

UNIVERSITY DEPARTMENTS  
ANNA UNIVERSITY CHENNAI : : CHENNAI 600 025  
REGULATIONS - 2009  
CURRICULUM I TO IV SEMESTERS (FULL TIME)  
M.TECH. LEATHER TECHNOLOGY

**SEMESTER I**

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
<b>THEORY</b>						
1.	MA9121	<a href="#">Applied Mathematics for Leather Technology</a>	3	1	0	4
2.	LE9111	<a href="#">Advanced Leather Chemistry</a>	3	0	0	3
3.	LE9112	<a href="#">Advanced Leather Process Technology</a>	3	0	0	3
4.	LE9113	<a href="#">Advanced Organic and Inorganic Chemistry</a>	3	0	0	3
5.	LE9114	<a href="#">Advanced Leather Biotechnology</a>	3	0	0	3
<b>PRACTICAL</b>						
6.	LE9117	<a href="#">Advanced Techniques in Leather Processing – I</a>	0	0	6	3
<b>TOTAL CREDIT</b>			<b>15</b>	<b>1</b>	<b>9</b>	<b>19</b>

**SEMESTER II**

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
<b>THEORY</b>						
1.	LE9121	<a href="#">Instrumental Methods in Leather Science</a>	3	0	0	3
2.	LE9122	<a href="#">Advanced chemistry and technology of leather chemicals</a>	3	0	0	3
3.	LE9123	<a href="#">Treatment and Disposal of Tannery Waste</a>	3	0	0	3
4.	E1	Elective I	3	0	0	3
5.	E2	Elective II	3	0	0	3
<b>PRACTICAL</b>						
6.	LE9126	<a href="#">Leather Chemicals and Instrumental Laboratory</a>	0	0	6	3
<b>TOTAL CREDIT</b>			<b>15</b>	<b>0</b>	<b>6</b>	<b>18</b>

**SEMESTER III**

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
<b>THEORY</b>						
1.	LE9131	<a href="#">Environmental Management System</a>	3	0	0	3
2.	E3	Elective III	3	0	0	3
3.	E4	Elective IV	3	0	0	3
4.	E5	Elective V	3	0	0	3
5.	LE9135	<a href="#">Seminar</a>	0	0	2	1
<b>PRACTICAL</b>						
6.	LE9136	<a href="#">Project Work Phase – I</a>	0	0	12	6
<b>TOTAL CREDIT</b>			<b>12</b>	<b>0</b>	<b>14</b>	<b>19</b>

### SEMESTER IV

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
<b>PRACTICAL</b>						
1.	LE9141	<a href="#">Project Work Phase – II</a>	0	0	24	12
<b>TOTAL CREDIT</b>			<b>12</b>	<b>0</b>	<b>14</b>	<b>19</b>

**TOTAL CREDITS TO BE EARNED FOR THE AWARD THE DEGREE = 68**

### LIST OF ELECTIVES

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
1.	LE9151	<a href="#">Science and Technology of Leather Supplements and Synthetics</a>	3	0	0	3
2.	LE9152	<a href="#">Colloid and Surface Chemistry</a>	3	0	0	3
3.	LE9153	<a href="#">Advanced Coordination Chemistry</a>	3	0	0	3
4.	LE9154	<a href="#">Chemistry and Physics of Collagen</a>	3	0	0	3
5.	LE9155	<a href="#">Nano Technology for Leather</a>	3	0	0	3
6.	LE9156	<a href="#">Engineering Economics in Leather Production</a>	3	0	0	3
7.	LE9157	<a href="#">Industrial Safety and Occupational Health</a>	3	0	0	3
8.	LE9158	<a href="#">Energy Management in Leather Industries</a>	3	0	0	3
9.	LE9159	<a href="#">Marketing of Leather and Leather Chemicals</a>	3	0	0	3
10.	LE9160	<a href="#">Eco Labelling for Leather Sector</a>	3	0	0	3

\* - Apart from the above listed electives students will be encouraged to choose electives offered by other departments from Faculty of Technology

**MA9121**                      **APPLIED MATHEMATICS FOR LEATHER TECHNOLOGY**                      **L T P C**  
**3 1 0 4**

**UNIT I                      TENSOR ANALYSIS                      9**  
Tensor Algebra, Metric Tensor, Christoffel Symbols and covariant differentiation, Riemann-Christoffel Curvature Tensor, Cartesian Tensors

**UNIT II                      FOURIER TRANSFORMS                      9**  
Fourier Transforms, Complex, Sine and Cosine Transforms, Finite Fourier Transforms, Applications to heat conduction problems

**UNIT III                      CALCULUS OF VARIATIONS                      12**  
Simple variational problems with fixed boundaries, Euler`s equations, conditional extrema, Iso perimetric problems, Approximate solutions, Direct methods, Euler`s finite difference method, Ritz method

**UNIT IV                      METHOD OF WEIGHTED RESIDUALS                      7**  
Basics of variational principle, Applications to ordinary and partial differential equations, sub-domain method, Collocation method, least square method, Galerkin method

**UNIT V                      QUALITATIVE ANALYSIS OF ORDINARY DIFFERENTIAL EQUATION                      8**  
Stability of nonlinear systems, Elements of control Theory

**L: 45 , T : 15 ,TOTAL : 60 PERIODS**

#### **REFERENCES**

1. Ramanaiah, G. T., "Tensor Analysis", S. Viswanathan Pvt. Ltd., 1990.
2. Narayanan S, Manicavachagom Pillai T K and Ramanaiah G, "Advanced Mathematics for Engineering Students," Vol.III, S.Viswanathan Pvt. Ltd., 1990.
3. Finalyson, B. A., "The Method of Weighted Residuals and Variational Principles", Academic Press, 1972.
4. Geo, S. G. and Raghavendra V, "Ordinary Differential Equations and Stability Theory", Tata McGraw Hill, 1980.
5. Pushpavanam S., "Mathematical Methods in Chemical Engineering", Prentice Hall of India.

**LE9111**                      **ADVANCED LEATHER CHEMISTRY**                      **L T P C**  
**3 0 0 3**

**UNIT I                      STRUCTURE OF SKIN AND COLLAGEN                      9**  
Matrix structure of skin and molecular structure of collagen including functional groups and ultra as well as microstructural details - Collagen as a membrane and enzymatic hydrolysis of connective tissue proteins.

**UNIT II                      CHEMICAL PRINCIPLES INVOLVED IN PRETANNING OPERATIONS                      9**  
Salt less/less salt curing methods - Swelling mechanisms; porosity of hides and skins. Diffusion of lime and sharpening agents into skin; Osmotic and lyotropic opening of fibres. Nucleophilic displacement pathways in unhairing, mechanisms of unhairing based on chemical and

enzymatic methods – concepts; changes in fibre structure during liming; mechanism of deliming, bating and degreasing - Role of mineral acids, neutral salts and non-swelling acids, in pickling, the chemistry of pickling and the fibre structure and the importance of pore size characteristics of pickled pelts.

**UNIT III CHEMISTRY OF TANNING MATERIALS 9**

Classification, isolation, characterization and structural elucidation of vegetable tannins; biogenesis and biosynthesis of hydrolysable and condensed tannins - Aqueous chemistry of Chromium (III), Aluminium (III), Iron (II) and (III), Titanium (IV), and Zirconium (IV) - coordinative interactions and hydrolytic behaviour of coordinated ligands, olation, oxolation and polymerisation and their relevance to mineral tanning.

**UNIT IV PHYSICS AND CHEMISTRY OF TANNING METHODS 9**

Transport of tanning materials into pelt, diffusion equilibria and mechanism of vegetable, mineral and combination tannages, role of crosslinking and fibre coating in matrix stability.

**UNIT V PHYSICS AND CHEMISTRY OF POST TANNING OPERATIONS 9**

Physicochemical interactions of syntans, fatliquors and dyes with collagen and leather - Role of surface charge and importance of electrostatic, H-bond, dipole-dipole and hydrophobic interactions. Theory of finishing with special emphasis to optical properties of pigments and binders. Role of interfacial phenomena in leather finishing.

**TOTAL : 45 PERIODS**

**REFERENCES**

1. Flaherty, F.O., Roddy, W.T. and Lollar, R.M. "The Chemistry and Technology of Leather, Vol.I, Preparation for tannages", E. Robert Krieger Publishing Company, New York, 1978.
2. Flaherty, F.O., Roddy, W.T. and Lollar, R.M. "The Chemistry and Technology of Leather Vol. II, Type of tannages" E. Robert Krieger Publishing Corporation, New York, 1977.
3. Bienkiewicz, "Physical Chemistry of Leather Making", Krieger Publishing Co., Florida 1982.

**LE9112 ADVANCED LEATHER PROCESS TECHNOLOGY L T P C  
3 0 0 3**

**UNIT I UTILITY, FASHION AND SPECIAL LEATHERS 10**

Different types of raw materials used, properties required, physical and chemical standards required and process details to achieve the specifications of different types of leathers such as upholstery, washable garment, water resistant leathers, chamois, glove and fashion leathers. Processing of exotic leathers such as reptiles, crocodiles, lizards, fish, ostrich etc.,

**UNIT II CLEANER PROCESSING - BEAMHOUSE 8**

Eco-friendly process technologies: Salt free curing options, sulphide free unhairing systems, ammonia - free deliming, salt free pickling systems, solvent free degreasing systems. Paradigm shift from chemical processing of hides and skins to bio beam house processing.

**UNIT III CLEANER PROCESSING: TANNING, POST TANNING AND FINISHING 8**

Less chrome and chrome-free tanning systems. Formaldehyde free syntan; VOX, AOX free post tanning; solvent free finishing systems; Latest concepts and trends in leather processing. Eco-labelling. integrated strategies to achieve permissible BOD, COD and TDS standards of tannery effluents



**UNIT IV BACTERICIDES AND FUNGICIDES 6**  
Anti bacterial and anti fungal compounds. Cis-trans isomerism.

**UNIT V CHEMISTRY OF TRANSITION METALS 9**  
D-block element with special emphasis on Chromium, Titanium, Iron, Aluminium and Zirconium including their redox behaviour.

**TOTAL : 45 PERIODS**

#### REFERENCES

1. March, J. "Advanced organic chemistry, Reactions, mechanisms and structure, 6th Ed. Reprinted" Wiley Eastern, New Delhi, 2001.
2. Finar, I.L., "Organic Chemistry", Vol.I and II, Fifth Edition, Reprinted ELBS Ed., New Delhi, 1991.
3. Solomons, T.W.G., "Organic Chemistry", 3rd Ed., Wiley, New York, 1984.
4. Norman, R.O.C., "Principles of Organic Synthesis", 2nd Ed., Chapman and Hall, London, 1978.
5. Torgeson, D.G., "Fungicides - An advanced treatise, agricultural and industrial applications, environmental interactions", Vol I and II, Academic Press, New York, 1967.
6. Fieser, L.F. and Fieser, M., "Reagent for Organic Synthesis,"Wiley, New York (1967).
7. Harborne, J.B., Mabry, T.J. and Mabry, H., "The Flavonoids", Chapman & Hall, London, 1975.
8. Cotton, F. and Wilkinson, G., "Advanced inorganic chemistry", John Wiley, New York, V Edition, 1988.
9. Huheey, J.E., Keiter, E.A. and Keiter, R.L., "Inorganic Chemistry: Principles of structure and reactivity", 4th edition, Harper Collins, New York, USA, 1993.
10. Kettle, S.F.A., "Co-ordination compounds", ELBS, 1975.

**LE9114 ADVANCED LEATHER BIOTECHNOLOGY L T P C  
3 0 0 3**

**UNIT I MICROBIAL BIOTECHNOLOGY 8**  
Microbial fermentation methods. Types of fermentations. Fermentation equipments, preparation of media, preparation of inoculum, separation and purification of products. Application of microbial biotechnology in the tanning industry namely enzymatic unhairing and effluent treatment.

**UNIT II PROTEIN AND ENZYME CHEMISTRY 10**  
Protein classification, separation, chromatographic and electrophoretic techniques, criteria of homogeneity. Enzyme classification, methods of estimation, sources of enzymes, purification and properties, specificity, activation, inhibition, application of enzymes in leather and other industries. Immobilization of enzymes and microbial cells in leather and allied industries - microbial genetics.

**UNIT III MOLECULAR BIOLOGY 8**  
DNA; genetic role, structure and replication - Structure of RNA and transcription - genetic Code - protein synthesis - control of gene expression - genetic engineering - principles and methods - recombinant DNA technology and its potentials. Artificial culturing of Skin.

**UNIT IV BIOCHEMICAL ENGINEERING 12**  
Basic principles, chemical reactions - mechanisms, kinetics, rates of reactions. Analysis of chemical reactions - types of reactions, batch, fed-batch, continuous, well-mixed, plug flow

tubular, mass and enthalpy balances, choice of reactor - Transport phenomena in biosystems - mass transfer in gas-liquid systems, application to effluent treatment diffusion, transport through living membranes - Design of fermentor and other fermentation vessels - instrumentation and control - downstream processes - recovery of particulates - application of various systems.

**UNIT V BY- PRODUCT UTILISATION**

**7**

Animal based raw materials and their possible uses - Industries based on animal based raw materials with particular references to India; Role of enzymes and micro organisms in animal wastes utilization. Biological treatment of waste water.

**TOTAL : 45 PERIODS**

**REFERENCES**

1. Stanbury, P.F. and Whitaker, A. and Hall, S., "Principles of Fermentation Technology", 2<sup>nd</sup> Edn., Pergamon Press, 1999.
2. Nelson, D.L. and Cox, M.M., "Lehninger principles of biochemistry", 4th Edn., W.H.Freeman Company, 2005.
3. Stent, G.S. and Calendar, C. "Molecular Genetics : An introductory narrative", 2nd Edn., Freeman, San Francisco, 1978.
4. Wiseman, A., "Topics in Enzyme and Fermentation Biotechnology" (Several volumes). New York, 1983.
5. Brown, T. A., "Gene Cloning and DNA Analysis: An Introduction", Blackwell Publishing, 5<sup>th</sup> Edn., 2005.

**LE9117 ADVANCED TECHNIQUES IN LEATHER PROCESSING - I**

**L T P C  
0 0 6 3**

Advanced processing techniques with emphasis on eco friendly leather manufacture. Case studies for specific product mix (upper, garment, upholstery, glove) with details of chemical audit, energy audit, water consumption during processing.

**TOTAL : 90 PERIODS**

**LE9121 INSTRUMENTAL METHODS IN LEATHER SCIENCE**

**L T P C  
3 0 0 3**

**UNIT I ANALYSIS OF VARIOUS SPECTROSCOPIC TECHNIQUES**

**10**

Electromagnetic spectrum and spectroscopic techniques, principles of magnetic resonance, mass and microwave spectroscopic techniques, block diagram of the instruments involved, the fields of application of spectroscopic techniques including study of solid surfaces.

**UNIT II CHROMATOGRAPHIC TECHNIQUES**

**8**

Theory and application of different chromatographic techniques such as paper, TLC, HPLC, ion-exchange, gel permeation, gel filtration, GLC and affinity.

**UNIT III APPLICATIONS OF SPECTROSCOPIC AND CHROMATOGRAPHIC METHODS IN LEATHER SCIENCE 12**

Application of spectroscopy to the analysis of mineral tanning salts, formaldehyde, dyes, pigments and effluents, NMR techniques in the characterization of synthetic tanning agents, fatliquors, finishing agents - Application of chromatographic techniques in separation, analysis and characterization of mixtures containing compounds such as biocides, peptides, proteins, mineral tanning salts, vegetable tannins, dyes and finishing agents with special emphasis on the characterization of polymers.

**UNIT IV ELECTROANALYTICAL METHODS 5**

Theory and applications of electroanalytical techniques like - Polarography, coulometry, cyclic voltammetry and chrono-potentiometry.

**UNIT V PRINCIPLES OF MICROSCOPIC AND OTHER TESTING METHODS IN LEATHER SCIENCE 10**

Principles involved in the morphological investigation on leather and polymers, various microscopic techniques including electron microscopy, mechanical testing devices and criteria for the measurement of mechanical properties - Imaging techniques for surface applications. Differential Scanning Calorimetry(DSC). Thermo Gravimetric Analysis (TGA).

**TOTAL : 45 PERIODS**

**REFERENCES**

1. Willard, H.H., Merritt Jr. L.L., Dean, J.A. and Settle Jr. F.A., "Instrumental Methods of Analysis", 6<sup>th</sup> Edn., CBS Publishers & Distributors, Delhi, 1986.
2. Ebsworth, E.A.V., Rankin, D.W.H. and Craddock, S., "Structural Methods in Inorganic Chemistry", ELBS, 1988.
3. Mendham, J. and Denney, R.C., "Vogel's Textbook of Quantitative Chemical Analysis",
4. Wesley publishing co, 6<sup>th</sup> Edn., 2000.
5. Ahuja, S. and Jespersen, N., "Modern Instrumental Analysis", Elsevier, 2006.
6. Engelhardt, H., "Practice of High Performance liquid Chromatography", Springer - Verlag, Berlin, 1986.
7. Bovey, F.A., "High Resolution NMR of macromolecules", Academic Press, New York, 1972.
8. Samuelson, P.O., "Ion Exchange Separation in Analytical Chemistry", John Wiley, New York, 1963.

**LE9122 ADVANCED CHEMISTRY AND TECHNOLOGY OF LEATHER CHEMICALS L T P C  
3 0 0 3**

General Classifications, Chemistry, Process Flow Sheets, Equipment needs, Quality criteria, Product Specifications and Pollution & Hazard Control in the manufacture of the following :

**UNIT I SYNTANS 9**

Chemistry and Technology for the manufacture of synthetic tanning agents based on phenol - formaldehyde, urea-formaldehyde, melamine-formaldehyde, sulphones, metal-complex, polymeric retans like acrylic, styrene- maleic and lubricating syntans.

**UNIT II FATLIQUORS 9**

Role of Surfactants in the manufacture of leather chemicals particularly fat liquors, acrylic binders



and lacquer emulsions. General chemistry and technology for the manufacture of fat liquors based on natural and synthetic oils, AOX free i.e. Absorbable Organic Halogen free fat liquors, odour free fish oil/cod oil based fat liquors, phosphated fat liquors, and water proof fat liquors.

**UNIT III BINDERS 7**

Technology for the manufacture of casein binders, casein-wax binders and cationic protein binders. Emulsion binders based on acrylates and urethanes. Adhesives used in the fabrication leather products. Physical properties and performance levels of binders and adhesives.

**UNIT IV DYES & PIGMENT DISPERSIONS 9**  
**(i) DYES**

Chemical and application orientated classification of dyes used in leather manufacture and properties thereof. Arylamines and health hazards.

**(ii) PIGMENT DISPERSIONS**

Classification of pigments and their properties. Manufacture of pigments dispersions with and without casein. Use of ball mill, triple roll mill and bead mill in the manufacture of pigment dispersions. Cationic pigment dispersions and their role in leather finishing.

**UNIT V TOP COATS 11**

Manufacture of nitro based lacquers and lacquer emulsions; manufacture of nitro free lacquers and lacquer emulsions. Role of solvents in the manufacture of lacquers and lacquer emulsions and VOC (Volatile Organic Compounds) restrictions in the use of such products in leather finishing. Aqueous poly urethane top coats - use and importance. Manufacture of wax emulsions, type of waxes used, cationic wax emulsions, slip agents, feel modifiers, and pull-up oils.

Manufacturing methods, properties and uses of waxes, shoe creams and finishes for leather goods.

**TOTAL : 45 PERIODS**

**REFERENCES**

1. Shah, K.M., "Handbook of Synthetic Dyes and Pigments", Vol. I - Synthetic Dyes, Vol. II & III Pigments, Multi-tech Publishing Company, 1998.
2. Journal of the American Leather Chemists Association
3. Journal of the Oil and Colour Chemists Association.
4. Colour Index Directory of Dyes and Pigments published by Society of Dyers and Colourists.
5. Groggins, P.H., "Unit processes in Organic Synthesis", McGraw-Hill Book Company, New York, 1958.

**LE 9123 TREATMENT AND DISPOSAL OF TANNERY WASTE L T P C  
3 0 0 3**

**UNIT I PHYSICO-CHEMICAL TREATMENT OF WASTEWATER 8**

Screening – Flow Equilisation – Theory on Coagulation & Flocculation – Sedimentation – Filtration – Detail study and design aspects with reference to tannery wastewater.

**UNIT II INTRODUCTION TO BIOLOGICAL TREATMENT OF WASTEWATER 7**

Introduction to microbial metabolism – Bacterial growth – Kinetics of Biological Growth

**UNIT III BIOLOGICAL TREATMENT OF WASTEWATER 8**  
Aerobic suspended growth system - Aerobic attached growth system - Anaerobic suspended growth system - Anaerobic attached growth system – Advanced Biological System – UASB – EGSB

**UNIT IV ADVANCED WASTEWATER TREATMENT FOR THE REMOVAL OF REFRACTORY ORGANIC COMPOUNDS 12**  
Theories on Advanced Oxidation Process viz., Photocatalytic treatment, Membrane Separation, Homogenous catalysis system using hydrogen peroxide, ozone etc - Heterocatalytic systems using metal oxides, activated carbon – Removal of Inorganic Compounds through electro dialysis, reverse osmosis, multiple effect evaporator, ion-exchange.

**UNIT V SOLID WASTE DISPOSAL 10**  
Secured land fill: leachability studies and management of leachates – Biomethanisation of Solid waste: with reference to energy recovery – Thermal incineration – Bacterial composting – Vermicomposting – Bioremediation.

**TOTAL : 45 PERIODS**

#### **REFERENCES**

1. Arceivala S.J. "Waste water treatment and disposal" Marcel Dekkar Inc., New York, 1981.
2. Tchobanoglous, G., Burton, F.L. and Stensel, H.D. (Eds), "Waste water Engineering, treatment, disposal and reuse: Metcalf and Eddy", 3<sup>rd</sup> edn. Tata-McGraw Hill Publishing, New Delhi, 1991.
3. Besselievie, B.E. and Schwartz, M. "The Treatment of Industrial wastes", 2<sup>nd</sup> edn., McGraw Hill, 1976.
4. McCarty P., Parkin, G.F. and Sawyer, C.N., "Chemistry for Environmental Engineering", 4th Edition, McGraw Hill, 1994.
5. Jordening H.J. and Winter, J., "Environmental Biotechnology", Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, 2004.
6. Carre, M.C., Vulliermet, A. and Vulliermet, B., "Environment and Tannery", Centre Technique du Cuir, Lyon, France, 1983.
7. UNEP/IEO & UNIDO - Tanneries and the Environment - A Technical guide, UNEP/IEO, Paris, 1991.
8. Hester, R.E. and Harrison, R.M., "Waste treatment and disposal", The Royal Society of Chemistry Cambridge CB4 4WF, 1995.

**LE9126 LEATHER CHEMICALS AND INSTRUMENTAL LABORATORY L T P C**  
**0 0 6 3**  
**LEATHER CHEMICALS LABORATORY 45**

Analysis and characterisation of natural and synthetic fatliquors in terms of charge, fat content, stability to acids and electrolytes - Evaluation of dyes and pigments in terms of hue, brilliance, particle size determination - Pigment volume concentration - Evaluation of pigment formulation for stability against sedimentation - Quality control methodologies for impregnating resins, binders, lacquers and lacquer emulsion top coats, urethane lacquer and emulsions - Analysis of tannery effluents for their B.O.D., C.O.D., total solids, chrome, sulphide, and leathers for biocides & formaldehyde.

**INSTRUMENTAL LABORATORY****45**

Ion exchange and gel filtration chromatographic techniques for the separation of mineral tanning species and determination of charge - UV and visible spectrophotometric techniques and their applications in the determination of chromium, iron, formaldehyde, dyes, NMR methods for fatliquors - Functional group identification in polymers using IR and NMR techniques. <sup>13</sup>C spectra of polymeric syntans. GPC for molecular weight determination of polymeric syntans - Leather surface examination by electron microscope.

**TOTAL : 90 PERIODS****LE9131****ENVIRONMENTAL MANAGEMENT SYSTEMS****L T P C  
3 0 0 3****UNIT I            LEGISLATIONS ON ENVIRONMENTAL POLLUTION CONTROL AND  
MANAGEMENT****9**

Environmental legislations. Water (Prevention and Control of Pollution) Act 1974, Air ((Prevention and Control of Pollution) Act 1986, Hazardous waste management rules. Standards for discharge of treated liquid effluent into land and water bodies including sea environment. Standards for disposal of gaseous emissions (SO<sub>2</sub>, SPM, NH<sub>3</sub>, H<sub>2</sub>S and HC) into atmosphere. Introduction to REACH regulations.

**UNIT II            CLEAN DEVELOPMENT MECHANISM (CDM)****9**

Overview on sustainable development. Green house gasses reduction mechanism. Project cycle for the CDM. CDM for small scale projects. Risks and opportunities for industries. Financing of CDM projects. Case studies.

**UNIT III           OCCUPATIONAL HEALTH HAZARDS AND INDUSTRIES****7**

Factory Act 1987 of India, Occupational health and safety requirements, Compliance of rules and guidelines of Factory Act applicable to industries.

**UNIT IV           ENVIRONMENTAL IMPACT ASSESSMENT (EIA)****11**

Principles of environmental impact assessment. Guidelines and legislature requirements for siting of industrial units/complexes. Preparatory procedures for EIA study, Evaluation of impact on air, water and land environment. Monitoring of ambient environment, including air, water and land, noise. Liquid and solid waste management.

**UNIT V            ENVIRONMENTAL AUDIT (EA)****9**

Principles of environmental auditing, cleaner technologies in industrial processes and evaluation of processes. Auditing techniques in preparation of EA.

**TOTAL : 45 PERIODS****REFERENCES**

1. Canter, W.L., "Environmental Impact Assessment", McGraw-Hill Inc., 2<sup>nd</sup> edition, 1996.
2. Rau, J.G. and Wooten, D.C., "Environmental Impact Analysis Handbook", McGraw-Hill, 1980.
3. UNEP/IED Technical Report Series No.2., "Environmental Auditing", ISBN 92 807 1253 5, 1990.
4. Jain, R.K., Urban, L.V., Stacey, G.S. and Balbach, H.E., "Environmental Assessment", McGraw-Hill, 1993.
5. Woolsten, H., "Environmental Auditing - An Introduction and Practical Guide", London, 1993.
6. Hillary, R., "The Eco-management and Auditscheme: A practical guide", Technical Communications (Publishing) Ltd. UK, 1993.

**LE9135**

**SEMINAR**

**L T P C**  
**0 0 2 1**

Students are expected to pursue one month industrial training during the summer vacation. Seminar presentations need to be made based on their comprehension on their industrial exposure.

**LE9136**

**PROJECT WORK PHASE I**

**L T P C**  
**0 0 12 6**

Under Project Work Phase I the students are expected to pursue preliminary work on a project undertaken by and assigned to him/her by the Department. A report should be submitted based on the information available in the literature or data determined in the laboratory/industry. The objective of the project work is to make use of the knowledge gained by the student at various stages of the degree programme. Project Work Phase I is intended to facilitate the better completion of project extended through Project Work Phase II in Semester IV.

**VIVA VOCE**

The object of the viva-voce examination is to determine whether the objectives of the Project work have been met by the student as well as to assess the originality and initiative of the student as demonstrated in the Project Work.

**LE9141**

**PROJECT WORK PHASE II**

**L T P C**  
**0 0 12 6**

The students should continue their work proposed in Project Work Phase I and are expected to complete the proposed work. A report should be submitted based on the data determined in the laboratory/industry. The objective of the project work is to make use of the knowledge gained by the student at various stages of the degree programme. This helps to judge the level of proficiency, originality and capacity for application of the knowledge attained by the student at the end of the programme.

**VIVA VOCE**

The object of the viva-voce examination is to determine whether the objectives of the Project work have been met by the student as well as to assess the originality and initiative of the student as demonstrated in the Project Work.

**LE9151 SCIENCE AND TECHNOLOGY OF LEATHER SUPPLEMENTS AND SYNTHETICS**

**L T P C  
3 0 0 3**

**UNIT I POLYMERS 5**

Polymer and rubber industries in India. Chemistry and Technology of the most common polymeric materials used in leather industry as supplements.

**UNIT II POLYMERIZATION TECHNIQUES 15**

Concept of a macromolecule, natural and synthetic polymers, modes of polymerization, radical, condensation, stereo-regular polymerization, polymerization kinetics, mechanism, anionic and cationic polymerization. Polymers with linear, branched and cross linked structure, thermoplastic and thermosetting polymers, bulk, solution, suspension and emulsion polymerization.

**UNIT III ANALYSES AND TESTING OF POLYMERS 10**

Molecular weight and distributions of polymers, different methods of molecular weight determinations, colligative properties, viscometry, light scattering techniques, thermal analysis of polymers, crystallinity, glass transitions and other mechanical properties, spectral analysis such as IR, UV and NMR of polymers.

**UNIT IV INDUSTRIAL POLYMERS 10**

Manufacture of industrially important polymers for plastics, fibres and elastomer - Polyethylene, polypropylene, polyvinyl chloride, polyvinyl acetate, copolymers, formaldehyde resins, polyvinyl alcohol, polyacrylonitrile, polystyrene, polyurethane, fluoro-carbon polymers, epoxy resins, polyamides, polyesters, alkyd resins, silicone polymers, cellulose.

**UNIT V FABRICATION 5**

Fabrication of polymeric materials, compounding and mixing, casting, extrusion, fibre spinning, moulding, coating foam fabrication. Manufacture of rubber and elastomers, Natural rubber, processing, vulcanizing synthetic elastomers, butadiene copolymer, nitrile rubber, polyisoprene, polybutadiene.

**TOTAL : 45 PERIODS**

**REFERENCES**

1. Ebevele, R.O., "Polymer science and technology", CRC Press, 2000.
2. Williams, D.J., "Polymer Science and Engineering", Prentice Hall, New York, 1971.
3. Austin, G.T., "Shrere's Chemical Process Industries", 5th ed., McGraw Hill International Book Co., Singapore, 1984.
4. Elrich, F.R., "Science and Technology of Rubber", Academic Press, New York, 1978.
5. Lubin, G. and Peters, S.T., "Handbook of composites", Van Nostrand Reinhold Co., New York, 1997.
6. Rodriguez, F., "Principles of Polymer System", Temple Press, London, 1965.
7. Miles, D.C. and Briston, J.H., "Polymer Technology", Temple Press, London, 1965.
8. Moncrieff, R.W., "Man-made Fibres", 5th Edn., Heywood Books, London, 1970.
9. Billmeyer Jr. F.W., "Textbook of Polymer Science", 3<sup>rd</sup> ed., John Wiley Interscience, New York, 1984.

LE9152

**COLLOID AND SURFACE CHEMISTRY**

L T P C

3 0 0 3

**UNIT I SURFACE TENSION, INTERFACIAL TENSION AND SURFACE ACTIVITY 9**

Definition, effect of temperature, spreading, wetting etc. - Young Laplace and Kelvin equations -Gibbs Law and its application - Critical evaluation of methods of surface tension determination.

**UNIT II BULK PROPERTIES OF SURFACTANT SOLUTIONS AND MONOLAYERS 9**

Critical micelle concentration (CMC) - Shape, Size, Aggregation, Hydration, Correlation times, Weight of micelles, etc. Different models and thermodynamics of micelle formation. Factors affecting CMC, Monolayers, types, their behaviour and industrial application. Lyophobic sols, Lyophilic systems and stability.

**UNIT III ADSORPTION BY SOLIDS 9**

Gibbs adsorption equation, Langmuir, Freundlich and BET isotherms. Double layer and Electrical aspects and industrial application. Compositions and structure of solid surface.

**UNIT IV SURFACTANTS 9**

Chemical and physico-chemical types, properties; Rheology : Viscosity, Non-Newtonian flow and Viscoelasticity - Birefringence: electrical and streaming ; X-ray and Neutron scattering. Various diffusional aspects and applications.

**UNIT V APPLICATION TO LEATHER TECHNOLOGY 9**

Wetting, cohesion & adhesion, contact angle, foams, detergency, emulsions, stability, surface properties and membrane technology.

**TOTAL : 45 PERIODS**

**REFERENCES**

1. Garret, H.E., "Surface Active Chemicals", Pergamon Press, London, 1972.
2. Adamson, A.W., "Physical Chemistry of Surfaces, 3rd Edn.", Wiley Inter-Science, New York, 1990.
3. Bienkiewicz, "Physical chemistry of leather making", Krieger Publishing Co., Florida, 1983.
4. Kitahara, A. and Watanabe, A., "Electrical Phenomena at interfaces", Pub:- Marcel Dekker Inc., New York, 1984.
5. Datyner, A., "Surfactants in Textile Processing", Marcel Dekker Inc., New York, 1983.
6. Shaw, D.J., "Introduction to Colloid and Surface Chemistry", 3rd ed., Butterworths, London, 1980.
7. Surfactant Science Series, John-Wiley Interscience Publications, New York, 1992.

LE9153

**ADVANCED CO-ORDINATION CHEMISTRY**

L T P C

3 0 0 3

**UNIT I CONCEPTS IN CHEMICAL BONDING 5**

Concepts and types of chemical bonding, group theoretical approach to structure and reactivity.

**UNIT II THEORIES OF CO-ORDINATION 10**

Valence bond theory, ligand field theory, molecular orbital theory, importance of ligand field stabilization energy, coordination geometrics and various oxidation states of metal ions.

**UNIT III                      SYNTHESIS, STRUCTURE AND SPECTROSCOPY OF TRANSITION METAL COMPLEXES                      15**

Synthetic strategies to transition metal complexes, spectroscopy of co-ordination compounds, structure and property relations in 'd' block elements. Aqueous chemistry of chromium, titanium, iron, aluminium and zirconium including their redox behaviour.

**UNIT IV                      REACTIVITIES OF TRANSITION METAL COMPLEXES                      10**

Ligand substitution process and their kinetics and mechanisms. Electron transfer reactions of metal complexes. Stability constant and equilibrium constants.

**UNIT V                      METAL PROTEIN INTERACTIONS                      5**

Metal - protein interactions and their role in structural stability of protein.

**TOTAL : 45 PERIODS**

**REFERENCES**

1. Cotton, F. and Wilkinson, G., "Advanced inorganic chemistry", John Wiley, New York, V Edition, 1988.
2. Huheey, J., "Inorganic Chemistry", 4<sup>th</sup> Edn., 1993.
3. Kettle, S.F.A., "Co-ordination compounds", ELBS, 1975.
4. Tobe, M.L., "Inorganic reaction mechanism", Nelkson, London, 1972.
5. Jorgenson, C.K., "Modern ligand field theory", North Holland, London, 1971.
6. Leaver, A.B.P., "Inorganic electronic spectroscopy", Elsevier, Amsterdam, 1968.
7. Drago, R.S., "Physical methods in inorganic chemistry", Rein Hold, New York, NY, USA, 1965.
- 8.

**LE9154**

**CHEMISTRY AND PHYSICS OF COLLAGEN**

**L T P C**  
**3 0 0 3**

**UNIT I                      MOLECULAR STRUCTURE OF COLLAGEN                      12**

Collagen triple helix; helix stabilization -synthetic collagen like polypeptides - denaturation - renaturation. Native collagen fibrils - axial structure - 3 Dimensional structure - stabilisation - assembly - fibril organisation. X-ray Diffraction studies of collagen. Electron microscopic appearance of collagen. Polymorphic ordered aggregates - Segment long spacing crystallites - Fibrous long spacing crystallites.

**UNIT II                      CHEMISTRY OF COLLAGEN AND ITS DISTRIBUTION                      5**

Collagen chains - molecules of nomenclature - common and distinctive chemical features - pro and chains - carbohydrates - structure and functions of pro collagens.

**UNIT II                      BIOSYNTHESIS OF COLLAGEN, CROSSLINKING, DEGRADATION                      13**

Transcription and translation - collagen genes and mRNA - synthesis of pro chains - intracellular processing of collagen - extracellular modifications. Steps in collagen biosynthesis and their significance - specific enzymes and their reaction.

Chemistry and properties of crosslinks - intramolecular and intermolecular crosslinks -difunctional and multifunctional crosslinks - lathyrism and (functional significance of) crosslinks - analysis of collagen crosslinks.

Mammalian collagenases - pathway of collagen degradation - sources of collagenases - methodology, assay and purification - biological properties - mechanism of action. Action of collagenases on collagen fibres - molecular weights of collagenases - latent collagenases. Inhibitors of collagenases.

**UNIT IV ISOLATION AND CHARACTERISATION OF COLLAGEN 6**

Extractability - selective precipitation behaviour - chromatographic properties - Electrophoretic properties. Amino acid composition and primary structure.

**UNIT V PHYSICO-CHEMICAL TECHNIQUES FOR COLLAGENOUS MATRICES 8**

Microscopy and spectroscopy techniques for collagen morphology. Non-invasive methods of liquid and solid imaging of biological specimen and their relevance to location of defects in hides/skins.

**TOTAL : 45 PERIODS**

**REFERENCES**

1. Ramachandran, G.N. (Ed) "Chemistry of Collagen, Treatise on collagen Vol.1, Academic Press, 1967.
2. Gould, B.S. (Ed) 'Biology of Collagen', Treatise on collagen, Vol.2, Academic Press, 1968.
3. Ramachandran, G.N. and Reddy, A.H.(Eds) "Biochemistry of collagen", Plenum, New York, 1976.
4. Pieze, K.A. and Reddy, A.H. (Eds), "Extracellular Matrix Biochemistry", Elsevier, New York, 1984.
5. Ramanathan, N. (Ed), "Collagen", Interscience Publishers, New York and London, 1962.
6. Eyre D.R., Paz M.A. and Gallop P.M., Annu. Rev. Biochem. 53, 717-748, 1984.
7. Nimni M.E.(ed) Collagen: Vol.3, Boca Raton CRC, 1988.
8. Olsen B.R. and Nimni M.E.(ed) "Collagen", Vol.4 Molecular Biology, Boca Raton CRC, 1989.
9. Miller, E.J. and Rhodes, R.K., "Structural and Contractile Proteins Extracellular matrix" Methods Enzymol vol.82, 1982.
10. Hay, E.D., "Cell Biology of Extracellular Matrix", 2<sup>nd</sup> Edn., Plenum Press, New York, 1991.
11. Kucharz, E.J., "The Collagens : Biochemistry and Pathophysiology", Berlin Springer, Verlag, 1992.
12. Fratzl, P; 'Collagen: Structure and Mechanics', Springer, 2008.

**LE9155 NANO TECHNOLOGY FOR LEATHER L T P C  
3 0 0 3**

**UNIT I INTRODUCTION TO NANOTECHNOLOGY 5**

The nanoscale. What is nanotechnology? Consequences of the nanoscale for technology and society. Beyond Moore's Law.

**UNIT II NANOMATERIALS: FABRICATION 9**

Structure and bonding  
Electronic band structure  
Electron statistics  
Bottom-up vs. top-down  
Epitaxial growth  
Self-assembly.



**UNIT III NANOMATERIALS: CHARACTERIZATION 9**  
 Structural  
 XRD, TEM, SEM, STM, AFM  
 Chemical  
 Optical

**UNIT IV APPLICATION OF NANO TECHNOLOGY IN TANNING, POST TANNING AND FINISHING 11**  
 Collagen – Skin Matrix – Association of nano materials with collagen matrix at various stages of processing – Pre tanning. Tanning. Post Tanning and Finishing.

**UNIT V NANO LEATHER CHEMICALS 11**  
 Manufacture of Nano based materials for leather manufacture: syntans, fatliquor, coloring and finishing chemicals

**TOTAL : 45 PERIODS**

**REFERENCES**

1. C. P. Poole, F. J. Owens, "Introduction to Nanotechnology", Wiley-Interscience, 2003.
2. B. Bhushan, "Springer Handbook of Nano-Technology", Springer, 2004.

**LE9156 ENGINEERING ECONOMICS IN LEATHER PRODUCTION L T P C 3 0 0 3**

**UNIT I PRINCIPLES OF PRODUCTION MANAGEMENT AND ORGANISATION 15**  
 Planning, organization, staffing, coordination, directing, controlling, communicating, organization as a process and a structure; types of organizations  
 Method study; work measurement techniques; basic procedure; motion study; motion economy; principles of time study; elements of production control; forecasting; planning; routing; scheduling; dispatching; costs and costs control, inventory and inventory control.

**UNIT II ENGINEERING ECONOMICS FOR PROCESS ENGINEERS - INTEREST, INVESTMENT COSTS AND COST ESTIMATION 10**  
 Time Value of money; capital costs and depreciation, estimation of capital cost, manufacturing costs and working capital, invested capital and profitability.

**UNIT III PROFITABILITY, INVESTMENT ALTERNATIVE AND REPLACEMENT 8**  
 Estimation of project profitability, sensitivity analysis; investment alternatives; replacement policy; forecasting sales; inflation and its impact.

**UNIT IV ANNUAL REPORTS AND ANALYSIS OF PERFORMANCE 4**  
 Principles of accounting; balance sheet; income statement; financial ratios; analysis of performance and growth.

**UNIT V ECONOMIC BALANCE AND QUALITY AND QUALITY CONTROL 8**  
 Essentials of economic balance – Economic balance approach, economic balance for insulation, evaporation, heat transfer.  
 Elements of quality control, role of control charts in production and quality control.

**TOTAL : 45 PERIODS**



## REFERENCES

1. Handley, W., "Industrial Safety Hand Book", 2nd Edn., McGraw Hill Book Company, 1977.
2. Heinrich, H.W., Petenen, D. and Roos, N., "Industrial accident prevention", McGraw-Hill, New York, 1980.
3. Blake, R.P., "Industrial Safety", 2<sup>nd</sup> Edn., Prentice Hall Inc., New Jersey, 1963.
4. Mannan, S(ed.), "Lees' Loss Prevention in the process industries", Vol. 1 to 3(3<sup>rd</sup> Edn.), Elsevier, 2005.
5. Marshall, V.C., "Major Chemical hazards", John Wiley & Sons, New York, 1987.
6. Guidelines for Chemical Process Quantitative Risk Analysis prepared for centre for Chemical Process Safety of the American Institute of Chemical Engineering, 1989.

**LE9158**                      **ENERGY MANAGEMENT IN LEATHER INDUSTRIES**                      **L T P C**  
**3 0 0 3**

**UNIT I**                      **ENERGY SOURCES**                      **9**

Conventional energy sources - non-renewable energy sources - coal, oil. Exploitation of natural energy resources and present trend. Need for energy conservation. Energy and future mankind.

Non-conventional energy sources - renewable energy sources - solar, wind, hydel, tidal energy. Potential of renewable energy source. Future energy sources.

**UNIT II**                      **ENERGY SOURCES OF LEATHER INDUSTRIES**                      **9**

Normal energy sources utilised in leather industries. Utilisation pattern of various energy sources.

Energy intensive unit operation in tannery, footwear, leather products units

**UNIT III**                      **ENERGY MANAGEMENT**                      **9**

Need for optimisation of energy utilisation. Production and energy utilisation. Process improvements for energy conservation. Use of energy efficient equipments for all applications. Energy conservation by effective maintenance techniques - house keeping and energy utilisation. Creating awareness of energy conservation among employees and various methods.

**UNIT IV**                      **ENERGY AUDITS**                      **9**

Definition of energy audit - need for regular energy audit in leather industries - methodology. Various steps involved in energy audits – implementation of audit recommendations.

**UNIT V**                      **ADOPTION OF RENEWABLE ENERGY SOURCES**                      **9**

Application of renewable energy sources in leather industries - solar energy - process hot water - Leather dyeing - salt and chrome recovery - wind energy - pumping - rural drum operations.

**TOTAL : 45 PERIODS**

## REFERENCES

1. Jernold H. Krentz, "Energy conservation and Utilisation", Allyu and Bacun Inc, 1976.
2. Gemand M. Gramlay, "Energy" Macmillan Publishing Co., New York, 1975.
3. Rused, C.K. "Elements of Energy Conservation", McGraw Hill Book Co., 1985.

**UNIT I MARKETING CONCEPTS 8**

Definition of basic management and marketing concepts - role of marketing in the production function - marketing concepts relevant to consumer durable like leather and leather chemicals.

**UNIT II HIDES AND SKINS - LEATHERS 8**

Indian livestock population over two decades - hides and skins availability, their sizes, marketing centres, channels, prices over two decades - leather production centres - channels, prices - leather products - centres and marketing channels.

**UNIT III MARKETING FUNCTION 9**

Market classification and segmentation - consumer market and buying behaviour - market management and forecasting - market planning and control - competition marketing strategy - product life cycle strategy - product and price strategy - sales promotion, publicity, advertising, packaging- marketing organisations- techniques of marketing research for consumer products.

**UNIT IV INTERNATIONAL TRADE 10**

General concepts of international marketing, principles relevant to leather and leather chemicals - global market for leather and leather chemicals - important production and consumption centres, product wise in the world - major world suppliers of leather chemicals.

**UNIT V EXPORT TRADE INDIA 10**

India's export trade in leather. India's share in the global level - India's competitors and their strength. International prices. Indian Government policies in the export promotion. Role of Indian and overseas promotional institutions for export growth - strategies for export promotion. Market constraints - quality, image, brand name, merchandising methods.

**TOTAL : 45 PERIODS****REFERENCES**

1. Kotler, P., "Marketing Management", 5<sup>th</sup> Edn., Prentice Hall, New Delhi, 1984.
2. "Report of All India Survey on Raw Hides and Skins", CLRI, Chennai, 1987.
3. Report on Capacity Utilisation and Scope for Modernisation in Indian Tannery Industry, CLRI, Chennai, 1990.
4. World Statistical compendium for Raw Hides and Skins, Leathers and Leather Footwear (FAO of UN).
5. Employment and working conditions and competitiveness in Leather and Footwear Industry (ILO of UN).
6. Thyagarajan, G., Srinivasan, A.V. and Amudeswari, A, "Indian Leather 2010, A technology, Industry and Trade Forecast", CLRI, Madras, 1994.
7. Sadulla, S., "The Leather Industry" Kothari's Deskbook Series, H.C. Kothari Group (Publications Division), Madras 1995.
8. "Tanning of hides and skins", ILO, Geneva, 1981, reprinted 1989.
9. "Report of nationwide survey on leather product units in India", CLRI, Chennai, 1997.

<b>UNIT I</b>	<b>INTRODUCTION TO ECO-LABELING</b>	<b>9</b>
Eco-labeling concept; Genesis of eco-labeling; basis of eco-labeling concept; various developments in eco-labeling concept; national standards; issues associated with meeting eco-label requirements; benefits of eco-label.		
<b>UNIT II</b>	<b>NATIONAL STANDARDS</b>	<b>9</b>
Eco-mark: criteria for eco-mark; award of eco-mark; promotion of eco-mark; industry response to eco-mark. Eco-mark for leather: Genesis of eco-mark for leather; Generic cleaner process systems and alternatives; generic end-of-pipe options; eco-mark for leather production; industry's response to eco-mark.		
<b>UNIT III</b>	<b>ECO-LABELING IN EUROPEAN UNION</b>	<b>9</b>
Eco-mark: criteria - Environmental and market related; EU eco-label performance; response of the industry and impact of EU eco-label.		
<b>UNIT IV</b>	<b>RESTRICTED SUBSTANCES IN LEATHER</b>	<b>9</b>
Overview of restricted substances; various developments pertaining to restriction of substances and background: PCP and TCP, formaldehyde, amines, Cr (VI), C10 – C13 chloralkanes, arsenic, cadmium, lead; possible sources of restricted substances, possible generation of restricted substances during manufacturing; generic solutions to avoid or scavenge restricted substances.		
<b>UNIT V</b>	<b>IMPACT OF EU ECO-LABEL ON INDIA'S LEATHER EXPORT</b>	<b>9</b>
Overview of EU leather footwear and garment industry; EU eco-label for leather footwear; capability of Indian industry to meet EU eco-label requirements; impact of EU eco-label on India's export		

**TOTAL : 45 PERIODS**

#### **REFERENCE**

1. Future of Eco-labeling; Frieder Rubik, Institute for Ecological Economy Research (IÖW), Heidelberg, Germany; and Paolo Frankl, University of Rome, Italy.