**SYLLABUS**

**FOR**

**TWO-YEAR M. TECH. PROGRAMME**

**IN**

**TEXTILE CHEMICAL PROCESSING**



|  |
| --- |
| **NAAC – A Grade** |

**DEPARTMENT OF TEXTILE ENGINEERING**

**COLLEGE OF ENGINEERING & TECHNOLOGY**

**(An Autonomous and Constituent College of BPUT, Odisha)**

**Techno Campus, Mahalaxmi Vihar, Ghatikia,**

**Bhubaneswar-751029, Odisha, INDIA**

[**www.cet.edu.in**](http://www.cet.edu.in)

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**COURSE: M. Tech. (TE – Textile Chemical Processing), Duration: 2 years (Four Semesters)**

**Abbreviations Used: U= UG, I= Integrated, P= PG**

**PC= Professional Core PE= Professional Elective OE= Open Elective**

**LC= Lab Course MC= Mandatory Course AC= Audit Course**

**L= Lectures P= Practical/Laboratory IA\*= Internal Assessment**

**T= Tutorial PA= Practical Assessment EA=End-Semester Assessment**

**\*Internal Assessment Max. Mark (30 marks) consists of Mid Semester (20 marks) and Quiz+Assignment (10 marks)**

**Subject Code Format:**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
| **Prog (U/I/P)** | **Type (PC/PE/OE/LC/MC/AC)** | **Department (CE/EE/IE/ME/…)** | **Semester (1/2/…/0)** | **Serial No. (1/2/3/…/99)** |

**1st SEMESTER**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Sl. No.** | **Subject** **Type** | **Subject Code** | **Subject****Name** | **Teaching Hours** | **Credit** | **Maximum Marks** |
| **L** | **T** | **P** | **IA** | **EA** | **PA** | **Total** |
| 1 | Core 1 | PPCTE101 | Advanced Chemical Processing | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| 2 | Core 2 | PPCTE102 | Chemistry of Dyes and Textile Chemicals | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| 3 | Professional Elective 1(Any One) | PPETE101 | Characterization of polymer and fibrous material CPFM | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| PPETE102 | High Performance Fibers |
| 4 | Professional Elective 2(Any One) | PPETE103 | Manufactured Fiber Technology | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| PPETE104 | Technical Textile |
| 5 | Mandatory  | PMCMH101 | Research Methodology & IPR | 2 | 0 | 0 | 2 | 30 | 70 | - | 100 |
| 6 | Lab 1 | PLCTE101 | Evaluation of Textile Material Lab | 0 | 0 | 4 | 2 | - | - | 100 | 100 |
| 7 | Lab 2 | PLCTE102 | Textile Chemical Processing Lab-I | 0 | 0 | 4 | 2 | - | - | 100 | 100 |
| **Total** | **14** | **0** | **8** | **18** | **150** | **350** | **200** | **700** |
| 8 | Audit 1 | Any one subject from Appendix-I | 100 |
| **Grand Total** | **800** |

**2nd SEMESTER**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Sl. No.** | **Subject** **Type** | **Subject Code** | **Subject****Name** | **Teaching Hours** | **Credit** | **Maximum Marks** |
| **L** | **T** | **P** | **IA** | **EA** | **PA** | **Total** |
| 1 | Core 3 | PPCTE201 | Advances in Finishing of Textiles | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| 2 | Core 4 | PPCTE202 | Sustainability issues in textile chemical processing | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| 3 | Professional Elective 3(Any One) | PPETE201 | Application of Nano Technology inTextiles | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| PPETE202 | Textile reinforced composites |
| 4 | Professional Elective 4(Any One) | PPETE203 | Process Control in Textiles Wet Processing | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| PPETE204 | Biotechnology in Textiles |
| 5 | Practical 1 | PPRTE201 | Mini Project with Seminar | 0 | 0 | 4 | 2 | - | - | 100 | 100 |
| 6 | Lab 3 | PLCTE201 | Textile Chemical Processing and Evaluation Lab-II | 0 | 0 | 4 | 2 | - | - | 100 | 100 |
| 7 | Lab 4 | PLCTE202 | Advanced Material Characterization and Computer Colour Matching Lab | 0 | 0 | 4 | 2 | - | - | 100 | 100 |
| **Total** | **12** | **0** | **12** | **18** | **120** | **280** | **300** | **700** |
| 8 | Audit 2 | Any one subject from Appendix-II | 100 |
| **Grand Total** | **800** |

**3rd SEMESTER**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Sl. No.** | **Subject Type** | **Subject Code** | **Subject****Name** | **Teaching Hours** | **Credit** | **Maximum Marks** |
| **L** | **T** | **P** | **IA** | **EA** | **PA** | **Total** |
| 1 | Professional Elective 5(Any One) | PPETE301 | Theory and Principle of colour management, application and communication | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| PPETE302 | Bio Polymers |
| 2 |  Open Elective | Any one subject from Appendix-III | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| 3 | Project 1 | PPRTE301 | Phase-I Dissertation | 0 | 0 | 20 | 10 | - | - | 100 | 100 |
| **Total** | **6** | **0** | **20** | **16** | **60** | **140** | **100** | **300** |

**4th SEMESTER**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Sl. No.** | **Subject Type** | **Subject Code** | **Subject****Name** | **Teaching Hours** | **Credit** | **Maximum Marks** |
| **L** | **T** | **P** | **IA** | **EA** | **PA** | **Total** |
| 1 | Project 2 | PPRTE401 | Phase-II Dissertation | 0 | 0 | 32 | 16 | - | - | 100 | 100 |
| **Total** | **0** | **0** | **32** | **16** | **-** | **-** | **100** | **100** |

**Abstract of Credit and Marks Distribution**

|  |  |  |  |
| --- | --- | --- | --- |
| **Sl. No.** | **Semester** | **Maximum Credits** | **Maximum Marks** |
| 1 | 1st Semester | 18 | 800 |
| 2 | 2nd Semester | 18 | 800 |
| 3 | 3rd Semester | 16 | 300 |
| 4 | 4th Semester | 16 | 100 |
| **Total** | **68** | **2000** |

**NB:**

* **Any one of the Courses in Appendix-I is to be Decided by the Concerned Department for Audit-1 (1st Sem)**
* **Any one of the Courses in Appendix-II is to be Decided by the Concerned Department for Audit-2 (2nd Sem)**
* **Any one of the Courses in Appendix-III is to be Decided by the Concerned Department for Open Elective (3rd Sem)**

**Semester-1**

**Core 1: Advanced Chemical Processing (PPCTE101)**

**Module-I**

Combined pre-treatment methods: Basic criteria for combining pre-treatment methods, combined desizing and bleaching, scouring and bleaching, desizing - scouring and bleaching of natural, manmade and blended textiles.

Short liquor methods: Concept of short liquor processing, advantages and limitations. Short liquor pre-treatment and dyeing of various textiles.

Fastness determination: Various Fastness criteria of dyed and printed textile. Grading and methods to determine fastness relating to washing, light, perspiration, sublimation and chlorine treatment.

**Module-II**

Evaluation of auxiliaries: Importance and method of evaluation of wetting agents, optical brighteners, flame-retardants, water repellents and soil release agents.

Reduction in wastage of energy: Development of new continuous and batch machines as well as modified processes.

Reduction in waste water load: Specification of water for use in industries and its discharge to public sewage, bio-degradation of chemicals. Measurement of waste water load. Preventive measures to reduce this load.

Theory of coloration of textiles: Basic approaches for application of colouring materials on various textiles, dye-fibre interaction through physical and chemical forces.

Thermodynamic study of dyeing: Study of vat dye on cotton, acid dye on wool and nylon. Dyeing equilibrium and concept of half time dyeing.

Development in chemical processing: Various developments in pre-treatments, dyeing, printing and finishing of textiles in reference to use of water, right first time dyeing and controlled application techniques.

**Module-III**

Process and quality control: Detailed study of chemical processing methods. Control of process parameters. Quality of raw and processed materials. Evaluation of quality of processed textiles after each processing step.

Shade reproduction and repetition: Theory and tristimulus values of colour, colour coordinates. Primary, secondary and tertiary colours. Colour yield. Analysis of shade. Preparation of shade data for reproduction.

Automation in dye house: Automation in dyeing machineries, colour rooms. On- line monitoring of concentration of dye and chemicals.

**Books Recommended:**

1. Bird C L and Boston W S, “The theory of coloration of textiles”, Dyers Company

Publication Trust, Bradford, England, 1975.

2. Manivaskaram N, “Treatment of Textile Processing Effluent”, Sakthi Publications,

Coimbatore, 1995.

3. Peters R H, “Textile Chemistry”, Vol- III, Elsevier Scientific Publishing Co., New York,

1975,

4. Smethwurst G, “Basic water Treatment”, IBT Publications, Delhi, 1989.

5. Sule A D , “Computer colour analysis”, New Age International (P) Ltd., New Delhi, 1997.

**Core 2: Chemistry of Dyes and Textile Chemicals (PPCTE102)**

**Module I:**

Introduction to Dye Chemistry- What is Dye? basis of colour, relation between colour and chemical constitution, colour index classification; Considerations in dye design; dye-substrate affinity, solubility & ionic groups, colour gamut; Colourant structural features, azo, anthraquinone, stilbene, thiozol, indigoid, quinacridone, quinoline, aminoketone & hydrozyketone, pthalocyanin, formazan& other dye classes.

Chemistry of dye intermediates-

Introduction- general synthesis route for e.g. primaries – dye intermediates – dyes; Importance of unit processes; important unit processes – nitration, sulphonation, halogenations, diazotisation, reduction of nitro group, preparation of selected intermediates.

**Module II:**

Chemistry of specific dye classes

Introduction to dye class, dye structure, common chromophores in the class, dye-fibre interaction, commercial products, impurities, standardisation, problems with generic dyes & drug room practises of anionic dyes, reactive dyes, disperse dyes, vat dyes, sulphur dyes, pigments, natural dyes, functional dyes and others.

Testing and analysis of dyes, Colour assessment & measurement: visual assessment of colour, instrumental methods, colorimetric analysis, dye identification, assessment of dyeing behaviour, computer colour matching; Evaluation & testing of dyes: standardisation & sampling, storage stability, physical forms, health & safety, in-service requirements, cost-effectiveness, dye-application properties.

**Module III:**

Functions and Properties of Process auxiliaries

The need for auxiliaries, the general types and characteristics of auxiliaries

Auxilliaries for Pretreatment; What is surfactant? Classification and properties, foaming and defoaming agents, Lubricating / anticreasing agents, Oligomer removers, sequestering agents, peroxide killers/ peroxide scavenger, core neutraliser, Enzymes, OBA’s

Auxiliaries in Dyeing and printing- Dispersing agents, solubilising agents, thickeners, acid liberating agents, alkalies, oxidising and reducing agents, electrolytes and pH control, exhausting agents, levelling and retarding agents, migration inhibitor for continuous dyeing, carriers, dyefixing agents, clearing agents, soaps and detergents.

Ecological concerns in Textile Auxiliaries- Ecological parameters for textile chemicals, Regulatory requirements, Eco-lable certification

**TEXT/REFERENCE BOOKS:**

1. Textile Analysis, E R Trotman and S R Trotman, Griffin, London
2. Systematic Analysis of surface Active Agents, Rosen & Goldsmith, Inter science Publisher Inc., New York,
3. Profiles in Analysis of Chemicals, N F Desai, Gokul Publishers
4. Dye house Laboratory Practices, T M Thompson, SDC
5. Evaluation of Textile Chemicals, V A Shenai and R H Mehra, Sevak Publication, Mumbai

**PE 1: Characterization of Polymer and Fibrous Material CPFM (PPETE101)**

**Module I:**

**Introductory:**

Basic textile polymers, thermoplastic and thermosetting polymers, Degree of polymerization and conditions that influences polymer characteristics and fibre performances, glass transition temperature. Orientation and crystalinity,

Spectroscopy:

Infrared spectroscopy. Introduction, experimental techniques, Infrared spectra of natural and synthetic fibres. Identification of fibres using IR. FTIR spectroscopy. Ray diffraction and Fluorescence. Principle, working procedure of X- ray diffraction technique. X-ray diffraction of natural and synthetic fibres.

X-ray Fluorescence and its application to textile related materials. NMR and Mass Spectroscopy: Principle, working procedure and application of NMR and Mass Spectroscope.

**Module II:**

Chromatographic Methods:

Theoretical considerations of chromatography.Gas chromatography– Instrumentation, qualitative analysis, quantitative analysis, theory and applications.High Pressure Liquid Chromatography– Instrumentation and applications.

**Module III:**

Electron Microscopy

Basic theory of electron microscopy. Imaging system, image-translating system of electron microscope. Principle, working procedure and application of scanning Electron Microscope and Transmission electron microscope.

Thermal Analysis:

Instrumentation, qualitative analysis, quantitative analysis, theory and applications of DTA, DSC, TGA.

**Reference books:**

1. Instrumental Methods of Analysis 7th Edition by H.H.Willard; L.L.Merritt, JohnA Dean, Frank A Settle, Jr. CBS Publishers & Distribution, Delhi.
2. Instrumental Methods of Chemical Analysis 5th Edition by Galen W. Ewing.
3. Basic Concepts of Analytical Chemistry, 2nd Edition by S.M. Khopkar
4. The Analytical Chemistry of Synthetic dyes Edited by K.Venkataraman. Wiley–Interscience Pub. John Wiley & Sons , NewYork.
5. Hand Book of Textile Testing Part 1to4, Bureau of Indian Standards.
6. Instrumental Analysis of Cotton Cellulose & Modified Cotton Cellulose–Robert T.O’ Connor.
7. Textile Laboratory Manual–W–Garner Vol.I & II.
8. Physical Methods of Investigating Textiles–ED R. Meredith & J.W.S. Hearle.
9. Handbook of Environmental Health & Safety–Principles & Practices– Herman Koren, Michael Bisesi Vol.-I&II.
10. Textile Testing & Its Role in Textile Business with Special Reference to Eco Friendly Textiles & Eco-Testing–Dr. G. S. Nadiger & S. Subramanian.
11. Vibrational Spectroscopy Theory & Applications–D.N.Sathyanarayana.
12. Analytical Methods for a Textile Laboratory–J.W.Weaver.
13. Mass Spectroscopy–E. Constantin & A. Schanell.
14. Profiles in Analysis of Chemicals–Dr. N.F. Desai.
15. Introduction to Electron Microscopy–Saul Wischnitzer.
16. X-ray Diffraction Methods in Polymer Science–Alexander Leray E.

**PE 1: High Performance Fibers (PPETE102)**

**MODULE I**

Definition, classification and structural requirements of high performance and specialty fibres, Polymerization, spinning and properties of aramids, aromatic polyesters, rigid rod and ladder polymers such as PBZT, PBO, PBI, PIPD, Manufacture of carbon fibres from polyacrylonitrile, viscose and pitch precursors, Concept of gel spinning and spinning of UHMPE fibres, structure and properties for UHMWPE fibre. Elastomeric polymers and fibres, Lyocell fibre production.

**MODULE II**

Conducting fibres: Polymer conductivity, processing of conducting polymers into fibres and fibre coatings. Spinning and properties of polyaniline (PANI) fibre. Glass and ceramic fibre: manufacturing process and applications. Methods of synthesis, production and properties of: glass and ceramic fibres. Basalt fibres and their applications. Specialty fibres: profile fibres, optical fibres, bi component fibres and hybrid fibres, Superabsorbent polymers and fibres.

**MODULE III**

Polyvinyl alcohol based fibres, Ultra-fine fibres: definition, manufacturing, characteristics and applications of microdenier fibres, Specialty fibres from new polymers, hybrid fibres, nano-composite fibres, Other specialty fibres: absorbent fibres, hollow fibres and profile fibres, bi-component fibres, optical fibres.

**Suggested references**

1. Salem David R., Structure Formation in Polymeric Fibres, First edition, Hanser Publishers,2000.
2. Ward I M, Developments in Oriented Polymers, Elsevier Applied Science,1987
3. Yang H H, Kevlar aramid fiber, John Wiley & Sons, Chichester, 1993.
4. Mukhopadhyay S K, ‘High-performance fibres’, *Textile Progress*, 1993, 25, 1–85.
5. Ozawa S and Matsuda K, High Technology Fibers Part B, edited by Lewin M and Preston J, Marcel Dekker, New York, 1989.
6. V. K. Kothari, Textile fibres: Developments and Innovations, First edition, IAFL publications,2000
7. Some review and research papers

**PE 2: Manufactured Fiber Technology (PPETE103)**

**Module I**

Polymer rheology in shear as well as extension. Polymer entanglements. Flow instabilities in Polymer fluids. Principles of solidification. Heat and mass transfer. Melt spinning. Force and momentum balance in spinline.

**Module II**

Stress induced crystallization. Experimental observations from melt spinning of polyamides and polyesters. Solution spinning. Dry and wet spinning. Transport phenomena. Kinetic and thermodynamic effects in solution spinning. Solution spinning of viscose and acrylic fibres. Dry jet wet spinning. Post spinning processes. Drawing and heat setting. Stress-strain-structure relationship.

**Module III**

Effect of post spinning operations on fibre structure and properties. Spin finish applications. Introduction to electrospinning.

**Recommended Books:**

1. Billmeyer, Fred W., and Fred W. Billmeyer. Textbook of polymer science. Vol. 19842. New York: Wiley, 1984.
2. Cook, J. Gordon. Handbook of textile fibres: man-made fibres. Elsevier, 1984.
3. Lewin, Menachem. Handbook of fiber chemistry. Crc press, 2006.
4. Mishra, S. P. A text book of fibre science and technology. New Age International, 2000.
5. Gupta, V. B., and V. K. Kothari, eds. Manufactured fibre technology. Springer Science & Business Media, 2012.
6. Murthy, HV Sreenivasa. Introduction to textile fibres. WPI Publishing, 2018.
7. Moncrieff, Robert Wighton. Man Made Fibres. 1966.
8. Hearle, John WS, and William Ernest Morton. Physical properties of textile fibres. Elsevier, 2008.
9. Gowariker V R, Viswanathan N V and Sridhar J. Polymer Science, New Age International Ltd., New Delhi, 1996.
10. Vaidya, A. A. Production of synthetic fibres. Prentice-Hall of India Private Limited, 1988.
11. Meredith, Reginald. Mechanical Properties of Textile Fibres. (1956).
12. Ugbolue, S C O. Structure/property relationships in textile fibres. Textile progress 20, no. 4 (1990): 1-43.

**PE 2: Technical Textile (PPETE104)**

**Module 1:**

**Introduction, definition, classification, market and scope:** Definition, classification, products, market overview and growth projections of technical textiles. Fibres, yarns and fabric structures in technical textiles and their relevant properties.

**Geotextiles and other geosynthetics:** Types and application of geosynthetics. Functions and application areas of geotextiles. Fibres and fabric selection criteria for geotextile applications. Mechanics of reinforcement, filtration and drainage by geotextiles. Soil characteristics. Methods of prediction of geotextile life and long term survivability in soil.

**Module 2:**

**Automotive Textiles:** Application of textiles in automobiles. Requirement and design for pneumatic tyres, airbags and belts. Methods of production and properties of textiles used in these applications.

**Protective Textiles – Protection against cold, bullets, cuts:** Clothing requirements for thermal protection, ballistic protection. Extreme winter clothing with low heat transmission and comfort properties. Mechanism of high velocity impact absorption. Materials used in bullet proof and cut resistant clothing. Design for soft and hard armour. Design principles and evaluation of these protective clothing in these applications.

**Theory of filtration, types and concepts, filter fabrics:** Textile and other filter media for dry and wet filtration. Mechanisms of separation. Requirements for good filter media and filtration. Fibre and fabric selection for filtration.

**Module 3:**

**Agro textiles, Architectural Fabrics, Textiles for Packaging etc.:** Type and properties of fabrics used in these applications. Raw material, method of production and areas of application of agro textiles. Different types of architectural fabrics and their property requirements. Design of temporary and permanent structures using fabrics. Different types of fabrics used for packaging. Their production techniques and properties.

**Sports textiles**, Fundamental Aspects of Sports Textiles, Classification, Requirements, Textile structures, Comfort and performance, Testing and Evaluation, Aerobic clothing, athletic clothing, clothing of various sports, games shorts, gloves, jackets, shorts, socks, sweatshirts, swimwear

**Suggested texts and reference materials:**

1. Handbook of Technical Textiles, Eds. A.R. Horrocks and S.C. Anand, Woodhead Publishing, U.K, 2000.
2. Wellington Sears Handbook of Industrial Textiles, Ed. S. Adanur, Alburn University, USA, Taylor & Francis, 1995.
3. Textiles in Automotive Engineering, Walter Fung and Mike Hardcastle, Woodhead Publishing, 2001.
4. Geotextiles, N.W.M. John, Chapman and Hall, New York, 1987.
5. Technical Textile Yarns: Industrial and Medical Applications, Edited by R.Alagirusamy and A. Das, Woodhead Publishing Ltd, 2010 in association with Textile Institute.

**MC: Research Methodology & IPR (PMCMH101)**

**Module I:**

Introduction to RM: Meaning and significance of research. Importance of scientific research in decision making. Types of research and research process. Identification of research problem and formulation of hypothesis. Research Designs.

Types of Data: Primary data Secondary data, Design of questionnaire; Sampling fundamentals ad sample designs, Methods of data collection, Measurements and Scaling Techniques, Validity & Reliability Test.

**Module II:**

Data Processing and Data Analysis-I, Data editing, Coding, Classification and Tabulation, Descriptive and Inferential Analysis, Hypothesis Testing- Parametric Test (z test, t test, F test) and non-parametric test (Chi square Test, sign test, Run test, Krushall-wallis test).

**Module III:**

Data Analysis II: Multivariate Analysis- Factor Analysis, Multiple Regression Analysis. Discriminant Analysis, Use of Statistical Packages.

**Reference Books:**

1. Research Methodology, Chawla and Sondhi, Vikas

2. Research Methodology, Paneerselvam, PHI

**Course Outcomes:**

**CO1:** Understood the Meaning of research problem, Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.

**CO2:** Got the knowledge of How to get new ideas (Criticizing a paper) through the Literature Survey (i.e. Gap Analysis).

**CO3:** Understood the Filing patent applications- processes, Patent Search, Various tools of IPR, Copyright, Trademarks.

**CO4:** Understood How to apply for Research grants and Significance of Report Writing, Steps in Report Writing, Mechanics and Precautions of Report Writing, Layout of Research Report.

**CO5:** Got the knowledge of How to write scientific paper & Research Proposal - Structure of a conference and journal paper, how (and How Not) to write a Good Systems Paper:

**Lab 1: Evaluation of Textile Material Lab (any five) (PLCTE101)**

**List of Experiments:**

|  |  |
| --- | --- |
| 1 | Introduction : principles and effects of test conditions in measuring basic physical, mechanical and aesthetic properties of textile materials Standards & test methodsProduct specification |
| 2 | Yarn characteristics,Yarn count & twist,Yarn evenness & hairiness |
| 3 | Yarn strength,Fiber strength testing,Filament yarn stretch & bulk |
| 4 | Woven fabric construction, Fabric defects |
| 5 | Fabric tensile properties,Fabric tearing & bursting strengths |
| 6 | Seams & stitches,Seam strength,Fabric abrasion properties |
| 7 | Fabric bending,Fabric drape,Measuring hand |

**Reference:**

* Booth J.E., “Principle of Textile Testing”, Butterworth Publications, London, 1989
* Saville B.P., “Physical Testing of Textiles”, Textile Institute, Manchester, 1998
* Kothari V. K., “Testing and Quality Management”, Progress in Textile Technology Vol.1, IAFL Publications, New Delhi, 1999.
* Robert S Merkel, "Textile Product Serviceability by Specification", Pearson Books, 2006, ISBN: 9780023805653
* Physical testing of textiles, B. P. Saville, Woodhead
* Watson’s textile design and colour Seventh Edition Edited by Z. Grosicki, Woodhead
* Chemical testing of textiles, Edited by Q. Fan, Woodhead
* Total colour management in textiles, Edited by J. Xin, Woodhead
* Fabric testing, Edited by J. L. Hu, Woodhead

**Lab 2: Textile Chemical Processing Lab-I (Any Ten) (PLCTE102)**

**List of Experiments:**

1. Desizing of cotton-acid desizing, enzyme desizing, oxidative desizing of cotton and evaluation of efficiency of desizing; iodine staining and weight loss method
2. Bleaching of Cotton by sodium hypochlorite and hydrogen peroxide; Bleaching of polyester and nylon with Sodium chlorite and hydrogen peroxide; Evaluation of efficiency of bleaching using whiteness index
3. To study dyeing of different types of reactive dyes on viscose and cotton
4. To study dyeing of acid dyes on wool and silk
5. To study dyeing of polyesters using different disperse dyes and dyeing techniques and measurement of absorbance of extracted dye.
6. Dyeing of Natural dye on wool and cotton followed by application of mordants
7. Shade matching on Cotton using Vat and Reactive Dyes
8. Direct style of printing of Reactive Dyes on cotton
9. Direct style of printing of Pigments on cotton and polyester
10. Resist style of printing – White resist under reactive dyed ground
11. Special print effect – Tie and Dye style of printing
12. Application of cross linking agent and testing of finished fabric for crease recovery angle, tensile and tear strength
13. Application of softeners and testing of finished fabric for its feel, drapability, effect on absorbency, yellowing, shade change, sewability testing, Handlometer /surface friction assessment.
14. Application of Optical brightening agent and evaluation of fabric for its whiteness.
15. Application of antibacterial agents and testing of finished fabric for antibacterial property.
16. Determination of colour fastness to various agencies like washing, light and rubbing
17. Determination of colour fastness to perspiration and bleaching agents
18. Determination of colour fastness to sublimation and hot pressing.
19. Evaluation of colour fastness to Bleach with hypochlorite and peroxide.

**Audit -1**

**[To be decided by the Department]: Refer Appendix-I**

**Semester-2**

**Core 3: Advances in Finishing of Textiles (PPCTE201)**

**Module I**

Different concept and mechanism of application of chemical finishes by padding, low wet pick up and foam processing methods. Modern developments on application of textile chemical finishes.

**Module II**

Chemistry, properties and application of softening agents, antistatic finishes, water repellent and oil repellent finishes, ant-pilling finishes, soil release finishes, flame retardant finishes, antimicrobial finishes. Concept of UV-A and UV-B, factors affecting UV protection.

Principles, practice and chemistry of easy care, durable press, low formaldehyde and zero formaldehyde based cross-linking finishes.

**Module III**

Chemical finishing in relation to environmental issues. Surface and polymer treatment using Plasma and other modern technology like LBL, Sol-gel, Nanocoating

**Recommended text books:**

1. Thomas Vickerstaff, The physical chemistry of dyeing. Second Edition. Interscience, New York-London, 2003.
2. Hg. von MenachemLewin und Stephen B. Sello, Handbook of fiber science and technology. Vol. II. Chemical processing of fibers and fabrics. Functional finishes: Part B. Marcel Dekker, Inc. New York/Basel, 1984
3. M. Lewin and S. B. Sello, Chemical processing of fibers and fabrics—functional finishes, Part B, Marcel Dekker, New York, 1984
4. J.T. Marsh, An Introduction to Textile Finishing, Chapman and Hall Ltd, UK (1948)
5. V.A Shenai, Technology of Textile Finishing, Sevak Publication, Mumbai
6. H. Mark, N. S. Wooding, and S. M. Atlas, Eds., Chemical aftertreatment of textiles, Wiley-Interscience Division of John Wiley and Sons, Inc., New York, 1971.,
7. W. Schinlder and P J Hauser, Chemical Finishing of Textiles, 1st Edition, Woodhead, UK, 2004.
8. Derek Heywood, Textile finishing, SDC, UK, 2003.

**Core 4: Sustainability Issues in Textile Chemical Processing (PPCTE202)**

**Module I:**

Sustainability, Green Processing technologies, which require fewer chemicals, consume less energy and water and release cleaner effluent, Technologies using organic and natural fibers,

**Module II:**

Biocomposites, Process technologies using new enzymes, ozone, and foam technology, Low-salt reactive dyes, Combined dyeing and finishing, Industrial Hazardous Waste Management, in-plant management, reduction, recycling and disposal of waste,

**Module III:**

Laws related to environmental protection specially with reference to textile industry, Compliance, certification, social accountability and ethical practices.

**Reference:**

1. S.S Muthu (ed.) series, Textiles and Clothing Sustainability, Textile Science and Clothing Technology,
2. Environmental Aspects of Textile Dyeing - 1st Edition. Print Book & E-Book. ISBN 9781845691158, 9781845693091, Elsevier
3. Assessing the Environmental Impact of Textiles and the Clothing Supply Chain2014, Wood Head Publication: Subramanian Senthilkannan Muthu
4. Challenges in Sustainable Wet Processing of Textiles, S. Saxena, A.S.M. Raja & A. Arputharaj, Spinger, DOI 10.1007/978-981-10-2185-5\_2
5. Journals, Current Issues

**PE 3: Application of Nano Technology in Textiles (PPETE201)**

**Module I**

Introduction to Nanoscience and Nanotechnology; Size and surface dependence of their physical and chemical properties such as mechanical, thermodynamical, electronic, catalysis etc; Synthesis of Nanomaterials used in Textiles such as carbon nanotube, fullerenes, metal and metal oxide nanoparticles i.e. nano silver, nano silica, nano titania, nano zinc oxide, nano magnesium oxide etc.;

**Module II**

Surface functionalization and Dispersion of nanomaterials; Nanotoxicity, Characterization techniques i.e. XRD, AFM, SEM/ TEM, DLS etc.; Nanomaterial applications in textiles and polymers; Nanocomposites: definition types, synthesis routes; nanocomposite fibres and coatings e.g. gas barrier, antimicrobial, conducting etc.; Nanofibres: preparation, properties and applications i.e. filtration, tissue engineering etc.; Nanofinishing: self-cleaning, antimicrobial, UV protective etc.;

**Module III**

Nanocoating on textile substrates: Plasma Polymerisation, Layer-by-layer Self Assembly, Sol-Gel coating etc.

**Recommended Books:**

1. P Brown, K Stevens, “Nanofibers and nanotechnology in Textile”, WoodHead publishing.
2. A.K. Haghi, G.E. Zaikov, “Development of Nanotechnology in Textile”, Nova Publishers, NewYork.
3. Sakka, Sumio, and Hiromitsu Kozuka, eds. Handbook of sol-gel science and technology. 1. Sol-gel processing. Vol. 1. Springer Science & Business Media, 2005.
4. Mishra Rajesh, and Jiri Militky. Nanotechnology in Textiles: Theory and Application. Woodhead Publishing, 2018.

**PE 3: Textile reinforced composites (PPETE202)**

**Module I**: Definition, classification and materials used in composites

Definition of composites, textile composites and textile structural composites, Materials for composites, Fibre - glass, carbon, aramid, boron, ceramic and natural fibres, Matrices, classification, properties and selection of matrices, Polymer matrix, Thermoset matrix – epoxy, polyester, vinyl ester etc, Thermoplastic matrix – polyether ether ketone, polyphenylene sulphide, polysulfone, Metal matrix and Ceramic matrix, Carbon–Carbon Composites, Recycling Fiber-Reinforced Composites

**Textile structures used in composites**

Reinforcement structures, Classification of Textile Reinforced Structures based on axis and dimension; non-axial, mono-axial, biaxial, triaxial and multiaxial structures, UD, 2D,3D structures, Structural anisotropy, parallel arrangement and series arrangement of components, Chopped strand and Milled fibres, Hybrid fabrics, Non-crimp fabrics, Laminates, Stitched structure, Embroidery structures, Composite Rope, Braided structures

**Module II: Manufacturing Methods**

Methods of composite processing, Hand and machine lay-up, spray-up moulding, vacuum-bag and pressure-bag moulding, autoclave, compression moulding, liquid resin molding, resin transfer moulding, Poltrusion, filament winding, injection moulding, thermoplastic processing, automated tape laying.

**Characterization of Composites**

Characterization of Composites, Mechanical Analysis, Tensile, bending, compression, impact, fatigue behavior, DMA, Thermal properties Internal Geometry of reinforcement structures, Fibre volume fraction and surface geometry, Morphological characterization of composites reinforced by various textile structures, study of fibre-matrix behaviour at interface, Damage analysis,Failure mechanisms, matrix cracking, fibre fracture, debonding, delamination, fibre pullout, micro-buckling, kink bands, Fractography, Failure criteria, Non-Destructive Testing, electromagnetic, chemical spectroscopy.

**Module III: Theory of composites**

Theory of composites, Composite concepts and theory, Rule of mixture, the synergy effect, Logarthmic mixing rule, Geometry of reinforcement - Particular, granular, fibrillar, lamellar, Properties of components, properties of interface, mechanism of adhesion, Fibre volume fraction calculation.

**Applications of Textile structural composites**

Automotives, marine, aerospace, sports, protection systems, wind energy, machine components, construction engineering

**Suggested texts and reference materials:**

1. Textile structural composites by Tsu Wei Chou and Frank K. Ko, ELSEVIER, 1989
2. 3D Fibrous assemblies, by Jinlian Hu, WOODHEAD, 2009
3. High performance fibre composites, by J G Morley, Harcourt Brace Jovanovinch, 1987
4. Textile structural composites, by S Advani, Conference proceedings, 2007
5. Design and Manufacturing of Textile structural composites by *A Long, WOODHEAD*

**Books Recommended**

1. Fibre reinforced composites by P.K.Mallick CRC press.

2. HANDBOOK OF TECHNICAL TEXTILES *Edited by* A R Horrocks and S C Anand.

**PE 4: Process Control in Textiles Wet Processing (PPETE203)**

**Module I: Introductory:**

Introduction to textile chemical testing – aim and scope. Quantitative chemical analysis of textile fibres and their blends, Process control flow chart and control measures in each.

**Module II: Preparatory:** Quantitative estimation of bleaching agents (hypochlorite, chlorite and peroxide) and dyes. Test of Desizing, scouring, mercerization. Estimation of mechanical and chemical degradation of cotton, wool, silk and polyester (aldehyde and carboxyl group estimation in cellulosics, amino group, estimation of protein fibres, fluidity/viscosity measurement, critical dissolution time

**Dyeing:** Colour fastness of dyes on textiles (wash, light, rubbing, hot press, perspiration, etc). International standards (AATCC, ISO, ASTM, BIS)

**Module III: Auxiliaries, Finishing & Printing:**

Evaluation of various chemicals, auxiliaries used in wet processing plants. Methods of evaluation of various finishes on textile material. Measurement of viscosity of chemical ingredients, printing paste, instruments used in chemical analysis.

**TEXT BOOKS**

1. Analytical Methods for a Textile laboratory, JW Weaver
2. Technology of Textile Processing, VA Shenai
3. An Introduction to Textile Bleaching, JT Marsh
4. AATCC Technical Manual Vol.-76,
5. Chemical Testing of Textiles, Qinguo Fan,CRC Woodhead
6. Textile Processing and Properties: Preparation, Dyeing, Finishing and performance, T.L. Vigo, ELSEVIER
7. Chemical Technology in the Pre Treatment Processes of Textiles, S.R.Karmakar, ELSEVIER
8. Process Control in Textile Manufacturing, A Majumdar, A. Das, R Alagirusamy, V K Kothari, Woodhead

**PE 4: Biotechnology in Textile Processing (PPETE204)**

**Module-I**

Enzyme engineering: Isolation and purification of enzymes; immobilization of enzymes: enzyme engineering; synzymes; Uses of enzymes in textile industries. Developments in singeing, desizing and its eco-aspects, size recovery, bleaching and its eco-aspects, classification of enzymes, Mode of action of enzyme, Factors affecting efficiency of enzyme treatment. Enzyme retted flax using different formulations, influence of enzymatic pretreatment on the colours of bleached and dyed flax fibers, combined bioscouring and bleaching of cotton fibers, effect of ultrasound on the performance of industrial enzymes used in cotton bio-preparation/bio-finishing applications, Enzymatic degumming, enzymatic H2O2 bleaching.

**Module-II**

Biotechnology in retting of jute, Deterioration of textiles, painted surfaces, and their prevention. Use of enzymes in detergents. Dyes from microorganisms, napththoquinone dye, antraquinone dye, indigo dye. Textile in waste water treatment, biofilters and bioscrubbers, Fungi in decolouration, degradation of azo dye by P. chrsosporium, Gram negative bacteria degrading dye stuffs. Natural fiber improvement, biobased fibre (biopolymers), chemical process substitutions, New textiles with antimicrobial properties, biofinishing, improvement of texure and of cotton. Herbal softner for textile

**Module-III**

Microorganisms and their enzymjes in bioprocessing, cellulose, amylase, pectinase, catalase, laccases, lipages, peroxidases. Biofabric, biotech production of natural fiber, modification of properties of textile, production new polymeric natural, polyamides (i.e. protein polymers) and polysters(production of biopolysters). Bacterial cellulose and polysaccharides viz., chitin, alginate, dextran and hyluronic acid, Transgenic cotton

**References.**

1. Biotechnology in Textile processing, by Georg M. Guebitz, Artur Cavaco-paulo, Ryszard Kozlowski, The Hawarth Press, Inc.
2. Biotechnology in Textile by Ryszard Kozlowski, Georg M. Guebitz, Artur Cavaco-Paulo ISBN : /9781560221432, CRC Press
3. Journals

**Mini Project with Seminar (PPRTE201)**

**[To be decided by the Department]**

**Lab 3: Textile Chemical Processing & Evaluation Lab-II (PLCTE201)**

**List of Experiments:**

1. Absorption and transmission measurement, Lambda **Max by** UV Vis Spectrophotometer
2. Lambert-Beer’s law, Dye strength determination, Dye exhaustion calculation.
3. Measurement & Interpreting fabric reflectance and K/S results.
4. Measurement of light fastness of reactive & direct dye.
5. Measurement of wash fastness
6. Rubbing fastness.
7. Perspiration fastness
8. Evaluation of Dyed samples and interpreting CIE L\*a\*b\* **results, DE, Whiteness** Yellowness index.
9. Experimenting with colorimeter, Pantone shade
10. Color vision/blindness, Eye color testing, Light sources, Irradiance
11. Colorfastness tests
12. Effluent **testing:** BOD, COD,
13. Effluent **testing: TDS**, TSS
14. Determination of cellulose **decomposition,**
15. Antimicrobial Test
16. HLB Value
17. Formaldehyde Content

**Lab 4: Advanced Material Characterization and Computer Colour Matching Lab. (Any Ten) (PLCTE202)**

1. Colour data base preparation in computer colour shade prediction
2. Colour Perception test, Metamerism.
3. Computational colour calculation in MATLAB r2XYZ, XYZ2Lab, Colour Difference
4. FTIR study for identifying and interpreting fibres and chemical processes.
5. Raman spectroscopy
6. Computer colour matching, Making of database of dyes.
7. shade matching, shade correction, colour difference, measurement, shade sorting, measurement of whiteness and yellowness index, etc on the CCM instrument.
8. SEM with EDS:
9. STA Analysis and Interpretation, Determination of Glass Transition Temperature
10. UV Visible colour sensors with Arduino.
11. Hydrodynamic Diameter and Zeta Potential.
12. NMR
13. GLC
14. Atomic Absorption Spectroscopy

**Audit-2**

**[To be decided by the Department]: Refer Appendix-II**

**Semester-3**

**PE 5: Theory and principle of colour management, application and communication (PPETE301)**

**Module I:**

**Color theory:**

Additive and subtractive system, Grass man Law, Trichmoaticity, Opponent theory. Munsell colour order system. Beer-Lambest law, Kubelka-Munk Equation. Spectrophotometric curves and their relationship to pre-received colour. Instruments for the measurement of the colour of transparent and opaque objects. Principles of spectrophotometry. Source of natural light, sources of artificial light, CIE illuminants, Absorption & scattering of light. transmittance, Optical density, K/S, Colorimeters. Munsell’s system of colour specification. Relationship of hue, value and chroma.

**Module II:**

Colour perception

Basic concept of colour perception, construction of human eye, brief idea about the relation between colour and chemical constitution. Various causes of colour generation.

Visual description

Visual description of colour, colour order systems, types, their utility and limitations, detailed description of Munsell colour order system.

Physical aspects

Additive and subtractive mixing of colour, Interaction of light with object – reflection, transmission and scattering, factors governing transmission, Beer’s law, Lambert’s law, scattering of light, Kubelka-Munk function. Concept and definition of light sources, illuminant and colour temperature. Various light sources and corresponding illuminants. Colour rendering index,

Color measurements and Parameters: Colour measuring instruments – colorimeters, spectrophotometers and their components. Measuring geometry, Standard observer colour matching functions. Tristimulus values. Chromaticity coordinates. Metamerism. Whiteness & Yellowness Indices, Computer aided Colour matching and recipe prediction. CIE L\*a\*b\*, CIE L\*c\*h\*, CIE colour space, DE, DE CMC. Measurement conditions. CCM applications and reports for QC. Shade correction

**Module III:**

**Color Communication:**

Device dependent and device independent colour spaces, Computer and display RGBs, Imaging Systems and sensors, Colour space transformations, Colour Gamut, ICC profile.

Pantone and HTML reference. Shade Card, Visual Perception chromatic adaptation and colour constancy.

**TEXT BOOKS:**

1. R. McDonald, Colour Physics for Industry, Society of Dyers and Colourists, Bradford, UK , 1997
2. A.K. Roy Choudhury, " Modern Concept of Color and Appearance" published jointly by Science Publishers, Inc., Enfield, NH 03748, USA, and Oxford & IBH Publishing Co. Pvt. Ltd.New Delhi, 2000.
3. M L Gulrajani, Colour Measurement: Principles, advances and industrial applications. Edited by Woodhead Publishing Series in Textiles No. 103, ISBN 1 84569 559 3, 2010.
4. A.K. Roy Choudhury, Principles of colour and appearance measurement, Volume1. Object Appearance, Colour Perception and Instrumental Measurement (Woodhead, UK). Released on 27 Jan 2014.
5. A.K. Roy Choudhury, Principles of colour and appearance measurement, Volume 2: Visual Measurement of Colour, Colour Comparison and Management, released on 13 Oct., 2014.
6. Committee on Colorimetry of the Optical Society of America, *The science of color*, Thomas Y. Cromwell, New York, 1953.
7. K McLaren, *The Colour Science of Dyes and Pigments*, Adam-Hilger, Bristol (U.K.), 1983.
8. Kurt Nassau, *The Physics and Chemistry of Colour*, Wiley-Interscie­nce, New York, 1983.
9. H. S. Shah and R. S. Gandhi, *Instrumental colour measurements and computer aided colour matching for textiles*, Mahajan, India, 1990.
10. R W G Hunt, *Measuring Colour*, Ellis Horwood, Chichester (U.K.), 1987.
11. D. B. Judd and G. Wyszecki,*Color in business, science and industry,* 2nd.Ed., John Wiley & sons, New York, 1963.

**PE 5: Bio Polymers (PPETE302)**

**MODULE I**

**Basics of Biotechnology**

Definition, origin and historical development, concepts of biotechnology in general and that of White Biotechnology in particular. Definition of molecular biotechnology and its emergence. The basic biological and chemical processes of cells, tissues, and organisms and their significance in biotechnology research and product development. Different types of enzymes, their mechanism of action as bio-catalysts and in fermentation.

**Bio-modified Plant Fibres and Fibres from Biopolymers**

Bt cotton; Naturally coloured cotton; Coloured silk; Spider silk;Biosteal™; Chitin fibre.

**Bio dyes**

Use of Cells for Dye Production; **Microbial production of indigo; Dyes produced in Bioreactor; Fungal dyes -** Mushroom and lichen dyes; Insect dyes – Lac and cochineal.

**MODULE II**

**Enzymes in Chemical Processing**

**Cotton –** Desizing; Scouring; Bleaching; Finishing – Bio-polishing; Bio-washing.

**Wool –**Bio-clipping of Wool; Carbonisation of wool; Reduction of wool-fibre stiffness and prickle; De-scaling; Anti-shrink

Silk – Degumming; Bio-finishing

Jute and other Bast Fibres – Jute Retting;Degumming of bast fibrous plants; Enzymatic Treatment of bast fibres; Bio-preparation of Linen Fabric

**MODULE III**

Polyester-Bio catalytic modification of polyester

Bio effluent treatment, Dye removal by immobilized fungi; Biodegradation of dyes, Enzyme based detergents, Bio-tagging

**TEXT BOOKS:**

**Open Elective**

**[To be decided by the Department]: Refer Appendix-III**

**Project 1: (PPRTE301)**

**[To be decided by the Department]: Dissertation (Phase-I)**

**Semester-4**

**Project 2: (PPRTE401)**

**[To be decided by the Department]: Dissertation (Phase-II)**