impact of mechanical design on operational efficiency and product quality.	CO-3
4	Discuss eco-friendly and energy-efficient operation practices for leather machinery.	Apply knowledge of sustainable practices and modern technologies to real-world machine operations.	CO-4

5	Analyze factors affecting machine performance, maintenance, and leather product quality.	Develop problem-solving skills for optimizing machine performance and ensuring quality output.	CO-5

b. Micro Projects

S. No.	Micro Project Topics	Purpose / Expected Learning	Relevant CO(s)
1	Preparation of flowchart for mechanical operations in leather machines (splitting, shaving, fleshing, rolling).	Develop analytical and visualization skills for machine workflow and process sequencing.	CO-2
2	Experimental study on effect of roller speed or pressure on leather thickness and uniformity.	Apply theoretical knowledge of mechanics to practical machine operation experiments.	CO-2
3	Development of energy-efficient or eco-friendly machine operation protocol.	Promote sustainable processing and operational optimization skills.	CO-4
4	Measurement and comparison of leather quality parameters (softness, tensile strength) under different machine settings.	Evaluate and improve leather product quality through mechanical optimization.	CO-4
5	Design a sustainable leather machine layout minimizing energy consumption and material waste.	Develop problem-solving and design skills for efficient, sustainable manufacturing.	CO-5

c. Other Activities

1. Seminar Topics:

S. No.	Seminar Topic	Purpose / Expected Learning	Relevant CO(s)
1	**Design Principles and Classification of Leather Machines**	Understand the mechanical design, classification, and working principles of key leather machinery.	CO-1
2	**Mechanisms in Splitting, Shaving, and Fleshing Machines**	Study different mechanical linkages, gear systems, and motion mechanisms used in primary operations.	CO-2
3	**Automation and Control Systems in Modern Leather Machinery**	Learn about PLC, sensor integration, and automation techniques for productivity enhancement.	CO-3
4	**Maintenance and Troubleshooting of Leather Machinery**	Explore preventive and corrective maintenance techniques for improved machine reliability.	CO-3
5	**Energy-Efficient Leather Processing Machines**	Evaluate energy consumption patterns and technologies for minimizing operational costs and carbon footprint.	CO-4
6	**Ergonomics and Safety in Operation of Leather Machines**	Study ergonomic design and safety protocols to enhance operator comfort and reduce accidents.	CO-4
7	**Sustainable Mechanical Operations in Leather Manufacturing**	Discuss eco-friendly machine practices and the role of mechanical systems in sustainability.	CO-5
8	**Emerging Trends: Smart and IoT-Enabled Leather Machines**	Explore smart manufacturing and Industry 4.0/5.0 applications in leather machinery.	CO-5
9	**Comparative Study of Indian and International Leather Machinery Standards**	Analyze standardization, precision, and design differences across global manufacturers.	CO-2, CO-3

10	**Future Scope of Robotics and Mechatronics in Leather Industry**	Identify future technologies that can revolutionize mechanical operations and labor efficiency.	CO-5

2. Surveys:

S. No.	Survey Activity	Purpose / Expected Learning	Relevant CO(s)
1	**Survey of Leather Machinery Manufacturing or Assembly Units**	To study the layout, workflow, and mechanical design of major leather machines such as sammying, shaving, and staking machines. Understand manufacturing standards, materials used, and assembly procedures.	CO-3
2	**Survey of Tannery Mechanical Sections (Splitting, Shaving, Fleshing, Rolling)**	To observe the working principles, motion mechanisms, and mechanical efficiency of various leather machines used in tanning operations.	CO-3
3	**Survey of Leather Testing and Quality Control Laboratories**	To understand performance evaluation, calibration methods, and mechanical testing procedures for machines and finished leather.	CO-3
4	**Survey of Effluent Treatment Plant (ETP) or Eco-friendly Leather Units**	To analyze mechanical systems used in waste treatment, energy recovery, and automation for sustainable processing.	CO-5
5	**Survey of Maintenance and Service Workshops for Leather Machinery**	To learn about maintenance schedules, lubrication systems, fault diagnosis, and preventive maintenance practices for high-precision leather machines.	CO-4
6	**Survey of Automation and IoT-Enabled Leather Machinery Units**	To explore integration of sensors, PLCs, and data-driven control systems in modern machines for process optimization and remote monitoring.	CO-5
7	**Survey of Leather Machinery Suppliers and Spare Parts Dealers**	To gather information on machine specifications, technological updates, pricing trends, and market availability of machinery components.	CO-2, CO-3
8	**Survey of Academic and Research Institutions with Leather Technology Labs**	To study academic–industry collaboration, lab-scale prototypes, and applied research in machine design and testing.	CO-1, CO-5

3. Visit:

S. No.	Visit Place / Activity	Purpose / Expected Learning	Relevant CO(s)
1	Visit to a leather machinery manufacturing or assembly unit.	Observe design, assembly, and operation of leather machines in real-world settings.	CO-3
2	Visit to a leather tannery for observing mechanical operations (splitting, shaving, fleshing, rolling).	Provide practical exposure to machine operations and process workflow.	CO-3
3	Visit to a leather testing and quality assurance laboratory.	Learn testing methods, machine performance evaluation, and quality assessment.	CO-3

4	Visit to an effluent treatment plant (ETP) or sustainable leather processing unit.	Understand environmental compliance, waste management, and eco-friendly machine operation.	CO-5

d. Self-Learning Topics

S. No.	Self-Learning Topic	Purpose / Expected Learning	Relevant CO(s)
1	Study of advanced leather machine designs and automation technologies.	Understand modern machinery innovations and their impact on processing efficiency.	CO-2, CO-3
2	Exploration of energy-efficient and eco-friendly machine operation practices.	Promote sustainable and green leather machine operation techniques.	CO-4, CO-5
3	Analysis of mechanical defects, troubleshooting techniques, and maintenance of leather machines.	Develop problem-solving skills for improving machine performance and leather quality.	CO-3, CO-4
4	Comparative study of conventional vs. optimized or automated machine processes.	Learn advantages and limitations of modernized machine operations.	CO-2, CO-5
5	Research on specialty leather machines (for waterproof, patent, metallic leathers).	Enhance understanding of specialized machine design and operation.	CO-4
6	Review of industry standards, machine safety regulations, and operational compliance.	Gain knowledge about quality assurance, safety, and regulatory practices.	CO-3, CO-5
7	Study on energy conservation, waste minimization, and sustainable machine operation.	Awareness of environmental sustainability in leather manufacturing.	CO-5
8	Investigation of modern leather finishing machines and surface coating technologies.	Understand mechanical principles, automation, and quality evaluation in finishing.	CO-4

M) Suggested Course Evaluation Matrix: The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and sessional work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate **CO attainment**.

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Sessional Work Assessment (SWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Sessional Work & Self Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	15%	15%	20%	20%	33%	20%	20%
CO-2	20%	25%	20%	20%	33%	25%	20%
CO-3	25%	25%	20%	20%	34%	20%	20%
CO-4	25%	20%	20%	20%	--	20%	20%
CO-5	15%	15%	20%	20%	--	15%	20%

Total Marks	**30**	**70**	**20**	**20**	**10**	**20**	**30**
			50				

Legend:

***:** Other Activities include self- learning, seminar, visits, surveys, product development, software development etc.

******: Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

N) Suggested Specification Table for End Semester Theory Assessment: Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

Unit Title and Number	**Total Classroom Instruction (CI) Hours**	**Relevant COs Number(s)**	**Total Marks**	**ETA (Marks)**		
				Remember (R)	**Understanding (U)**	**Application & above (A)**
Unit–1.0 Fundamentals of Mechanics for Leather Machines	8	CO-1	11	4	4	3
Unit–2.0 Machine Elements in Leather Machines	12	CO-2	17	4	6	7
Unit–3.0 Mechanics of Leather Processing Machines	10	CO-3	17	4	6	7
Unit–4.0 Finishing and Surface Coating Machines	10	CO-4	14	4	6	4
Unit–5.0 Sustainable and Advanced Leather Machinery	8	CO-5	11	4	3	4
Total Marks	**48**	**-**	**70**	**20**	**25**	**25**

Note: Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	**Laboratory Practical Titles**	**Relevant COs Number(s)**	**PLA/ELA**		
			Performance		**Viva-Voce (%)**
			PRA (%)	**PDA (%)**	
1	Demonstration and measurement of forces and torque in machine elements	CO-1	50	40	10

2	Assembly and disassembly of linkages and simple kinematic pairs		50	40	10
3	Velocity and acceleration analysis of mechanisms (slider-crank, four-bar)		50	40	10
4	Load testing and lubrication study of shafts and bearings	CO-2	45	45	10
5	Stress and deflection analysis in shafts and beams		50	40	10
6	Operation of splitting, shaving, and fleshing machines	CO-3	50	40	10
7	Measurement of operational parameters (roller speed, pressure, tension)		50	40	10
8	Troubleshooting of common issues in leather machine operation		50	40	10
9	Demonstration of leather finishing operations (spray, roller, embossing)	CO-4	50	40	10
10	Detection and correction of finishing defects		50	40	10
11	Demonstration of eco-friendly machine operation and energy optimization	CO-5	50	40	10
12	Comparative study of conventional vs. optimized machine operation		50	40	10

Legend:

PRA*: Process Assessment

PDA**: Product Assessment

Note: This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course teacher for each experiment/ practical to assess the student performance.

P) Suggested Instructional/Implementation Strategies:

Q) List of Major Laboratory Equipment, Tools and Software:

S. No.	Name of Equipment, Tools, and Software	Broad Specifications	Relevant Experiment / Practical Number(s)
1	Force/Torque Measurement Setup	Digital torque and force sensors, suitable for measuring mechanical loads in machine components	1, 2, 3
2	Kinematic Mechanism Models	Slider-crank, four-bar, and other linkage models for motion study	2, 3
3	Gear and Belt Drive Trainers	Trainer kits with gears, pulleys, belts for studying speed ratios and power transmission	4, 5, 6
4	Shaft and Bearing Testing Rig	Load application and measurement, lubrication study setup	4, 5
5	Universal Testing Machine (UTM)	For tensile strength, compression, and deflection measurement of leather or components	6, 8, 10

6	Leather Machine Models / Mini-Assembly Units	Splitting, shaving, fleshing, rolling mini-machines for practical operation	7, 8, 9
7	Roller Speed and Pressure Measurement Instruments	Tachometers, pressure gauges for machine operational parameters	7, 8
8	Finishing Machine Simulator	Spray, roller, and embossing unit for surface coating operations	9, 10
9	Environmental Parameter Measurement Kit	pH meter, temperature, and effluent testing tools for sustainable operation	11, 12
10	Micro-pipettes and Standard Glassware	For handling small samples and preparing solutions during experiments	1–12
11	Data Analysis Software (Excel / GraphPad Prism / MATLAB)	For plotting graphs, statistical analysis, and performance evaluation	3, 6, 7, 10
12	Laboratory Oven / Hot Plate	Temperature-controlled heating for sample drying and process simulation	4, 5, 6
13	Water Bath	Digital/thermostatic for controlled reaction conditions	6, 7, 9
14	Centrifuge	For sample separation in mechanical studies (optional for experiments involving materials)	5, 6
15	Safety Equipment	Gloves, goggles, lab coats, emergency stop buttons for machinery	1–12

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1	Mechanics of Leather Machines	D. K. Gupta	Wiley, 2nd Edition, ISBN: 978-81265XXXXX
2	Principles of Mechanical Engineering for Leather Processing	R. H. M. Wilson	Leather Industries Research Association, 3rd Edition, ISBN: 978-08516XXXXX
3	Kinematics and Dynamics of Machinery	J. J. Uicker, G. R. Pennock, J. E. Shigley	Oxford University Press, 5th Edition, ISBN: 978-01956XXXXX
4	Mechanical Design of Leather Processing Machines	V. S. Sharma	Springer, 1st Edition, ISBN: 978-3030XXXXX
5	Sustainable and Energy-Efficient Leather Machinery	S. K. Rout	CRC Press, 1st Edition, ISBN: 978-0367XXXXX
6	Laboratory Manual for Mechanics of Leather Machines	P. K. Gupta	New Age International, 1st Edition, ISBN: 978-81224XXXXX

(b) Open Educational Resources (OER):

S. No.	Resource Type	Title / Description	Link / Reference	Relevant Practical / Module
1	Learning Package	Mechanics of Leather Machines – NITTTR e-Module	NITTTR e-Learning Portal	Theory + All Practicals
2	Users' Guide	Guide to Mechanical Analysis of Leather Machinery	ResearchGate PDF	Practicals 1, 2, 3, 5, 6
3	Manufacturers' Manual	Leather Machine Operation Manual	[Manufacturer Website / PDF]	Practicals 6, 7, 8, 9

4	Lab Manual	Experiments in Mechanics of Leather Machines	NITTTR e-Lab Resources	All Practicals 1–12
5	Video Lectures / Demonstrations	Mechanical Operations in Leather Processing	YouTube / NITTTR Channel	Practicals 6–10
6	Interactive Simulations	Kinematic and Dynamic Simulation of Machines	PhET Simulations	Practicals 2, 3, 4

A) Course Code : 2472403(T2472403/S2472403)
B) Course Title : Thermodynamics

C) Pre- requisite Course(s) : Chemistry, Physics and Mathematics

D) Rationale :

Thermodynamics provides the fundamental principles governing energy, heat, and work interactions in engineering systems. Understanding these concepts enables students to analyze and design engines, refrigerators, and power cycles efficiently. It forms the basis for advanced studies in mechanical, chemical, and aerospace engineering, bridging theoretical knowledge with practical applications.

E) Course Outcomes (COs): After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/ laboratory/ workshop/ field/ industry.

After completion of the course, the students will be able to-

CO1: Explain the fundamental concepts of thermodynamics, including system, surroundings, and thermodynamic properties.

CO2: Describe the first and second laws of thermodynamics to analyze energy conversion in closed and open systems.

CO3: Describe the performance of thermodynamic cycles such as Carnot, Rankine, and refrigeration cycles.

CO4: Analyze the properties of pure substances and ideal gases to solve engineering problems.

CO5: Describe problem-solving skills for practical applications of thermodynamics in real-world engineering systems.

F) Suggested Course Articulation Matrix (CAM):

PSO-1: Apply knowledge of chemistry, biochemistry, and material science to analyze, process, and enhance the quality of hides and skins into value-added leather products.

PSO-2: Utilize modern analytical tools and sustainable processing techniques for innovation, quality improvement, and environmental compliance in leather and allied industries

Course Outcomes (COs)	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design / Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2
CO-1	3	2	-	-	-	-	-	-	-
CO-2	3	3	2	2	-	-	1	-	-
CO-3	3	3	-	-	-	-	1	-	-
CO-4	3	3	3	3	-	2	2	-	1
CO-5	3	3	3	3	3	3	3	3	3

Legend: High (3), Medium (2), Low (1) and No ma1pping (-)

***** PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Course Code	Course Title	Scheme of Studies (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (SW+SL)	Total Hours (CI+LI+SW+SL)	Total Credits(C)
		L	T				
2472403	Thermodynamics	03	-	02		05	04

Legend:

CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)

LI: Laboratory Instruction (Includes experiments/practical performances in laboratory, workshop, field or other locations using different instructional/Implementation strategies)

Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.

TW: Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

SL: Self Learning, MOOCs, spoken tutorials, open educational resources (OERs)

C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)

Note: TW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

H) Assessment Scheme:

Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
		Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
		Progressive Theory Assessment	End Theory Assessment	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2472403	Thermodynamics	30	70	20	30			150

Legend:

PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)

PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)

TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.

Note:

- ETA & ELA are to be carried out at the end of the term/ semester.
- Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done **internally (40%)** as well as **externally (60%)**. Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self-learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/ presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activities.

I) Course Curriculum Detailing: This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Term Work (TW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

J) Theory Session Outcomes (TSOs) and Units: T2472403

Major Theory Session Outcomes (TSOs)	Units (with elaboration)	Relevant CO(s)
TSO.1a Explain the basic concepts and laws of thermodynamics. **TSO.1b** Differentiate between various thermodynamic systems and processes. **TSO.1c** Apply the zeroth and first laws of thermodynamics to simple engineering systems.	**Unit–1.0: Fundamentals of Thermodynamics** 1.1 Introduction, system, boundary, and surroundings 1.2 Types of systems and properties 1.3 Thermodynamic equilibrium and processes 1.4 Zeroth Law and temperature measurement 1.5 First Law of Thermodynamics and energy interactions	CO-1
TSO.2a Analyze energy transfers using internal energy, enthalpy, and specific heat. **TSO.2b** Apply the First Law to closed and open systems. **TSO.2c** Determine work and heat interactions in engineering applications.	**Unit–2.0: Energy and First Law Applications** 2.1 Work and heat transfer 2.2 Internal energy and enthalpy 2.3 First Law for closed systems 2.4 Steady flow energy equation 2.5 Applications to compressors, turbines, and pumps	CO-2
TSO.3a Apply the Second Law of Thermodynamics. **TSO.3b** Explain the concept of entropy and its significance. **TSO.3c** Solve problems on reversible and irreversible processes.	**Unit–3.0: Second Law of Thermodynamics and Entropy** 3.1 Limitations of the First Law 3.2 Statements of Second Law (Kelvin–Planck and Clausius) 3.3 Carnot cycle and efficiency 3.4 Entropy and T–S diagrams 3.5 Clausius inequality and principle of increase of entropy	CO-3

TSO.4a Explain thermodynamic properties of pure substances and their phase transformations. **TSO.4b** Interpret P–V, T–S, and h–S diagrams. **TSO.4c** Use property tables and charts for engineering calculations.	**Unit–4.0: Properties of Pure Substances and Steam** 4.1 Phase change processes 4.2 P–V–T relationships 4.3 Use of property tables and Mollier charts 4.4 Steam generation and quality 4.5 Superheated and compressed steam	CO-4
TSO.5a Analyze basic thermodynamic cycles used in power and refrigeration systems. **TSO.5b** Determine performance parameters and efficiencies. **TSO.5c** Discuss methods for improving thermal efficiency.	**Unit–5.0: Thermodynamic Cycles and Applications** 5.1 Carnot, Otto, and Diesel cycles 5.2 Rankine cycle and steam power plant 5.3 Brayton and gas turbine cycles 5.4 Vapor compression refrigeration cycle 5.5 Regeneration and reheat cycles	CO-5

Note: One major TSO may require more than one Theory session/Period.

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: (Not Applicable)

L) Suggested Term Work and Self-Learning: S2472403 Some sample suggested assignments, micro project and other activities are mentioned here for reference.

a. Assignments

S. No.	Assignment Topics	Purpose / Expected Learning	Relevant CO(s)
1	Explain the first law of thermodynamics and its applications to closed and open systems.	Reinforce understanding of energy conservation and application of first law in practical systems.	CO-1
2	Compare different thermodynamic cycles (Carnot, Rankine, Otto, Diesel) and their efficiencies.	Develop analytical skills to evaluate and compare cycle performance for energy conversion.	CO-2
3	Write short notes on entropy, second law of thermodynamics, and irreversibility.	Understand the concept of energy degradation and its impact on system efficiency.	CO-3
4	Discuss energy efficiency measures and sustainable practices in thermal systems.	Apply knowledge of thermodynamics to optimize energy usage and implement sustainable solutions.	CO-4
5	Analyze performance parameters of power and refrigeration cycles under different operating conditions.	Develop problem-solving skills for evaluating and improving system performance.	CO-5

b. Micro Projects

S. No.	Micro Project Topics	Purpose / Expected Learning	Relevant CO(s)
1	Preparation of a flowchart for energy conversion processes in thermal systems (engines, refrigerators, boilers).	Develop analytical and visualization skills for system workflow and energy flow sequencing.	CO-2
2	Experimental study on the effect of temperature or pressure variations on system performance.	Apply theoretical knowledge of thermodynamics to practical experiments and performance evaluation.	CO-2

3	Development of an energy-efficient or sustainable operation protocol for a thermal system.	Promote sustainable energy practices and optimization skills in real-world applications.	CO-4
4	Measurement and comparison of thermodynamic parameters (pressure, temperature, work output, efficiency) under different operating conditions.	Evaluate and improve system performance through data analysis and optimization.	CO-4
5	Design a model or simulation of a renewable energy system (solar thermal, heat recovery) to minimize energy loss.	Develop problem-solving and design skills for efficient and sustainable energy applications.	CO-5

c. Other Activities

1. Seminar Topics:

S. No.	Seminar Topics	Purpose / Expected Learning	Relevant CO(s)
1	Latest advancements in thermal power generation systems (engines, turbines, boilers)	Understand modern energy conversion technologies and their impact on efficiency	CO-2, CO-3
2	Energy-efficient thermal system design and operation	Explore methods to reduce energy consumption and improve system efficiency	CO-4
3	Automation and IoT in thermal systems	Learn about integration of sensors, monitoring, and automation for operational efficiency	CO-3, CO-5
4	Material selection and maintenance strategies for thermal equipment	Analyze durability, heat resistance, and maintenance of system components	CO-2
5	Quality control and performance evaluation of thermal systems	Understand correlation between operating conditions and system efficiency	CO-5
6	Environmental regulations and sustainable energy practices	Learn regulatory compliance, emission control, and green thermal technologies	CO-4
7	Design improvements for heat exchangers, turbines, and compressors	Develop problem-solving and design-thinking skills for efficiency enhancement	CO-5
8	Failure analysis and troubleshooting in thermal systems	Apply thermodynamic knowledge to diagnose and solve operational issues	CO-3
9	Innovations in renewable energy and cogeneration systems	Explore advanced technologies and their impact on sustainability and efficiency	CO-4
10	Role of Industry 4.0 in energy systems and thermal operations	Understand digitization, monitoring, and smart management in energy systems	CO-5

2. Surveys:

S. No.	Survey Topics	Purpose / Expected Learning	Relevant CO(s)
1	Survey of energy conversion devices (engines, turbines, refrigerators)	Understand real-world applications of thermodynamic principles in energy systems	CO-2, CO-3
2	Study of thermodynamic cycles in industrial processes	Analyze performance of Rankine, Carnot, and refrigeration cycles	CO-3
3	Survey of heat transfer methods in engineering systems	Evaluate conduction, convection, and radiation applications in practice	CO-1, CO-2
4	Investigation of energy efficiency and sustainability in thermal systems	Identify strategies for reducing energy consumption and environmental impact	CO-4, CO-5
5	Survey on properties and testing of working fluids (steam, refrigerants, air)	Understand the effect of fluid properties on system performance	CO-1, CO-2

6	Study of measurement techniques for temperature, pressure, and energy flow	Develop practical skills in instrumentation and thermodynamic data collection	CO-2, CO-5

3. Visit:

S. No.	Visit Topics / Place	Purpose / Expected Learning	Relevant CO(s)
1	Thermal power plant	Observe real-world energy conversion, thermodynamic cycles, and heat transfer processes	CO-2, CO-3
2	Refrigeration and air-conditioning plant	Understand refrigeration cycles, working fluids, and system efficiency	CO-3, CO-4
3	Steam and gas turbine units	Study turbine operation, efficiency, and performance evaluation	CO-3
4	Solar thermal energy facility	Learn about renewable energy applications and sustainable heat systems	CO-4, CO-5
5	Industrial boilers and heat exchangers	Observe practical applications of thermodynamic principles and energy efficiency	CO-2, CO-5
6	Research labs for thermophysical property measurement	Gain hands-on experience in measurement of temperature, pressure, and heat transfer	CO-1, CO-2

d. Self-Learning Topics

S. No.	Self-Learning Topics	Purpose / Expected Learning	Relevant CO(s)
1	Derivation and application of the first law of thermodynamics	Strengthen conceptual understanding and problem-solving skills in energy conservation	CO-1, CO-2
2	Entropy, second law of thermodynamics, and irreversibility	Develop insight into energy degradation and efficiency limits	CO-2, CO-3
3	Thermodynamic properties of pure substances and ideal gases	Learn to analyze system behavior under different conditions	CO-1, CO-2
4	Analysis of power cycles (Carnot, Rankine, Otto, Diesel)	Understand performance evaluation and optimization of engines	CO-3
5	Refrigeration and air-conditioning cycles	Apply thermodynamic principles to cooling systems and sustainable applications	CO-3, CO-4
6	Energy efficiency and renewable energy applications	Explore sustainable and modern practices in thermal systems	CO-4, CO-5
7	Use of software/tools for thermodynamic calculations (MATLAB, EES, Excel)	Develop computational skills for solving complex thermodynamic problems	CO-2, CO-5

M) Suggested Course Evaluation Matrix: The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and sessional work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate **CO attainment**.

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Sessional Work Assessment (SWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Sessional Work & Self Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		

CO-1	15%	15%	20%	20%	33%		
CO-2	20%	25%	20%	20%	33%		
CO-3	25%	25%	20%	20%	34%		
CO-4	25%	20%	20%	20%	--		
CO-5	15%	15%	20%	20%	--		
Total Marks	**30**	**70**	**20**	**20**	**10**		
			50				

Legend:

***:** Other Activities include self- learning, seminar, visits, surveys, product development, software development etc.

******: Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

N) Suggested Specification Table for End Semester Theory Assessment: Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

Unit Title and Number	Total Classroom Instruction (CI) Hours	Relevant CO(s) Number(s)	Total Marks	ETA (Marks)	Remember (R)	Understanding (U)	Application & Above (A)
Unit–1.0: Fundamentals of Thermodynamics	8	CO-1	11	11	4	4	3
Unit–2.0: Energy and First Law Applications	12	CO-2	17	17	4	6	7
Unit–3.0: Second Law of Thermodynamics and Entropy	10	CO-3	17	17	4	6	7
Unit–4.0: Properties of Pure Substances and Steam	10	CO-4	14	14	4	6	4
Unit–5.0: Thermodynamic Cycles and Applications	8	CO-5	11	11	4	3	4
Total Marks	**48**	—	**70**	**70**	**20**	**25**	**25**

Note: Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

O) Suggested Assessment Table for Laboratory (Practical):

Legend:

PRA*: Process Assessment

PDA**: Product Assessment

Note: This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student performance.

P) Suggested Instructional/Implementation Strategies:

Q) List of Major Laboratory Equipment, Tools and Software: (Not Applicable)

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1	**Engineering Thermodynamics**	P. K. Nag	McGraw Hill Education, 5th Edition, ISBN: 978-9354600359
2	**Thermodynamics: An Engineering Approach**	Yunus A. Çengel, Michael A. Boles	McGraw Hill, 9th Edition, ISBN: 978-9354601509
3	**Fundamentals of Classical Thermodynamics**	Gordon J. Van Wylen, Richard E. Sonntag	Wiley, 4th Edition, ISBN: 978-0471602720
4	**Applied Thermodynamics for Engineering Technologists**	T. D. Eastop, A. McConkey	Pearson Education, 5th Edition, ISBN: 978-0582091931
5	**Basic and Applied Thermodynamics**	P. K. Nag, M. Lakshmi Kantha	McGraw Hill Education, 3rd Edition, ISBN: 978-9353165026
6	**Thermodynamics Laboratory Manual**	K. M. Gupta, R. Prakash	New Age International, 1st Edition, ISBN: 978-8122432435

(b) Open Educational Resources (OER):

S. No.	Resource Type	Title / Description	Link / Reference	Relevant CO(s)
1	**Online Course / MOOC**	*Thermodynamics: An Engineering Approach* – Free NPTEL Course by IIT Kharagpur	https://nptel.ac.in/courses/112105123	CO-1, CO-2
2	**E-Book / PDF**	*Fundamentals of Engineering Thermodynamics* by Moran & Shapiro – Open Text (Preview Version)	https://openlibrary.org/works/OL458004W	CO-1, CO-3
3	**Lecture Notes**	*Thermodynamics Lecture Notes* – MIT OpenCourseWare	https://ocw.mit.edu/courses/mechanical-engineering/2-005-thermodynamics-fall-2013/	CO-2, CO-3
4	**Simulation / Interactive Tool**	*PhET Interactive Simulations – Energy Forms and Changes*	https://phet.colorado.edu/en/simulation/energy-forms-and-changes	CO-2, CO-4

5	**Video Tutorials**	*Thermodynamics Lectures – Khan Academy*	https://www.khanacademy.org/science/physics/thermodynamics	CO-1, CO-2
6	**Case Study / Research Article**	*Applications of Thermodynamic Cycles in Sustainable Energy Systems* – ScienceDirect Open Access	https://www.sciencedirect.com/journal/energy-reports/open-access	CO-4, CO-5
7	**Learning Module**	*Thermodynamics for Engineers* – OER Commons	https://www.oercommons.org/courses/thermodynamics-for-engineers	CO-1 to CO-5
8	**Virtual Lab**	*Virtual Thermodynamics Lab – Amrita Vishwa Vidyapeetham (Amrita Virtual Labs)*	https://vlab.amrita.edu/?sub=1&brch=5	CO-3, CO-4

(c) Others:

a. Learning Packages
b. Users' Guide
c. Manufacturers' Manual
d. Lab Manuals

A) Course Code : 2472404(T2472404/S2472404)
B) Course Title : Environmental Management in the Leather Industry
C) Pre- requisite Course(s) : Chemistry, Physics and Mathematics
D) Rationale :

This course focuses on understanding and managing the environmental impact of leather manufacturing processes. It equips learners with knowledge of pollution control, waste minimization, and sustainable production practices. Emphasis is placed on compliance with environmental regulations and the adoption of cleaner technologies for a greener leather industry

E) Course Outcomes (COs): After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/ laboratory/ workshop/ field/ industry.

After completion of the course, the students will be able to-

CO-1: Explain the sources and types of pollution generated in the leather manufacturing process.
CO-2: Describe various waste treatment and management techniques used in tanneries.
CO-3: Apply principles of cleaner production and sustainable practices in leather processing.
CO-4: Explain environmental policies, standards, and regulatory frameworks relevant to the leather industry.
CO-5: Explain strategies for implementing eco-friendly technologies and achieving sustainability goals in leather manufacturing.

F) Suggested Course Articulation Matrix (CAM):

PSO-1: Apply knowledge of chemistry, biochemistry, and material science to analyze, process, and enhance the quality of hides and skins into value-added leather products.

PSO-2: Utilize modern analytical tools and sustainable processing techniques for innovation, quality improvement, and environmental compliance in leather and allied industries

Course Outcomes (COs)	PO-1Basic and Discipline Specific Knowledge	PO-2Problem Analysis	PO-3Design / Development of Solutions	PO-4Engineering Tools	PO-5Engineering Practices for Society, Sustainability and Environment	PO-6Project Management	PO-7Life Long Learning	PSO-1	PSO-2
CO-1	3	2	-	1	2	-	1	-	1
CO-2	3	3	-	2	2	-	2	-	2
CO-3	3	3	3	2	3	-	2	-	3
CO-4	1	1	2	1	2	3	2	-	1
CO-5	2	2	2	1	3	2	3	-	3

Legend: High (3), Medium (2), Low (1) and No ma1pping (-)
***** PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Course Code	Course Title	Scheme of Studies (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (SW+SL)	Total Hours (CI+LI+SW+SL)	Total Credits(C)
		L	T				
2472404	Environmental Management in the Leather Industry	03	-	02		05	04

Legend:

CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)

LI: Laboratory Instruction (Includes experiments/practical performances in laboratory, workshop, field or other locations using different instructional/Implementation strategies)

Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.

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SL: Self Learning, MOOCs, spoken tutorials, open educational resources (OERs)

C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)

Note: TW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

H) Assessment Scheme:

Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
		Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
		Progressive Theory	End Theory Assessmen	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2472404	Environmental Management in the Leather Industry	30	70	20	30			150

Legend:

PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)

PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)

TWA: Term work & Self Learning Assessment (Includes assessment related to student

performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.

Note:

- ETA & ELA are to be carried out at the end of the term/ semester.
- Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done **internally (40%)** as well as **externally (60%)**. Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self-learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/ presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activities.

I) Course Curriculum Detailing: This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Term Work (TW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

J) Theory Session Outcomes (TSOs) and Units: T2472404

Major Theory Session Outcomes (TSOs)	Units	Relevant CO(s)
TSO.1a Explain the importance of environmental management and its relevance to the leather industry. **TSO.1b** Identify sources and types of pollution generated during leather processing. **TSO.1c** Describe the key environmental challenges faced by tanneries and related industries.	**Unit–1.0 Introduction to Environmental Management** 1.1 Overview of environmental management concepts 1.2 Environmental impacts of leather manufacturing 1.3 Need for sustainable leather production 1.4 Global and national environmental concerns	CO-1
TSO.2a Explain various types of waste generated in tanneries (solid, liquid, gaseous). **TSO.2b** Analyze the impact of waste on water, air, and soil quality. **TSO.2c** Suggest methods for waste minimization and cleaner production.	**Unit–2.0 Waste Generation and Characteristics in Tanneries** 2.1 Sources and types of waste 2.2 Composition and characteristics of tannery effluents 2.3 Environmental effects of untreated wastes 2.4 Measurement and analysis of pollution load	CO-2
TSO.3a Describe the principles and components of effluent treatment plants (ETP) for tanneries. **TSO.3b** Apply suitable treatment methods for different types of tannery effluents. **TSO.3c** Explain the role of biological and advanced oxidation processes in pollution control.	**Unit–3.0 Effluent and Waste Management Techniques** 3.1 Primary, secondary, and tertiary treatment 3.2 Sludge management 3.3 Common Effluent Treatment Plants (CETPs) 3.4 Solid waste management and disposal methods	CO-2, CO-3

TSO.4a Discuss the concept and importance of cleaner technologies in leather manufacturing. **TSO.4b** Determine the economic and environmental benefits of sustainable manufacturing.	**Unit–4.0 Cleaner Production and Sustainable Practices** 4.1 Principles of cleaner production 4.2 Resource optimization and recycling 4.3 Water and energy conservation methods 4.4 Use of eco-friendly chemicals and alternative tanning materials	CO-3, CO-4
TSO.5a Explain environmental laws, standards, and policies relevant to the leather industry. **TSO.5b** Interpret the requirements of environmental standards for compliance and certification. **TSO.5c** Propose strategies for implementing sustainable and eco-friendly technologies in leather industries. **TSO.5d** Assess the long-term benefits of green technologies and circular economy practices.	**Unit–5.0 Environmental Regulations and Management Systems** 5.1 Indian and international environmental laws 5.2 ISO 14001 Environmental Management System (EMS) 5.3 Pollution control board guidelines 5.4 Environmental auditing and impact assessment	CO-4,CO-5

Note: One major TSO may require more than one Theory session/Period.

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: (Not Applicable)

L) Suggested Term Work and Self-Learning: S2472404 Some sample suggested assignments, micro project and other activities are mentioned here for reference.

b. Assignments

S. No.	Assignment Topics	Purpose / Expected Learning	Relevant CO(s)
1	Explain the environmental impact of different stages in leather manufacturing.	To understand major sources of pollution and the need for sustainable production practices in the leather industry.	CO-1
2	Prepare a report on types and characteristics of tannery wastes (solid, liquid, and gaseous).	To analyze waste composition and identify their effects on air, water, and soil environments.	CO-2
3	Write short notes on various effluent treatment methods used in tanneries.	To reinforce knowledge of treatment processes, including physical, chemical, and biological methods.	CO-3
4	Discuss cleaner production technologies and resource optimization techniques in the leather industry.	To develop understanding of eco-friendly practices and conservation methods for water, energy, and chemicals.	CO-4
5	Analyze national and international environmental regulations governing leather industries.	To familiarize with laws, policies, and environmental management systems for compliance and certification.	CO-4
6	Prepare a case study on a sustainable or zero-liquid-discharge (ZLD) tannery.	To promote application-based learning and appreciation of best industrial practices for sustainability.	CO-5

b. Micro Projects

S. No.	Micro Project Topics	Purpose / Expected Learning	Relevant CO(s)

1	Survey and preparation of a flowchart showing the environmental impact points in leather processing stages.	To identify critical pollution sources and visualize the environmental footprint of leather manufacturing.	CO-1
2	Collection and analysis of tannery effluent samples for pH, BOD, COD, and TDS.	To gain practical exposure to effluent characterization and environmental monitoring methods.	CO-2
3	Design a small-scale model of an Effluent Treatment Plant (ETP) showing primary, secondary, and tertiary treatment units.	To understand the layout and function of different wastewater treatment components.	CO-3
4	Development of a waste minimization or cleaner production protocol for a specific leather process (e.g., tanning or dyeing).	To promote sustainable thinking and process optimization for pollution reduction.	CO-4
5	Case study on implementation of ISO 14001 Environmental Management System (EMS) or Zero Liquid Discharge (ZLD) in a tannery.	To understand environmental compliance, documentation, and sustainability reporting in practice.	CO-5

c. Other Activities

1. Seminar Topics:

S. No.	Seminar Topics	Purpose / Expected Learning	Relevant CO(s)
1	Environmental impact of leather manufacturing processes	Understand pollution sources and their effects on air, water, and soil	CO-1
2	Characterization and treatment of tannery effluents	Learn methods to analyze and treat industrial wastewater	CO-2
3	Solid waste management in tanneries	Explore strategies for handling and recycling solid wastes	CO-2
4	Cleaner production and green chemistry in leather processing	Learn sustainable practices for minimizing chemical and energy use	CO-4
5	Energy and water conservation techniques in tanneries	Understand approaches to optimize resource utilization	CO-4
6	Environmental laws, standards, and regulations for leather industries	Gain knowledge on compliance with national and international regulations	CO-4
7	Implementation of ISO 14001 Environmental Management System	Learn the framework for systematic environmental management	CO-5
8	Zero Liquid Discharge (ZLD) technologies in tanneries	Understand advanced wastewater management and sustainability measures	CO-5
9	Case studies of sustainable and eco-friendly tanneries	Explore real-world applications of environmental management practices	CO-5
10	Role of biotechnology and circular economy in reducing leather industry pollution	Learn innovative solutions for sustainable and eco-friendly leather production	CO-5

2. Surveys:

S. No.	Survey Topic	Purpose / Expected Learning	Relevant CO(s)
1	Study of effluent characteristics from different leather processing units	Understand the types, sources, and composition of wastewater generated in tanneries	CO-2
2	Analysis of solid waste generated in tanning, dyeing, and finishing processes	Identify waste streams and explore recycling or disposal methods	CO-2

3	Survey of water and energy consumption patterns in leather industries	Evaluate resource utilization efficiency and identify conservation opportunities	CO-4
4	Assessment of environmental compliance of local tanneries	Understand the application of environmental laws, regulations, and standards	CO-4
5	Study of cleaner production and pollution reduction practices in leather manufacturing	Explore practical implementation of sustainable and eco-friendly technologies	CO-5
6	Survey on adoption of ISO 14001 or other Environmental Management Systems in tanneries	Understand systematic environmental management and sustainability reporting	CO-5

3. Visit:

S. No.	Visit Topic / Location	Purpose / Expected Learning	Relevant CO(s)
1	Visit to a local tannery	Observe leather processing operations and identify potential environmental impacts	CO-1
2	Visit to a Common Effluent Treatment Plant (CETP)	Understand wastewater treatment processes and effluent management in leather industries	CO-2
3	Visit to a tannery implementing Zero Liquid Discharge (ZLD) system	Study advanced wastewater treatment and sustainable water management practices	CO-5
4	Visit to a tannery adopting cleaner production technologies	Learn practical applications of resource optimization, energy efficiency, and eco-friendly processes	CO-4
5	Visit to a tannery certified with ISO 14001 EMS	Understand implementation of environmental management systems and regulatory compliance	CO-5

d. Self-Learning Topics

S. No.	Self-Learning Topics	Purpose / Expected Learning	Relevant CO(s)
1	Review of global environmental issues in the leather industry	Develop awareness of international environmental challenges and sustainability trends	CO-1
2	Study of effluent treatment technologies and sludge management	Learn about innovative methods for wastewater treatment and solid waste handling	CO-2
3	Research on cleaner production practices and eco-friendly leather chemicals	Understand approaches for reducing environmental impact in leather processing	CO-4
4	Analysis of environmental laws, regulations, and standards applicable to tanneries	Gain knowledge of compliance requirements and regulatory frameworks	CO-4
5	Case studies on sustainable and zero-liquid-discharge (ZLD) tanneries	Learn best practices for achieving sustainability and resource efficiency	CO-5
6	Study of energy and water conservation techniques in leather manufacturing	Develop skills to optimize resource use and reduce environmental footprint	CO-4
7	Exploration of circular economy and green technologies in leather production	Understand strategies for recycling, reusing, and minimizing waste	CO-5

M) Suggested Course Evaluation Matrix: The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and sessional work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate **CO attainment**.

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Sessional Work Assessment (SWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Sessional Work & Self Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	15%	15%	20%	20%	33%		
CO-2	20%	25%	20%	20%	33%		
CO-3	25%	25%	20%	20%	34%		
CO-4	25%	20%	20%	20%	--		
CO-5	15%	15%	20%	20%	--		
Total Marks	**30**	**70**	**20**	**20**	**10**		
			50				

Legend:

***:** Other Activities include self- learning, seminar, visits, surveys, product development, software development etc.

******: Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

N) Suggested Specification Table for End Semester Theory Assessment: Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

Unit Title and Number	Total Classroom Instruction (CI) Hours	Relevant COs Number (s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit–1.0 Introduction to Environmental Management	8	CO-1	12	12	4	4
Unit–2.0 Waste Generation and Characteristics in Tanneries	10	CO-2	14	14	3	5
Unit–3.0 Effluent and Waste Management Techniques	10	CO-3	14	14	4	5
Unit–4.0 Cleaner Production and Sustainable Practices	12	CO-3, CO-4	16	16	3	5
Unit–5.0 Environmental Regulations and Emerging Trends	8	CO-4, CO-5	14	14	3	4

Total	48	-	70	70	17	23

Note: Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

O) Suggested Assessment Table for Laboratory (Practical): (Not Applicable)

Legend:

PRA*: Process Assessment

PDA**: Product Assessment

Note: This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course teacher for each experiment/ practical to assess the student performance.

P) Suggested Instructional/Implementation Strategies:

Q) List of Major Laboratory Equipment, Tools and Software: (Not Applicable)

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1	Environmental Management in Leather Industry	R. K. Sharma	CRC Press, 2nd Edition, ISBN: 978-0367XXXXX
2	Pollution Control in Tanning Industry	S. K. Rout	Springer, 1st Edition, ISBN: 978-3030XXXXX
3	Cleaner Production and Sustainable Practices in Tanneries	P. K. Gupta	Wiley, 1st Edition, ISBN: 978-81265XXXXX
4	Effluent Treatment and Waste Management in Tanneries	D. K. Jain	New Age International, 2nd Edition, ISBN: 978-81224XXXXX
5	Environmental Laws and Regulations for Leather Industries	M. L. Verma	Oxford University Press, 1st Edition, ISBN: 978-01956XXXXX
6	Sustainable and Eco-Friendly Leather Manufacturing	R. H. Wilson	Leather Industries Research Association, 1st Edition, ISBN: 978-08516XXXXX

(b) Open Educational Resources (OER):

S. No.	Resource Type	Title / Description	Link / Reference	Relevant Practical / Module
1	Learning Package	Environmental Management in Tanneries – NITTTR e-Module	NITTTR e-Learning Portal	Theory + All Practicals
2	Users' Guide	Guide to Effluent and Waste Management in Leather Industry	ResearchGate PDF	Practical analysis of tannery effluents and waste characterization
3	Manufacturers' Manual	Manual on Cleaner Production and Sustainable Leather Processing	[Manufacturer/Industry Manuals]	Application of cleaner technologies and energy-efficient operations
4	Lab Manual	Laboratory Manual for Environmental Monitoring in Tanneries	[NITTTR Lab Manual Repository]	Experiments on effluent testing, pollution

				measurement, and waste treatment
5	Case Studies	Case Studies on Sustainable and Eco-Friendly Tanneries	[Open Access Journals / NITTTR Repository]	Analysis of ZLD, recycling, and green technology implementations
6	Video / Webinar	Webinars on Environmental Regulations & ISO 14001 EMS	[YouTube / NITTTR Resources]	Understanding compliance, standards, and EMS implementation

(c) Others:

a. Learning Packages
b. Users' Guide
c. Manufacturers' Manual
d. Lab Manuals

A) Course Code : 2472405(T2472405)
B) Course Title : (c) Tannery Byproducts Utilization

C) Pre- requisite Course(s) :

D) Rationale :

The rationale of Tannery Byproducts Utilization is to promote sustainable and eco-friendly leather processing by converting waste materials into valuable products. It reduces environmental pollution, minimizes solid and liquid waste disposal issues, and supports resource efficiency. Additionally, it provides economic benefits through the production of collagen, gelatin, fertilizers, and bioenergy from tannery byproducts.

E) Course Outcomes (COs): After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/ laboratory/ workshop/ field/ industry.

After completion of the course, the students will be able to-

CO-1: Explain various tannery byproducts, understanding their composition and potential applications

CO-2: Analyze methods for processing tannery waste into value-added products

CO-3: Apply sustainable practices for byproduct utilization to reduce environmental impact.

CO-4: Describe the economic and industrial feasibility of products derived from tannery byproducts.

CO-5. Explain the importance of regulatory and safety considerations in handling and using tannery byproducts

F) Suggested Course Articulation Matrix (CAM):

PSO-1: Apply knowledge of chemistry, biochemistry, and material science to analyze, process, and enhance the quality of hides and skins into value-added leather products.

PSO-2: Utilize modern analytical tools and sustainable processing techniques for innovation, quality improvement, and environmental compliance in leather and allied industries

Course Outcomes (COs)	PO-1 Basic & Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design / Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability & Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2
CO-1	2	1	-	-	-	-	-	-	-
CO-2	2	2	-	-	2	1	1	-	2
CO-3	2	2	-	-	3	1	1	-	3
CO-4	2	2	-	-	2	1	1	-	2
CO-5	2	2	-	-	2	1	1	-	2

Legend: High (3), Medium (2), Low (1) and No ma1pping (-)

***** PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optiona

G) Teaching & Learning Scheme:

Course Code	Course Title	Scheme of Studies (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (SW+ SL)	Total Hours (CI+LI+SW+SL)	Total Credits(C)
		L	T				
2472405	(c) Tannery Byproducts Utilization	04	-	---		04	04

Legend:

CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)

LI: Laboratory Instruction (Includes experiments/practical performances in laboratory, workshop, field or other locations using different instructional/Implementation strategies)

Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.

TW: Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

SL: Self Learning, MOOCs, spoken tutorials, open educational resources (OERs)

C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)

Note: TW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

H) Assessment Scheme:

Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
		Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2472405	(b) Tannery Byproducts Utilization	30	70					100

Legend:

PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)

PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)

TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.

Note:

- ETA & ELA are to be carried out at the end of the term/ semester.
- Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done **internally (40%)** as well as **externally (60%)**. Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self-learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/ presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activities.

I) Course Curriculum Detailing: This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Term Work (TW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

J) Theory Session Outcomes (TSOs) and Units: T2472405

Major Theory Session Outcomes (TSOs)	Units	Relevant CO(s)
TSO.1a Explain the types and characteristics of tannery byproducts and their industrial relevance. **TSO.1b** Describe methods for collection, preservation, and storage of tannery byproducts. **TSO.1c** Identify challenges in byproduct handling and suggest solutions.	**Unit–1.0: Introduction to Tannery Byproducts** 1.1 Types of byproducts (hides, trimmings, splits, shavings, fleshing, chrome sludge) 1.2 Physical and chemical characteristics 1.3 Potential applications in leather and allied industries	CO-1
TSO.2a Explain processes for the conversion of tannery byproducts into value-added products. **TSO.2b** Analyze chemical and mechanical treatments for byproduct utilization. **TSO.2c** Evaluate environmental and economic benefits of byproduct processing.	**Unit–2.0: Processing of Tannery Byproducts** 2.1 Collagen extraction and gelatin production 2.2 Fertilizer and animal feed preparation 2.3 Biofuel and energy recovery 2.4 Enzyme and protein hydrolysate production	CO-2
TSO.3a Discuss regulatory, environmental, and safety aspects related to byproduct utilization. **TSO.3b** Apply environmental guidelines in planning byproduct utilization strategies. **TSO.3c** Assess compliance of industrial practices with environmental norms.	**Unit–3.0: Environmental and Regulatory Considerations** 3.1 Environmental impacts of tannery waste 3.2 Waste management regulations 3.3 Occupational safety and health guidelines 3.4 Sustainable practices in byproduct utilization	CO-3

TSO.4a Integrate technical, environmental, and economic knowledge to optimize byproduct utilization. **TSO.4b** Recommend strategies to maximize value and minimize waste from tannery byproducts.	**Unit–4.0: Integrated Utilization Approaches** 4.1 Cost-benefit analysis of byproduct utilization 4.2 Industrial case studies 4.3 Sustainable and circular economy approaches 4.4 Emerging technologies in byproduct valorization	CO-4
TSO.5a Analyze case studies and propose innovative solutions for industrial-scale byproduct management. **TSO.5b** Evaluate the impact of integrated strategies on profitability, sustainability, and environmental safety.	**Unit–5.0: Case Studies and Emerging Trends** 5.1 Successful byproduct valorization projects 5.2 Innovative uses in leather, bio-products, and allied sectors 5.3 Trends in sustainability and ethical utilization 5.4 Technological innovations in byproduct processing	CO-5

Note: One major TSO may require more than one Theory session/Period.

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: (Not Applicable)

L) Suggested Term Work and Self-Learning: Some sample suggested assignments, micro project and other activities are mentioned here for reference.

c. Assignments

S. No.	Assignment Topics	Purpose / Expected Learning	Relevant CO(s)
1	Prepare a costing sheet for a product using tannery byproducts (e.g., leather waste, shavings, or split leather).	To understand and apply costing concepts specifically for byproduct-based products, calculate production costs, and determine selling price.	CO-1
2	Analyze market potential and consumer preferences for products made from tannery byproducts.	To develop skills in market research, understand demand for sustainable/eco-friendly products, and position byproduct-based items effectively.	CO-2
3	Design a visual merchandising display plan for a product line utilizing tannery byproducts.	To apply merchandising techniques for promoting eco-friendly leather/fashion products and enhance consumer appeal.	CO-3
4	Develop an integrated strategy combining costing, marketing, and merchandising for a tannery byproduct-based product.	To learn how to optimize pricing, promotion, and display specifically for commercial success of sustainable byproduct products.	CO-4
5	Case study analysis of successful products or campaigns based on tannery byproducts (e.g., leather composites, eco-leather goods).	To assess real-world applications of integrated strategies in byproduct utilization and understand factors contributing to profitability and sustainability.	CO-5

a. Micro Projects

S. No.	Micro Project Title	Purpose / Expected Learning	Relevant CO(s)
1	Costing Analysis of Products from Tannery Byproducts	To apply costing techniques for products made from leather waste, shavings, splits, or other byproducts, calculate production costs, and suggest optimal pricing.	CO-1
2	Market Research on Tannery Byproduct-Based Products	To analyze consumer behavior, market trends, and preferences for sustainable products derived from tannery byproducts.	CO-2

3	Visual Merchandising Setup for Byproduct-Based Products	To design and implement an effective display plan for products made from tannery byproducts, considering layout, color, lighting, and signage.	CO-3
4	Integrated Commercial Strategy for Byproduct Products	To combine costing, marketing, and merchandising knowledge to create a comprehensive business plan for tannery byproduct-based products.	CO-4
5	Case Study on Successful Utilization of Tannery Byproducts	To evaluate real-world applications of tannery byproducts in value-added products, assessing profitability, market potential, and sustainability.	CO-5

c. Other Activities

1. Seminar Topics:

S. No.	Seminar Topic	Purpose / Expected Learning	Relevant CO(s)
1	Modern Costing Techniques in Leather and Fashion Products	To understand advanced costing methods and their impact on pricing and profitability.	CO-1
2	Emerging Trends in Leather and Fashion Marketing	To explore latest marketing strategies, consumer behavior, and product positioning techniques.	CO-2
3	Innovations in Visual Merchandising	To study modern display techniques, store layout, and in-store customer experience enhancement.	CO-3
4	Integrated Business Strategies for Leather Products	To analyze how costing, marketing, and merchandising work together to optimize product success.	CO-4
5	Sustainable and Ethical Utilization of Tannery Byproducts	To examine real-world practices in byproduct valorization, sustainability, and environmental impact.	CO-5
6	Role of Technology in Leather Product Commercialization	To explore digital tools, AI, and software applications in costing, marketing, and merchandising.	CO-4/CO-5
7	Case Studies of Successful Leather/Fashion Brands	To learn from real-life success stories and strategies in the industry.	CO-5

2. Surveys:

S. No.	Survey Topic	Purpose / Expected Learning	Relevant CO(s)
1	Consumer Preferences for Leather Products	To analyze customer choices, preferences, and buying behavior for different leather products.	CO-2
2	Pricing Perception and Willingness to Pay	To study how consumers perceive pricing and their willingness to pay for leather/fashion products.	CO-1/CO-2
3	Effectiveness of Visual Merchandising in Retail Stores	To evaluate how store layout, display, and presentation influence purchase decisions.	CO-3
4	Awareness and Acceptance of Sustainable Leather Products	To assess consumer awareness about eco-friendly products and sustainable practices in leather industry.	CO-5
5	Market Trends and Demand Analysis for Tannery Byproducts	To collect data on demand, potential applications, and industrial interest in byproduct utilization.	CO-2/CO-5
6	Brand Perception and Loyalty in Leather/Fashion Market	To analyze customer loyalty, brand image, and marketing effectiveness.	CO-2/CO-4

3. Visit:

S. No.	Visit Type / Organization	Purpose / Expected Learning	Relevant CO(s)
1	Leather Tannery	To observe tanning processes, byproduct generation, and handling techniques in a real industrial environment.	CO-1/CO-5
2	Leather Product Manufacturing Unit	To understand production workflows, costing, and quality control measures in leather/fashion products.	CO-1/CO-4
3	Retail Leather/Fashion Store	To study visual merchandising, store layout, product display, and consumer interaction.	CO-3
4	Byproduct Processing/Valorization Plant	To learn about converting tannery waste into value-added products such as collagen, fertilizers, or biofuels.	CO-2/CO-5
5	Leather Marketing & Export Organization	To gain insights into market trends, pricing strategies, branding, and export procedures.	CO-2/CO-4
6	Sustainable Leather Initiatives / Eco-Tanneries	To observe environmentally friendly practices, waste management, and sustainability initiatives in the leather industry.	CO-5

d. Self-Learning Topics

S. No.	Self-Learning Topic	Purpose / Expected Learning	Relevant CO(s)
1	Advanced Costing Techniques in Leather Products	To explore different costing methods, cost optimization, and pricing strategies independently.	CO-1
2	Digital Marketing Tools for Leather & Fashion Products	To learn online marketing strategies, social media promotion, and consumer engagement techniques.	CO-2
3	Modern Visual Merchandising Trends	To study innovative display methods, store design, and customer experience enhancement.	CO-3
4	Case Studies on Integrated Business Strategies	To analyze how costing, marketing, and merchandising work together for commercial success.	CO-4
5	Sustainable Practices and Tannery Byproduct Valorization	To learn about environmental impact, waste management, and converting byproducts into value-added products.	CO-5
6	Industry 4.0 Applications in Leather Manufacturing	To explore AI, IoT, and digital tools for process optimization, quality control, and product marketing.	CO-4/CO-5
7	Ethical and Green Leather Production	To understand the principles and practices of eco-friendly and socially responsible leather production.	CO-5

M) Suggested Course Evaluation Matrix: The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and sessional work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate **CO attainment**.

	Course Evaluation Matrix		
	Theory Assessment (TA)**	**Sessional Work Assessment (SWA)**	**Lab Assessment (LA)#**

COs	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Sessional Work & Self Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	15%	20%		20%	33%		
CO-2	20%	20%		20%	33%		
CO-3	25%	20%		20%	34%		
CO-4	25%	20%		20%	--		
CO-5	15%	20%		20%	--		
Total Marks	**30**	**70**	**20**	**20**	**10**		
			50				

Legend:

***:** Other Activities include self- learning, seminar, visits, surveys, product development, software development etc.

****: Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

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N) Suggested Specification Table for End Semester Theory Assessment: Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

Unit Title and Number	Total Classroom Instruction (CI) Hours	Relevant COs Number (s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit–1.0: Introduction to Tannery Byproducts	8	CO-1	12	4	4	4
Unit–2.0: Processing of Tannery Byproducts	10	CO-2	14	3	5	6
Unit–3.0: Environmental and Regulatory Considerations	10	CO-3	14	4	5	5
Unit–4.0: Integrated Utilization Approaches	12	CO-3, CO-4	16	3	5	8
Unit–5.0: Case Studies and Emerging Trends	8	CO-4, CO-5	14	3	4	7
Total Marks	48	-	70	17	23	30

Note: Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

O) Suggested Assessment Table for Laboratory (Practical): (Not Applicable)

Legend:

PRA*: Process Assessment

PDA**: Product Assessment

Note: This table can be used for both end semester as well as progressive assessment of practical. Rubrics to be prepared by the course teacher for each experiment/ practical to assess the student performance

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P) Suggested Instructional/Implementation Strategies:

Q) List of Major Laboratory Equipment, Tools and Software: (Not Applicable)

R) Suggested Learning Resources:

(a) Books:

S. No.	Title / Resource Type	Author(s) / Editor(s)	Publisher and Focus	Relevant Utilization Topics
1	Sustainable Practices in the Tannery Industry: Strategies for Eco-Friendly Leather Manufacturing (Book)	Moulay Abdelazize Aboulhassan, Salah Souabi	Academic/Engineering Publishers	A modern, dedicated look at **circular economy** principles, resource recovery, advanced

				wastewater treatment, and the sustainable utilization of **tannery solid wastes**.
2	Conversion of Tannery Waste into Value-Added Products (Book Chapter/Monograph)	Eleanor Brown, Cheng-Kung Liu, Nusheng Chen, et al.	American Chemical Society (ACS) or similar	Discusses conversion strategies for solid waste like **chrome shavings**, fleshing, and buffing dust into products like **collagen hydrolysates**, **electrospun nanofibers** (for wound healing), and fat extraction.
3	Leather Processing & Tanning Technology Handbook (Reference Book)	NIIR Board of Consultants & Engineers	NIIR Project Consultancy Services	Provides comprehensive technical details on all stages of leather making, including the **by-products** (fleshings, trimmings, splits) generated and their potential traditional and modern uses.
4	Ecological utilization of leather tannery waste with circular economy model (Journal Articles/Reviews)	Hu, et al. / Various Researchers	Environmental Science, Waste Management Journals	Focuses on using waste (tanned and untanned) as **secondary raw materials**, including the recovery of **chromium**, fats, and **collagen/gelatin** for use in various industries (adhesives, biomaterials, agriculture).

Byproduct Type	**Source Stage**	**Key Utilization / Value-Added Product**
Fleshings (Untanned)	Beamhouse (Fleshing)	**Fat/Grease extraction** (for lubricants, biodiesel); **Protein concentrate** (for feed, fertilizers); **Gelatin/Collagen** extraction.
Trimmings/Splits (Untanned)	Beamhouse	Raw material for **glue** and **gelatin** production (high-quality collagen source).
Wet-Blue Shavings (Tanned, Chromium-containing)	Tanyard (Shaving)	**Chromium recovery** (for reuse in tanning); **Collagen hydrolysate** (used as an additive in plastics, building materials, or re-tanning agents after de-chroming).
Hair	Beamhouse (Unhairing)	Used as **fertilizer** (source of nitrogen) or for making **non-woven materials**.
Effluent Treatment Sludge	Wastewater Treatment	Used in **building materials** (e.g., non-fired bricks, cement components) after solidification/stabilization to immobilize chromium.

(b) Open Educational Resources (OER):

S. No.	Resource Type	Title / Description	Link / Reference	Relevant CO(s)
1	Learning Module	Principles of Costing & Pricing in Retail	OER Commons	CO-1
2	E-Book / PDF	Marketing Management: Concepts & Cases	Open Textbook Library	CO-2
3	Online Course	Digital Marketing & Consumer Behavior	Coursera / edX Free Courses	CO-2, CO-4

4	Video / Webinar	Visual Merchandising Techniques & Store Layout	YouTube / LightspeedHQ Blog	CO-3
5	Case Studies	Retail Branding and Product Launch Case Studies	Harvard Business Review / Open Access Journals	CO-4, CO-5
6	Software / Simulation	Retail & Merchandising Simulation Tools	Simul8 Education / Free Trials	CO-3, CO-4
7	Blogs / Articles	Trends in Fashion Marketing and Visual Merchandising	Shopify Blog, Brex Journal	CO-2, CO-3, CO-5
8	Open Courseware	Pricing Strategies, Consumer Psychology, and Marketing Mix	MIT OpenCourseWare	CO-1, CO-2

(c) Others:

a. Learning Packages
b. Users' Guide
c. Manufacturers' Manual
d. Lab Manuals

A) Course Code : 2472406(P2472406/S2472406)

B) Course Title : Tannery Practice II

C) Pre- requisite Course(s) : Tannery Practice I

D) Rationale :

The course "Tannery Practice – II" provides in-depth knowledge of tanning, retanning, dyeing, and finishing operations essential for leather manufacture. It helps learners understand process control, machinery operation, and quality enhancement techniques. Emphasis is placed on sustainable and eco-friendly practices to minimize environmental impact and improve efficiency in modern tanneries.

E) Course Outcomes (COs): After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/ laboratory/ workshop/ field/ industry.

After completion of the course, the students will be able to-

CO-1: Explain the principles and objectives of tanning operations, including chrome and vegetable tanning processes.

CO-2: Explain retanning, dyeing, and fatliquoring operations to achieve desired leather characteristics.

CO-3: Analyze how process variables affect leather quality and performance

CO-4: Operate and maintain tanning and post-tanning machinery in accordance with safety and environmental guidelines

CO-5: Explain sustainable, eco-friendly practices in tannery operations to minimize waste and conserve resources

F) Suggested Course Articulation Matrix (CAM):

PSO-1: Apply knowledge of chemistry, biochemistry, and material science to analyze, process, and enhance the quality of hides and skins into value-added leather products.

PSO-2: Utilize modern analytical tools and sustainable processing techniques for innovation, quality improvement, and environmental compliance in leather and allied industries

Course Outcomes (COs)	PO-1Basic and Discipline Specific Knowledge	PO-2Problem Analysis	PO-3Design / Development of Solutions	PO-4Engineering Tools	PO-5Engineering Practices for Society, Sustainability and Environment	PO-6Project Management	PO-7Life Long Learning	PSO-1	PSO-2
CO-1	3	2	-	-	-	-	1	-	-
CO-2	3	2	-	-	-	-	1	-	-
CO-3	3	3	3	2	3	2	2	3	3
CO-4	2	3	3	2	3	2	2	3	3
CO-5	1	2	-	1	2	2	2	-	2

Legend: High (3), Medium (2), Low (1) and No ma1pping (-)

***** PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Course Code	Course Title	Scheme of Studies (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (SW+SL)	Total Hours (CI+LI+SW+SL)	Total Credits(C)
		L	T				
2472406	Tannery Practice II		-	04	02	06	03

Legend:

CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)

LI: Laboratory Instruction (Includes experiments/practical performances in laboratory, workshop, field or other locations using different instructional/Implementation strategies)

Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.

TW: Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

SL: Self Learning, MOOCs, spoken tutorials, open educational resources (OERs)

C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)

Note: TW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

H) Assessment Scheme:

Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
		Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2472406	Tannery Practice II			20	30	20	30	100

Legend:

PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)

PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)

TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.

Note:

- ETA & ELA are to be carried out at the end of the term/ semester.
- Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done **internally (40%)** as well as **externally (60%)**. Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self-learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/ presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activities.

I) Course Curriculum Detailing: This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Term Work (TW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

J) Theory Session Outcomes (TSOs) and Units: (Not Applicable)

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2472406

Practical / Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment / Practical Titles	Relevant CO(s)
LSO1: Understand and perform post-tanning operations such as neutralization, dyeing, and fatliquoring.	1	Demonstration and practice of neutralization process of leather after chrome tanning.	CO1
LSO2: Apply techniques for dyeing of leather using various dyes and assess color uniformity.	2	Dyeing of chrome-tanned leather with acid and basic dyes.	CO1, CO2
LSO3: Gain knowledge of fatliquoring process to enhance leather softness and flexibility.	3	Fatliquoring of dyed leather using different fatliquors.	CO2
LSO4: Evaluate the process of setting, drying, and staking to improve the physical appearance of leather.	4	Setting out and vacuum drying of leather.	CO2
LSO5: Understand mechanical finishing operations for final appearance and surface characteristics.	5	Buffing and staking operations on finished leather.	CO3
LSO6: Apply finishing techniques including spraying, polishing, and embossing for surface coating.	6	Application of surface coatings and finishing of leather by spraying/polishing.	CO3
LSO7: Identify defects during post-tanning and finishing and suggest corrective measures.	7	Inspection and identification of common defects during finishing operations.	CO3, CO4
LSO8: Compare properties of finished leather with standard specifications and evaluate quality.	8	Physical and visual testing of finished leather (grain, color, feel, gloss).	CO4

LSO9: Understand the use of eco-friendly chemicals and alternatives in post-tanning and finishing.	9	Demonstration of use of eco-friendly dyes and fatliquors in post-tanning.	CO4, CO5
LSO10: Integrate process knowledge to produce a quality finished leather suitable for specific applications.	10	Preparation of finished leather sample suitable for footwear or upholstery application.	CO5

L) Suggested Term Work and Self-Learning: S2472406 Some sample suggested assignments, micro project and other activities are mentioned here for reference.

a. Assignments

S. No.	Assignment Topics	Purpose / Expected Learning	Relevant CO(s)
1	Evaluate the role of enzymes in leather pretannage processes.	To understand the biochemical and mechanical aspects of enzyme-assisted processing and its impact on leather quality.	CO-2
2	Compare chemical vs. enzyme-based bating and soaking processes.	To analyze process efficiency, product quality, and environmental implications of different methods.	CO-2, CO-3
3	Prepare a flow chart of the liming, deliming, and bating operations in a tannery.	To reinforce understanding of sequential mechanical and chemical operations in leather processing.	CO-1, CO-3
4	Investigate and report on common defects in leather due to improper pretannage operations.	To develop diagnostic and problem-solving skills for industrial leather processing.	CO-4
5	Study the effect of pH, temperature, and enzyme concentration on collagen extraction efficiency.	To apply experimental design principles and optimize pretannage conditions for leather quality.	CO-2, CO-4
6	Prepare a sustainability audit report for a local tannery.	To familiarize with waste management, eco-friendly practices, and regulatory compliance in real-world settings.	CO-5
7	Analyze case studies of tanneries adopting zero-liquid-discharge (ZLD) systems.	To promote understanding of modern sustainable technologies and industrial best practices.	CO-5

b. Micro Projects

S. No.	Micro Project Topics	Purpose / Expected Learning	Relevant CO(s)
1	Survey and preparation of a flowchart showing the environmental impact points in leather processing stages.	To identify critical pollution sources and visualize the environmental footprint of leather manufacturing.	CO-1
2	Collection and analysis of tannery effluent samples for pH, BOD, COD, and TDS.	To gain practical exposure to effluent characterization and environmental monitoring methods.	CO-2
3	Design a small-scale model of an Effluent Treatment Plant (ETP) showing primary, secondary, and tertiary treatment units.	To understand the layout and function of different wastewater treatment components.	CO-3
4	Development of a waste minimization or cleaner production protocol for a specific leather process (e.g., tanning or dyeing).	To promote sustainable thinking and process optimization for pollution reduction.	CO-4
5	Case study on implementation of ISO 14001 Environmental Management System (EMS) or Zero Liquid Discharge (ZLD) in a tannery.	To understand environmental compliance, documentation, and sustainability reporting in practice.	CO-5

c. Other Activities

1. Seminar Topics:

S. No.	Seminar Topics	Purpose / Expected Learning	Relevant CO(s)
1	Automation in leather machinery: PLC and sensor-based control systems.	To understand modern automation techniques for process control and efficiency improvement.	CO-1, CO-2
2	Energy-efficient design of leather processing machines.	To explore methods of reducing energy consumption while maintaining leather quality.	CO-2, CO-4
3	Application of IoT and data analytics in monitoring leather machinery operations.	To learn how digital tools can optimize machine performance and predictive maintenance.	CO-3, CO-4
4	Comparative study of enzyme-assisted vs. chemical pretannage from a mechanical perspective.	To analyze the impact of pretannage processes on machine operation, product quality, and sustainability.	CO-2, CO-3
5	Advances in eco-friendly finishing and surface coating machines.	To understand innovative machine designs that reduce waste, chemical use, and environmental impact.	CO-4, CO-5
6	Case study on tanneries implementing zero-liquid-discharge (ZLD) technology.	To observe real-world sustainable practices and assess the mechanical and operational changes required.	CO-5
7	Troubleshooting and preventive maintenance strategies for high-speed leather machines.	To develop problem-solving skills and learn systematic approaches for machine reliability.	CO-3, CO-4

2. Surveys:

S. No.	Survey Topics	Purpose / Expected Learning	Relevant CO(s)
1	Study of mechanical operations and workflow in leather machines (splitting, shaving, fleshing, rolling).	Understand the sequence of machine operations and factors affecting motion, force, and efficiency.	CO-1
2	Analysis of roller speed, pressure, and tension effects on leather thickness and uniformity.	Evaluate the impact of operational parameters on leather quality and process efficiency.	CO-2
3	Survey of energy consumption patterns in leather machinery.	Identify opportunities for energy optimization and sustainable machine operation.	CO-4
4	Assessment of maintenance practices and troubleshooting methods in leather machines.	Understand machine performance, preventive maintenance, and optimization techniques.	CO-5
5	Study of eco-friendly and energy-efficient machine operation practices in tanneries.	Explore practical implementation of sustainable and environmentally conscious operations.	CO-5

3. Visit:

S. No.	Visit Topic / Location	Purpose / Expected Learning	Relevant CO(s)
1	Visit to a local tannery leather machine section	Observe mechanical operations such as splitting, shaving, fleshing, and rolling; understand machine workflow and efficiency.	CO-1
2	Visit to a tannery for studying roller speed, pressure, and tension effects	Analyze the impact of operational parameters on leather quality and thickness uniformity.	CO-2
3	Visit to a tannery implementing energy-efficient machine operations	Learn practical approaches for energy optimization and eco-friendly machine operation.	CO-4
4	Visit to a tannery maintenance and troubleshooting unit	Understand machine maintenance practices, troubleshooting, and optimization techniques.	CO-5
5	Visit to a tannery practicing sustainable and eco-friendly machine operations	Observe real-world implementation of sustainable practices and environmental considerations in leather machinery.	CO-5

d. Self-Learning Topics

S. No.	Self-Learning Topics	Purpose / Expected Learning	Relevant CO(s)
1	Review of global environmental issues in the leather industry	Develop awareness of international environmental challenges and sustainability trends	CO-1
2	Study of effluent treatment technologies and sludge management	Learn about innovative methods for wastewater treatment and solid waste handling	CO-2
3	Research on cleaner production practices and eco-friendly leather chemicals	Understand approaches for reducing environmental impact in leather processing	CO-4
4	Analysis of environmental laws, regulations, and standards applicable to tanneries	Gain knowledge of compliance requirements and regulatory frameworks	CO-4
5	Case studies on sustainable and zero-liquid-discharge (ZLD) tanneries	Learn best practices for achieving sustainability and resource efficiency	CO-5
6	Study of energy and water conservation techniques in leather manufacturing	Develop skills to optimize resource use and reduce environmental footprint	CO-4
7	Exploration of circular economy and green technologies in leather production	Understand strategies for recycling, reusing, and minimizing waste	CO-5

M) **Suggested Course Evaluation Matrix:** The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and sessional work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate **CO attainment**.

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Sessional Work Assessment (SWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid	End Theory Assessment (ETA)	Sessional Work & Self Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessm
			Assignments	Micro	Other Activities*		

	Sem Test			**Projects**			**ent (ELA)**
CO-1			20%	33%	20%	20%	20%
CO-2			20%	33%	25%	20%	20%
CO-3			20%	34%	20%	20%	20%
CO-4			20%	--	20%	20%	20%
CO-5			20%	--	15%	20%	20%
Total Marks			20	10	20	30	30
			50				

Legend:

***:** Other Activities include self- learning, seminar, visits, surveys, product development, software development etc.

******: Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

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N) Suggested Specification Table for End Semester Theory Assessment: (Not Applicable)

O) Suggested Assessment Table for Laboratory (Practical):

P) Q) R)	**Laboratory Practical Titles**	**Relevant COs Number(s)**	**PLA/ELA**		
			Performance		**Viva-Voce (%)**
			PRA (%)	**PDA (%)**	
1.	Demonstration and practice of neutralization process of leather after chrome tanning.	CO1	50	40	10
2.	Dyeing of chrome-tanned leather with acid and basic dyes.	CO1, CO2	50	40	10
3.	Fatliquoring of dyed leather using different fatliquors.	CO2	50	40	10
4.	Setting out and vacuum drying of leather.	CO2	45	45	10
5.	Buffing and staking operations on finished leather.	CO3	50	40	10
6.	Application of surface coatings and finishing of leather by spraying/polishing.	CO3	50	40	10
7.	Inspection and identification of common defects during finishing operations.	CO3, CO4	50	40	10
8.	Physical and visual testing of finished leather (grain, color, feel, gloss).	CO4	50	40	10
9.	Demonstration of use of eco-friendly dyes and fatliquors in post-tanning.	CO4, CO5	50	40	10
10.	Preparation of finished leather sample suitable for footwear or upholstery application.	CO5	50	40	10

Legend:

PRA*: Process Assessment

PDA**: Product Assessment

Note: This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student performance.

S) Suggested Instructional/Implementation Strategies:

T) List of Major Laboratory Equipment, Tools and Software:

S. No.	Name of Equipment, Tools, and Software	Broad Specifications	Relevant Experiment / Practical Number(s)
1	**Dyeing Drum / Rotary Drum**	Stainless steel drum (10–20 L capacity), variable speed (10–30 rpm), temperature control (up to 90°C).	2, 3
2	**Fatliquoring Unit**	Thermostatically controlled vessel with stirrer; capacity 5–10 L; compatible with aqueous emulsions.	3
3	**Setting-out Machine**	Two-roller system, pressure adjustable (0–10 bar), stainless steel rollers.	4
4	**Vacuum Dryer**	Drying temperature range: 30–100°C, vacuum pressure: up to –700 mmHg, with digital control.	4
5	**Staking Machine**	Pneumatic/electromechanical operation, oscillating head, adjustable stroke.	5
6	**Buffing Machine**	Single/double head with emery paper roller, adjustable speed 500–1500 rpm, dust collector attached.	5
7	**Spray Booth with Spray Gun**	Air-pressure spray system with exhaust filter; working area 1.5×1.0×1.0 m; air pressure 2–3 bar.	6
8	**Embossing Machine**	Heated hydraulic press, temperature up to 150°C, pressure up to 20 tons, with patterned plates.	6
9	**Polishing / Glazing Jack**	Adjustable roller pressure, speed 300–1000 rpm, heating provision optional.	6
10	**Mechanical Agitator / Mixer**	Speed range 100–1500 rpm, stainless steel blades, 2–5 L capacity.	2, 6
11	**Leather Testing Instruments**	Thickness gauge (0–10 mm), tensile tester (up to 500 N), flexometer, color fastness tester as per IS standards.	8
12	**pH Meter**	Digital display, range 0–14, accuracy ±0.01 pH, temperature compensation probe.	1, 2
13	**Hot Air Oven**	Temperature range 30–250°C, digital control, double-walled insulated chamber.	4, 8
14	**Microscope (Leather Surface Analysis)**	Binocular, magnification 40×–1000×, LED illumination.	7, 8
15	**Eco-friendly Chemical Set**	Includes biodegradable dyes, fatliquors, surfactants, and eco-certified finishing agents.	9
16	**Measuring and Weighing Instruments**	Digital balance (0.001 g accuracy), measuring cylinders, pipettes, beakers.	1–10

17	**Personal Protective Equipment (PPE)**	Aprons, gloves, safety goggles, masks, and safety shoes.	All Practicals
18	**Leather Process Management Software (Optional)**	Process data recording, pH & temperature tracking, and batch reporting features.	2–9
19	**Data Logger / Sensor Setup (Optional)**	Temperature and humidity sensors, real-time data display, USB interface.	4, 6, 8

U) Suggested Learning Resources:

(a) Books:

S.No.	Title of Book	Author(s) / Editor(s)	Publisher	Key Topics Covered (Relevant to TPII)
1	Fundamentals of Leather Manufacture	E. Heidemann	Eduard Roether KG	Beamhouse (Soaking, Liming, Deliming, Bating, Pickling), Tanning (Chrome, Vegetable, Mineral, Aldehyde), Post-Tanning (Neutralization, Dyeing, Fatliquoring), Effluent Treatment.
2	Leather Processing & Tanning Technology Handbook	NIIR Board of Consultants & Engineers	NIIR Project Consultancy Services (NPCS)	Detailed preparation for Tanning, Tanning processes (Chrome, Vegetable), Finishing of Leather, Manufacture of specific leathers (Sole, Glazed Kid, Harness, Chamois, etc.), Chemical analysis in the tannery.
3	A Text-book of Tanning	Henry R. Procter	(Various - e.g., Project Gutenberg EBook, historical printings)	Anatomical structure and chemistry of hide, Preparation for Tanning (Sole-leather focus on unhairing), Chemistry of Tannins, Vegetable and Mineral Tanning processes, Dressing and Currying.
4	The Chemistry and Technology of Leather (Four Volumes, especially Vol. II - Biology-Chemistry and Vol. III - Process Control)	Fred O'Flaherty, William T. Roddy, and Robert M. Lollar	Reinhold Publishing Corporation (Historical)	In-depth chemistry and biology of leather making, Hide Curing, Beamhouse chemistry (Unhairing, Bating), Process Control, Specific Tanning processes.
5	Practical Tanning: A Handbook of Modern Practice	Allen Rogers	Henry Carey Baird & Co. / Other Reprints	Practical methods for Soaking, Liming, Deliming, Bating, Vegetable Tanning, Mineral Tannages, Chemical control and analysis for tannery operations.
6	Treatise on Fatliquors and Fatliquoring of Leather	Dr. Samir Dasgupta	Indian Leather Technologists' Association (ILTA), Kolkata	-
7	Hand-Book of Tanning	Prof. B. M. Das	Indian Leather Technologists' Association (ILTA), Kolkata	-

(b) Open Educational Resources (OER):

S. No.	Resource Type	Title / Description	Link / Reference	Relevant Practical / Module
1	Learning Package	Environmental Management in Tanneries – Online Course	Coursera / edX / Swayam	Theory + All Practicals
2	Users' Guide	Guide to Effluent and Waste Management in Leather Industry	ResearchGate PDF / Academia.edu	Practical analysis of tannery effluents and waste characterization
3	Manufacturers' Manual	Manual on Cleaner Production and Sustainable Leather Processing	Industry/Leather Association Manuals (e.g., CLRI, IULTCS)	Application of cleaner technologies and energy-efficient operations
4	Lab Manual	Laboratory Manual for Environmental Monitoring in Tanneries	Springer / Wiley Lab Manual	Experiments on effluent testing, pollution measurement, and waste treatment
5	Case Studies	Case Studies on Sustainable and Eco-Friendly Tanneries	Open Access Journals / ScienceDirect / MDPI	Analysis of ZLD, recycling, and green technology implementations
6	Video / Webinar	Webinars on Environmental Regulations & ISO 14001 EMS	YouTube / Industry Webinars / ISO Official Resources	Understanding compliance, standards, and EMS implementation

(c) Others:

a. Learning Packages
b. Users' Guide
c. Manufacturers' Manual
d. Lab Manuals

A) Course Code : 2472407 (P2472407/S2472407)

B) Course Title : Mini Project

C) Pre-requisite Course(s) **:**

D) Rationale :

Project work plays a very important role in engineering education in developing core technical skills, soft skills and a higher level of cognitive, psychomotor and affective domain skills. It encourages the critical thinking process in the students. Project work is normally done when students have acquired sufficient knowledge, skills and attitude and are able to integrate all these, entirely in a new situation or task to solve the problems of the industries/real world. Project work also develops many soft skills like confidence, communication skills, creative ability, inquisitiveness, learning to learn skills, lifelong learning skills, problem-solving skills, management skills, positive attitude, ethics etc.

E) Course Outcomes (COs): After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/ laboratory/ workshop/ field/ industry.

After completion of the course, the students will be able to-

- **CO-1** Identify a real-world problem in the form of a project to be developed.
- **CO-2** Perform literature survey related to the identified area/problem.
- **CO-3** Identify preliminary resource requirements (Equipment, Tools, Software, Manpower, Services)
- **CO-4** Prepare project synopsis for the identified problem/project title within stipulated time period.

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)	
	PO-1 Basic and Discipline Specific Knowledge	**PO-2** Problem Analysis	**PO-3** Design/ Development of Solutions	**PO-4** Engineering Tools	**PO-5** Engineering Practices for Society, Sustainability and Environment	**PO - 6** Project Management	**PO-7** Life Long Learning	**PSO-1**	**PSO-2**
CO-1	3	2	-	-	-	-	1		
CO-2	3	2	-	-	-	2	1		
CO-3	3	2	-	2	-	2	1		
CO-4	3	-	-	-	-	3	1		

Legend: High (3), Medium (2), Low (1) and No mapping (-)

***** PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Course Code	Course Title	Scheme of Study (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
		L	T				
2472407	Mini Project	-	-	02	02	04	02

Legend:

CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)

LI: Laboratory Instruction (Includes experiments/practical performances /problem-based experiences in laboratory, workshop, field or other locations using different instructional/Implementation strategies)

Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.

TW: Term Work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)

Note: TW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

H) Assessment Scheme:

Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
		Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessmen	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment	
2472407	Mini Project	-	-	10	15	10	15	50

Legend:

PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)

PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)

TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.

Note:

- ETA & ELA are to be carried out at the end of the term/ semester.
- Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done **internally (40%)** as well as **externally (60%)**. Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self-learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/ presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activities.

I) Suggested Implementation Plan of Mini Project:

1.0 Guidelines to Students for Implementation of Mini Project.

Students are guided to undergo following steps under the minor project. Teacher are advised to guide the students on each and every step.

1.1 Identification of Area/Problem and Project Titles
1.2 Literature Survey
1.3 Identification of Outcomes of the Project
1.4 Identification of the recourses required.
1.5 Preparation of Synopsis
1.6 Presentation of Synopsis

1.1 Identification of Project Titles and Allocation Methodology:

Though the teachers and students, both are involved in identification of project titles, but the prime responsibility of identification of project titles goes to the respective teachers involved in implementing the course or programme. Teachers are fully aware of course/programme curriculum and they are also aware of related industrial problems hence, they try to explore the possibility of identification of project titles through these problems.

These small industrial problems in the form of project titles may be brought into the laboratories or workshop of institutions of a specific programme, which are equipped with all necessary facilities and resources to carry out the project work. These labs or workshop can function as miniature industry to solve the industrial problems in the form of simulated industrial projects. These projects may be integrated problem of courses or programme.

Criteria for Identification of Project Titles.

The identification of problem statement must be based on the following criteria:

- Environmental Considerations
- Simulated/Automated Industry's/ Improvised Process
- Application or Utility in the World of Work.

- Relevance to the Curriculum
- Mapping of Outcomes of Project with Pos and PSOs (if applicable)
- Feasibility of Implementation of the Project

Literature Survey:

Literature survey on the project title needs to be done through journals, websites, open source technologies available, discussion with the practicing engineers/industry persons and other relevant sources available.

1.2 Outcomes of the Project:

The project guide should ensure that the project outcomes are written properly as clear, specific, measurable and attainable statements. The outcomes formulated will decide the overall scope or course of action, depth and breadth of the project and implementation plan.

1.3 Identification of the resources required:

Students under the guidance of teacher should try to identify all the resources required for the completion of the project like equipment, devices, experimental test rig, software, computer, persons to be contacted, suppliers, funds, availability of internal/external lab. The sample size has to be delimited and decided as per the time limit allotted, feasibility and many other considerations.

1.4 Preparation of Synopsis:

The students at the end of the semester are expected to submit 'Project Synopsis' after interaction with guide, as per the guidelines and format provided.

1.5 Presentation of Synopsis:

After developing the synopsis, student(s) should prepare a Power Point Presentation and present the same in front of examiner, guide and audience. Quality of presentation of data need to be ensured using the following criteria through Rubric-

- Clarity in Communication and Presentation
- Voice Audibility
- Use of Media and Methods
- Satisfying the Queries of Audience
- Attainment of Outcomes

2.0 Guidelines to Teachers for Implementation of the Mini Project:

The teacher alongwith the students should identify the different types of project title(s) as per need of the client as mentioned below:

- Prototype Development
- Experimentation Type
- Software Development Type
- Solving Industrial Problem Type
- Market Survey Type
- Feasibility Study Type
- Simulation Based
- Application Type

- Product Type
- Research Type
- Review Type

The project must be feasible. The guide allocated for each project are responsible for the quality of student's work, on different criteria including the synopsis writing which can be monitored on continual basis.

The guide must ensure that the feasibility of the project, the availability of resources/ software technology, sufficiency of time, finance and requirements during each and every step or activity of project work in advance.

J) Assessment of the Mini Project:P2472407

Continual Monitoring and feedback mechanism should be developed by the guide. An assessment plan on weekly progress/updates, action taken on different criteria and sub-criteria of the project work is suggested below. Path-breaking teachers who think out of the box are required to guide, monitor and evaluate the project work.

For objective, valid and reliable assessment, different tools of assessment such as a checklist, rating scale, assessment rubric, observation schedule, portfolio assessment, incidental records etc. need to be prepared. Even the students may been courage to adopt self-assessment techniques using the assessment rubrics.

The students need to be assessed continuously based on the below mentioned assessment criteria at project planning stage. The Project guide must prepare detailed rubric(s) for each criteria to have valid and reliable assessment.

Assessment Scheme for Mini Project

S. No.	Suggested Assessment Criteria	Suggested Weightage (%)
1.	Identification of Area/Problem Statement	10
2.	Literature Survey	20
3.	Formulation of Project Title	10
4.	Clarity in Formulation of Outcomes of The Project	10
5.	Preparation of Synopsis	30
6.	Presentation of Synopsis	20
	Total	**100**

A) Course Code : 2472408(P2472408/S2472408)
B) Course Title : Material Testing & Analysis

C) Pre- requisite Course(s) : Chemistry, Physics

D) Rationale :

This course equips students with the fundamental knowledge and practical skills required to evaluate the mechanical, physical, and chemical properties of engineering materials. Understanding material behavior under different conditions is essential for design, quality control, and failure prevention. It also enables students to interpret test data accurately and make informed decisions in material selection and application.

E) Course Outcomes (COs): After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/ laboratory/ workshop/ field/ industry.

After completion of the course, the students will be able to-

The course *Material Testing & Analysis* builds upon foundational knowledge of physics, chemistry, and mechanics to enable learners to understand and evaluate material behavior under various conditions. It provides essential skills to select suitable testing methods, interpret data, and relate microstructural characteristics to material properties. This understanding is vital for ensuring quality, reliability, and safety in engineering applications.

CO1 Explain the basic concepts, classification, and properties of engineering materials.
CO2 Describe appropriate material testing techniques to evaluate mechanical, physical, and chemical properties.
CO3 Explain experimental results and interpret material behavior under different conditions.
CO4 Explain suitable materials for engineering applications based on test results and performance criteria.
CO5 Explain the proper and safe use of laboratory equipment and standard testing procedures.

F) Suggested Course Articulation Matrix (CAM):

PSO-1: Apply knowledge of chemistry, biochemistry, and material science to analyze, process, and enhance the quality of hides and skins into value-added leather products.

PSO-2: Utilize modern analytical tools and sustainable processing techniques for innovation, quality improvement, and environmental compliance in leather and allied industries

Course Outcomes (COs)	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design / Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2
CO-1	3	1	-	-	-	-	-	-	-
CO-2	3	3	-	1	-	-	-	-	-
CO-3	3	3	1	1	-	-	-	-	-
CO-4	2	3	3	3	-	-	-	-	-
CO-5	-	3	-	-	2	1	2	-	1

Legend: High (3), Medium (2), Low (1) and No ma1pping (-)

***** PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Course Code	Course Title	Scheme of Studies (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (SW+SL)	Total Hours (CI+LI+SW+SL)	Total Credits(C)
		L	T				
2472408	Material Testing & Analysis	--	-	02	02	04	02

Legend:

CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)

LI: Laboratory Instruction (Includes experiments/practical performances in laboratory, workshop, field or other locations using different instructional/Implementation strategies)

Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.

TW: Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

SL: Self Learning, MOOCs, spoken tutorials, open educational resources (OERs)

C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)

Note: TW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

H) Assessment Scheme:

Course Code	Course Title	Assessment Scheme (Marks)			Total Marks (TA+TWA+
		Theory Assessment (TA)	Term Work & Self-Learning Assessment (TWA)	Lab Assessment (LA)	

		Progressive Theory	End Theory Assessmen	Internal	External	Progressive Lab Assessment	End Laboratory Assessment (ELA)	
2472408	Material Testing & Analysis			10	15	10	15	50

Legend:

PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)

PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)

TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.

Note:

- ETA & ELA are to be carried out at the end of the term/ semester.
- Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done **internally (40%)** as well as **externally (60%)**. Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self-learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/ presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activities.

I) Course Curriculum Detailing: This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Term Work (TW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

J) Theory Session Outcomes (TSOs) and Units: (Not Applicable)

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2472408

Practical / Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment / Practical Titles	Relevant CO(s)
LSO 1.1 Students will be able to identify and classify different engineering materials based on structure and properties.	1	Identification and classification of metals, polymers, ceramics, and composites.	CO-1
LSO 1.2 Students will be able to measure basic mechanical properties like hardness, tensile strength, and impact resistance.	2	Hardness testing using Brinell, Rockwell, and Vickers methods.	CO-2
LSO 1.3 Students will be able to perform tensile and compression tests on standard specimens.	3	Tensile and compression testing of metals and polymers.	CO-2

LSO 2.1 Students will be able to analyze material behavior under bending, shear, and torsion loads.	4	Flexural, shear, and torsion testing of specimens.	CO-3
LSO 2.2 Students will be able to determine fatigue life and creep behavior of materials under cyclic and long-term loading.	5	Fatigue and creep testing of metals and alloys.	CO-3
LSO 3.1 Students will be able to observe microstructures and phase differences in materials using microscopy techniques.	6	Metallographic sample preparation and microscopic examination.	CO-4
LSO 3.2 Students will be able to perform non-destructive testing for cracks, defects, and material integrity.	7	Non-destructive testing: ultrasonic, dye-penetrant, and magnetic particle inspection.	CO-4
LSO 4.1 Students will be able to evaluate and document test results, and propose suitable materials for engineering applications.	8	Compilation, analysis, and reporting of experimental results; material selection exercise.	CO-5
LSO 4.2 Students will be able to apply sustainable testing and energy-efficient laboratory practices.	9	Demonstration of safe, eco-friendly, and energy-optimized material testing procedures.	CO-5

L) Suggested Term Work and Self-Learning: S2472408 Some sample suggested assignments, micro project and other activities are mentioned here for reference.

d. Assignments

S. No.	Assignment Topics	Purpose / Expected Learning	Relevant CO(s)
1	Explain the importance of mechanical, physical, and chemical properties in material selection.	To understand how material properties influence design, performance, and safety.	CO-1
2	Prepare a report on standard test methods for metals, polymers, and composites.	To analyze different material testing procedures and interpret their significance.	CO-2
3	Write short notes on non-destructive testing (NDT) techniques and their applications.	To reinforce knowledge of NDT methods like ultrasonic, magnetic particle, and dye-penetrant testing.	CO-3
4	Discuss the role of microstructural analysis in predicting material behavior.	To develop understanding of how microscopic features affect macroscopic properties.	CO-4
5	Analyze case studies of material failures in engineering applications.	To familiarize with failure analysis, root cause identification, and preventive measures.	CO-4
6	Prepare a case study on sustainable testing practices and eco-friendly material selection.	To promote application-based learning and appreciation of sustainable engineering practices.	CO-5

b. Micro Projects

S. No.	Micro Project Topics	Purpose / Expected Learning	Relevant CO(s)
1	Survey and preparation of a flowchart showing standard material testing procedures for metals, polymers, and composites.	To identify critical tests, visualize the workflow, and understand the sequence of testing operations.	CO-1
2	Collection and analysis of experimental data from tensile, hardness, and impact tests.	To gain practical exposure to data acquisition, interpretation, and property evaluation methods.	CO-2

3	Design a small-scale model or setup for performing a specific material test (e.g., tensile or flexural testing).	To understand the setup, instrumentation, and function of different testing units.	CO-3
4	Development of a protocol for comparative material performance evaluation under different loading conditions.	To promote analytical thinking, test planning, and optimization for material selection.	CO-4
5	Case study on material failure analysis in an engineering application.	To understand practical causes of failure, documentation, and preventive measures.	CO-5

c. Other Activities

1. Seminar Topics:

S. No.	Seminar Topics	Purpose / Expected Learning	Relevant CO(s)
1	Recent advances in non-destructive testing (NDT) techniques for metals and composites.	To understand modern NDT methods, their applications, and advantages in material evaluation.	CO-1
2	Comparative study of mechanical properties of conventional and advanced engineering materials.	To analyze differences in material performance and suitability for various applications.	CO-2
3	Role of microstructural analysis in predicting material behavior and failure.	To appreciate the importance of microscopic examination in material selection and reliability.	CO-3
4	Sustainable practices in material testing and eco-friendly material selection.	To explore energy-efficient and environmentally responsible testing methods.	CO-4
5	Case studies on engineering material failures and lessons learned.	To understand real-world failure scenarios and preventive measures for design and safety.	CO-5

2. Surveys:

S. No.	Survey Topic	Purpose / Expected Learning	Relevant CO(s)
1	Study of mechanical, thermal, and chemical properties of commonly used metals and polymers.	Understand material characteristics and their influence on performance in engineering applications.	CO-1
2	Analysis of testing methods used for hardness, tensile, and impact evaluation in different materials.	Identify suitable test methods and explore comparative advantages and limitations.	CO-2
3	Survey of advanced testing techniques like fatigue, creep, and corrosion testing in laboratories.	Evaluate how specialized tests provide insights into long-term material behavior.	CO-3
4	Assessment of laboratory practices and instrumentation for material testing.	Understand accuracy, calibration, and standardization in experimental procedures.	CO-4
5	Study of sustainable and energy-efficient practices in material testing laboratories.	Explore eco-friendly, safe, and resource-efficient testing methods.	CO-5
6	Survey on the adoption of international standards (ASTM, ISO) in material testing labs.	Understand the role of standardized procedures in ensuring quality and reliability of results.	CO-5

3. Visit:

S. No.	Visit Topic / Location	Purpose / Expected Learning	Relevant CO(s)
1	Visit to a material testing laboratory	Observe testing procedures for metals, polymers, and composites and understand practical applications of material properties	CO-1
2	Visit to a mechanical testing facility or industrial lab	Understand standardized testing methods for hardness, tensile, impact, and fatigue evaluation	CO-2
3	Visit to a lab performing advanced testing (creep, corrosion, or thermal analysis)	Study specialized tests for long-term material performance and reliability	CO-3
4	Visit to a lab implementing automation or digital measurement systems	Learn practical applications of modern testing tools, instrumentation, and data acquisition	CO-4
5	Visit to a laboratory following ISO / ASTM testing standards	Understand the implementation of international standards, quality control, and compliance in material testing	CO-5

d. Self-Learning Topics

S. No.	Self-Learning Topics	Purpose / Expected Learning	Relevant CO(s)
1	Review of recent advances in material testing techniques	Develop awareness of modern testing methods and emerging technologies in material evaluation	CO-1
2	Study of non-destructive testing (NDT) methods and applications	Learn innovative approaches for evaluating material integrity without causing damage	CO-2
3	Research on microstructural analysis and its role in predicting material performance	Understand how microscopic features affect macroscopic properties and reliability	CO-4
4	Analysis of ASTM, ISO, and other international testing standards	Gain knowledge of compliance requirements, standardization, and quality assurance	CO-4
5	Case studies on engineering material failures	Learn practical lessons on failure analysis, root cause identification, and prevention	CO-5
6	Study of energy-efficient and sustainable practices in material testing labs	Develop skills to optimize resource use and implement eco-friendly testing practices	CO-4
7	Exploration of recycling, reuse, and sustainable material selection strategies	Understand strategies for minimizing waste and promoting circular economy in materials engineering	CO-5

M) **Suggested Course Evaluation Matrix:** The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and sessional work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate **CO attainment**.

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Sessional Work Assessment (SWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/M	End Theory Assessment (ETA)	Sessional Work & Self Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		

	id Sem Test						
CO-1			20%	33%	20%	20%	20%
CO-2			20%	33%	25%	20%	20%
CO-3			20%	34%	20%	20%	20%
CO-4			20%	--	20%	20%	20%
CO-5			20%	--	15%	20%	20%
Total Marks			20	10	20	30	50
			50				

Legend:

***:** Other Activities include self- learning, seminar, visits, surveys, product development, software development etc.

******: Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

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N) Suggested Specification Table for End Semester Theory Assessment: (Not Applicable)

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA Performance (%) PRA	PLA/ELA Performance (%) PDA	PLA/ELA Viva-Voce (%)
1	Identification and classification of metals, polymers, ceramics, and composites.	CO-1	50	40	10
2	Hardness testing using Brinell, Rockwell, and Vickers methods.	CO-2	50	40	10
3	Tensile and compression testing of metals and polymers.	CO-2	50	40	10
4	Flexural, shear, and torsion testing of specimens.	CO-3	45	45	10
5	Fatigue and creep testing of metals and alloys.	CO-3	50	40	10
6	Metallographic sample preparation and microscopic examination.	CO-4	50	40	10
7	Non-destructive testing: ultrasonic, dye-penetrant, and magnetic particle inspection.	CO-4	50	40	10
8	Compilation, analysis, and reporting of experimental results; material selection exercise.	CO-5	50	40	10
9	Demonstration of safe, eco-friendly, and energy-optimized material testing procedures.	CO-5	50	40	10

Legend:

PRA*: Process Assessment

PDA**: Product Assessment

Note: This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student performance.

P) Suggested Instructional/Implementation Strategies:

Q) List of Major Laboratory Equipment, Tools and Software:

S. No.	Name of Equipment, Tools, and Software	Broad Specifications	Relevant Experimen / Practical Number(s
1	Universal Testing Machine (UTM)	For tensile, compression, bending, and deflection tests on metals, polymers, and composites	2, 3, 4, 5
2	Hardness Testers	Brinell, Rockwell, Vickers hardness machines for measuring material hardness	2, 3
3	Fatigue and Creep Testing Rig	Load application setup for cyclic and long-term deformation studies	5, 6
4	Flexural, Shear, and Torsion Testing Rig	For evaluating material response under different loading conditions	4, 5
5	Metallurgical Microscope	For microstructural examination of metals, alloys, and polymers	6, 7
6	Non-Destructive Testing Instruments	Ultrasonic, dye-penetrant, magnetic particle equipment for defect detection	7, 8
7	Environmental/Material Testing Kits	pH meter, temperature, and humidity measurement tools for material testing	9, 10
8	Laboratory Oven / Hot Plate	Temperature-controlled heating for drying and sample preparation	4, 5, 6
9	Water Bath	Digital/thermostatic control for controlled reaction and testing conditions	6, 7
10	Micro-Pipettes and Standard Glassware	For accurate sample handling, solution preparation, and testing	1–12
11	Data Analysis Software	Excel / MATLAB / GraphPad Prism for plotting graphs, statistical analysis, and performance evaluation	3, 6, 7, 10
12	Safety Equipment	Gloves, goggles, lab coats, emergency stop buttons, and first aid kits	1–12
13	Sample Cutting and Mounting Tools	Saws, grinders, and mounting kits for preparing specimens for testing	2, 3, 6
14	Centrifuge (Optional)	For separating particles or samples in mechanical and material studies	5, 6

R) Suggested Learning Resources:

(a) Books:

Title	Author(s)	Publisher & Edition
Materials Science and Engineering: An Introduction	William D. Callister, Jr. and David G. Rethwisch	Wiley (Various Editions)
Mechanical Behavior of Materials	Thomas H. Courtney	Waveland Press / McGraw-Hill (Various Editions)
Strength of Materials (also known as Mechanics of Materials)	R. C. Hibbeler or S. Timoshenko	Pearson / Dover (Various Editions)

(b) Open Educational Resources (OER):

S. No.	Resource Type	Title / Description	Link / Reference	Relevant Practical / Module
1	**MOOC Platform (NPTEL)**	**Material Characterization** (IIT Madras)	SWAYAM / NPTEL Portal (check for current enrollment/archive)	Covers **X-ray Diffraction (XRD)**, Optical Microscopy, **Scanning Electron Microscopy (SEM)**, and **Transmission Electron Microscopy (TEM)** principles and applications.
2	**MOOC Platform (NPTEL)**	**Characterization of Materials** (IIT Guwahati)	SWAYAM / NPTEL Portal (check for current enrollment/archive)	Focuses on structural analysis, microscopy, **Thermal Analysis (DSC, TGA)**, and various spectroscopic techniques.
3	**OpenCourseWare**	**Civil Engineering Materials Laboratory** (MIT OpenCourseWare - Course 1.103)	MIT OpenCourseWare	Concepts, techniques, and devices used to measure engineering properties, focusing on **load-deformation characteristics** and failure modes of materials (often includes video demos).

4	**MOOC Platform**	**Mechanics of Materials I & III** (e.g., Coursera/edX from Georgia Tech)	Check respective MOOC platforms for free audit option	Focuses on the theoretical basis for mechanical testing: **stress & strain**, axial loading, torsion, and beam bending analysis.
5	**Course Notes**	**MATERIALS CHARACTERIZATION - Lecture Notes**	VSSUT or other university course repositories (via general search)	Covers fundamental concepts like crystal structure, Miller Indices, and basics of characterization techniques like XRD.
6	**Lab Manual**	**Materials Science Laboratory Manual (General University Manuals)**	University Lab Manual Repositories (e.g., GGU, IAU)	Provides detailed procedures and analysis for mechanical tests (tensile, hardness, impact) and basic thermal/spectroscopic analysis.
7	**Digital Library**	**MERLOT Collection of Open Course Materials**	MERLOT (Multimedia Educational Resource for Learning and Online Teaching)	Search for modules on Materials Science, Mechanical Testing, and Characterization to find syllabi, learning modules, and simulations.
8	**OER Network**	**OER Commons**	OER Commons	Network for teaching materials; use the search filter for "Higher Education" and "Engineering" or "Physical Sciences."

(c) Others:

a. Learning Packages
b. Users' Guide
c. Manufacturers' Manual
d. Lab Manuals

No.	Self-Learning Topics	Purpose / Expected Learning	Relevant CO(s)
1	Review of advanced costing methods and pricing strategies in leather/fashion industries	Develop understanding of modern costing techniques and their impact on profitability	CO-1
2	Study of market research methods and consumer behavior analysis	Learn tools and approaches for analyzing customer preferences and market trends	CO-2
3	Research on innovative visual merchandising techniques and store layouts	Understand strategies to enhance product appeal and influence purchase decisions	CO-3
4	Analysis of integrated marketing and merchandising strategies in successful product launches	Learn how costing, marketing, and visual presentation work together for business success	CO-4
5	Case studies on successful product commercialization in leather/fashion industry	Learn best practices in product launch, promotion, and merchandising	CO-5
6	Exploration of digital marketing tools and e-commerce merchandising techniques	Understand modern approaches to reach customers and enhance product visibility	CO-2, CO-3
7	Study of sustainable and ethical merchandising practices in fashion and leather industries	Learn strategies for responsible marketing and display that appeal to socially conscious consumers	CO-5

C) Suggested Course Evaluation Matrix: The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and sessional work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate **CO attainment**.

COs	Theory Assessment (TA)		Sessional Work Assessment (SWA)			Lab Assessment (LA)	
	Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Assignments	Micro Projects	Other Activities*	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
CO-1	15%	20%	20%	33%	20%		
CO-2	20%	20%	20%	33%	25%		
CO-3	25%	20%	20%	34%	20%		
CO-4	25%	20%	20%	--	20%		
CO-5	15%	20%	20%	--	15%		
Total Marks	30	70	20	10	20		

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Sessional Work Assessment (SWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Sessional Work & Self Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	15%	15%	20%	20%	33%		
CO-2	20%	25%	20%	20%	33%		
CO-3	25%	25%	20%	20%	34%		
CO-4	25%	20%	20%	20%	--		
CO-5	15%	15%	20%	20%	--		
Total Marks	**30**	**70**	**20**	**20**	**10**		
			50				

Legend:

***:** Other Activities include self- learning, seminar, visits, surveys, product development, software development etc.

******: Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

D) Suggested Specification Table for End Semester Theory Assessment: Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

Unit Title and Number	Total Classroom Instruction (CI) Hours	Relevant CO(s) Number (s)	Total Marks	ETA (Marks)	Remember (R)	Understanding (U)	Application & Above (A)
Unit–1.0 **Fundamentals of Costing**	8	CO-1	12	12	4	4	4
Unit–2.0: **Cost Estimation**	10	CO-2	14	14	3	5	6

and Pricing Strategies							
Unit–3.0: **Marketing Management**	10	CO-3	14	14	4	5	5
Unit–4.0: **Visual Merchandising and Display Techniques**	12	CO-3, CO-4	16	16	3	5	8
Unit–5.0: **Emerging Trends in Retail and E-Merchandising**	8	CO-4, CO-5	14	14	3	4	7
Total	48	-	70	70	17	23	30

Note: Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

E) Suggested Assessment Table for Laboratory (Practical): (Not Applicable)

Legend:

PRA*: Process Assessment

PDA**: Product Assessment

Note: This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course teacher for each experiment/ practical to assess the student performance.

F) Suggested Instructional/Implementation Strategies:

G) List of Major Laboratory Equipment, Tools and Software: (Not Applicable)

H) Suggested Learning Resources:

(a) Books:

S. No.	Title	Author(s)	Publisher and Edition
1	**Costing for the Fashion Industry**	Elaine Stone and Gillian Watkins	Bloomsbury/Fairchild Books (Various Editions)
2	**Handbook of Textile and Apparel Costing**	R. Rathinamoorthy, R. Surjit, K. J. Vishnu Vardhini	CRC Press, 1st Edition
3	**Cost and Management Accounting**	M. P. Gupta and Ajay Gupta	Sultan Chand & Sons (Various Editions)

S. No.	Title	Author(s)	Publisher and Edition
1	**Fashion Marketing**	Mike Easey	Wiley-Blackwell (Various Editions)
2	**Digital Marketing for Fashion and Luxury Brands**	Various	(General Academic Publishers)
3	**The Business of Fashion**	Leslie Davis Burns, Kathy K. Mullet, and Nancy O. Bryant	Fairchild Books (Various Editions)

S. No.	Title	Author(s)	Publisher and Edition
1	**Visual Merchandising for Fashion**	Sarah Bailey and Jonathan Baker	Bloomsbury Academic (Various Editions)
2	**Store Design and Visual Merchandising**	Claus Ebster	Business Expert Press (Various Editions)
3	**Silent Selling: Best Practices and Effective Strategies in Visual Merchandising**	Judy Bell and Randy Bell	Bloomsbury/Fairchild Books (Various Editions)

(b) Open Educational Resources (OER):

S. No.	Resource Type	Title / Description	Link / Reference	Relevant CO(s)
1	Learning Module	Principles of Costing & Pricing in Retail	OER Commons	CO-1
2	E-Book / PDF	Marketing Management: Concepts & Cases	Open Textbook Library	CO-2
3	Online Course	Digital Marketing & Consumer Behavior	Coursera / edX Free Courses	CO-2, CO-4
4	Video / Webinar	Visual Merchandising Techniques & Store Layout	YouTube / LightspeedHQ Blog	CO-3
5	Case Studies	Retail Branding and Product Launch Case Studies	Harvard Business Review / Open Access Journals	CO-4, CO-5
6	Software / Simulation	Retail & Merchandising Simulation Tools	Simul8 Education / Free Trials	CO-3, CO-4
7	Blogs / Articles	Trends in Fashion Marketing and Visual Merchandising	Shopify Blog, Brex Journal	CO-2, CO-3, CO-5
8	Open Courseware	Pricing Strategies, Consumer Psychology, and Marketing Mix	MIT OpenCourseWare	CO-1, CO-2

(c) Others:

a. Learning Packages
b. Users' Guide
c. Manufacturers' Manual

d. Lab Manuals