SYLLABUS

Uttar Pradesh Textile Technology Institute, Kanpur

Affiliated to

DR. A.P.J ABDUL KALAM TECHNICAL UNIVERSITY, LUCKNOW

PROPOSED STUDY &EVALUATION SCHEME

FOR

M. TECH. TEXTILE CHEMISTRY

Based on

AICTE M. Tech Model Curriculum Structure (MCS)

(Effective from the Session: 2021-22)

Uttar Pradesh Textile Technology Institute
Textile Chemistry Department
Course Scheme for M. Tech in Textile Chemistry Effective from 2021-22
M. Tech Sem. I

Course Code	Subject	Scheme of Studies per week			Credits	Ses.	ESE	Total
		L	T	P				
KMTT101	Program Core-I: Quality Evaluation of Textiles	3	0	0	3	30	70	100
KMTC103	Program Core-II: Advances in Bleaching & Finishing	3	0	0	3	30	70	100
KMTC013 / KMTT012	Program Elective-I: Enzyme Technology for Textile processing / Advances in Knitting & Nonwoven	3	0	0	3	30	70	100
KMTT021 / KMTT022	Program Elective-II: Selected topics in Technical Textiles/ High Performance Fibres & Composites	3	0	0	3	30	70	100
KMTT104	Research Methodology & IPR	2	0	0	2	30	70	100
KMAU 011-018	Audit Course-I: *	2	0	0	0			
KMTT151	Evaluation of Textile materials Lab	0	0	4	2	20	30	50
KMTC153	Advances in Bleaching and Finishing Lab	0	0	4	2	20	30	50
					18			**600**

M. Tech Sem. II Semester

Course Code	Subject	Scheme of Studies per week			Credits	Sessional	ESE	Total
		L	T	P				
KMTT201	Characterization of Fibres & Polymers	3	0	0	3	30	70	100
KMTC203	Theory of Coloration in textiles	3	0	0	3	30	70	100
KMTT031/ KMTT032	Program Elective-III: Nano Technology in Textiles/ Advances in Fibre Production	3	0	0	3	30	70	100
KMTC044/ KTTT043	Program Elective-IV: Selected topics in Textile Chemical Processing/ Testing of Technical & Functional Textiles**	3	0	0	3	30	70	100
KMAU 021-028	Audit Course-II*	2	0	0	0			
KMTT251	Fibres & Polymer Characterization Lab	2	0	4	2	20	30	50
KMTC253	Coloration in textiles Lab	0	0	4	2	20	30	50
KMTC254	Mini Project with Seminar	2	0	0	2	30	70	100
					18			**600**

**Students are encouraged to go to Industrial Training/Internship for at least 2-3 months during semester break

Uttar Pradesh Textile Technology Institute
Textile Chemistry Department
Course Scheme for M. Tech in Textile Chemistry Effective from 2022-23
M. Tech Sem. III

Course Code	Subject	Scheme of Studies per week			Credits	Sessional	ESE	Total
		L	T	P				
KMTT051/ KMTT052/ KMTC053	Program Elective-V: Statistics & Control for Textile Industry/ Smart & Functional Textiles/ Environmental Practices in Textiles	3	0	0	3	30	70	100
KMOE 011-016	**Open Elective**: 1. Business Analytics, 2. Industrial Safety, 3. Operation Research, 4. Cost Management of Engineering Projects, 5. Composite materials 6. Waste to Energy	3	0	0	3	30	70	100
KMTC351 / KMTC352	Dissertation-I/ Industrial Project	2	0	20	10	150	250	400
					16			**600**

*Students going for Industrial Project/Thesis will complete these courses through MOOCs.

M. Tech Sem. IV

Course Code	Subject	Scheme of Studies per week			Credits	Sessional	ESE	Total
		L	T	P				
KMTC 451	Dissertation-II	0	0	32	**16**	200	400	**600**

Core 1: Quality Evaluation of Textiles

Core 2: Advances in Bleaching & Finishing

Core 3: Characterization of Fibres& Polymers

Core 4: Theory of Coloration in Textiles

Elective 1: Enzyme technology for Textile processing /Advances in Knitting & Nonwoven

Elective 2: Selected topics in Technical Textiles / High Performance Fibres& Composites

Elective 3: Nano Technology in Textiles/ Advances in Fibre Production

Elective 4: Selected topics in Textile Chemical Processing / Testing of Technical and Functional Textiles

Elective 5: Statistics & Control for Textile Industry/ Smart & Functional Textiles/ Environmental practices in Textiles

Open Elective:

1. Business Analytics,
2. Industrial Safety,
3. Operation Research,
4. Cost Management of Engineering Projects,
5. Composite materials, Waste to Energy

***Audit course 1 &2: Through online MOOCS/NPTEL**

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

Semester 1:

Core 1:

Code	Name of the course	Total Credits	Lectures/week	Practical/ week
KMTT101	**Quality Evaluation of Textiles**	**3+2**	**3**	**4**

Course Outcomes

1. **Measure various fibre quality parameters.**
2. **Measure mass variations in various textile strands**
3. **Test tensile properties of textile materials.**
4. **Evaluate durability and shrinkage of textile fabrics**
5. **Evaluate comfort properties of textiles**

Course Contents :-

UNIT 1: Fibre classification, properties and standards, methods of measuring fibre fineness, Methods of Measuring fible length, HVI testing- the basics, Application of HVI, AFIS- the basics, Testing & data analysis, maturity and fineness testing, Application of NIR spectroscopy for textile measurement, properties.

Unit 2:Mass Variation of Textile Strands: Depiction of mass Variation of textile strands in time and frequency domain; interpretation and significance of U% and CV% for textile strands; classification and analysis of yarn faults created by mass variation, **Variance Length Curves and Spectgrogram of Textile Strands**: Effect of specimen length and total length on mass variation measurements of textile strands; theory of construction of VL curve; analysis of variance length curves to understand and avoid the introduction of mass variation during the spinning operation; determination of periodic mass variation in the form of spectrogram; determination of theoretical wave length from spectrum; comparison between normal and ideal spectrum; type of faults and their representation in spectrogram; interpretation of superimposed waves in spectrogram

UNIT 3: Strength & Elongation tests:, definitions of different terms of tensile tests, factors affecting tensile testing, fibre strength, yarn strength & fabric strength test methods, Influence of testing factors on yarn tensile properties; measurement and application of yarn modulus; creep and stress relaxation of yarn; significance of estimating minimum yarn strength, seam strength.

UNIT 4: Hygral expansion, relaxation shrinkage, swelling shrinkage, methods of measuring dimensional stability, Snagging test, wrinkle recovery & pilling resistance, abrasion resistance test, factors affecting abrasion resistance,

UNIT 5: Thermal comfort, air permeability, moisture transport, sensorial comfort, water absorption and water repellency tests, colour fastness testing, objective evaluation of fabric handle. Kawabata system, FAST: fabric assurance by Simple testing, **Fabric Appearance and other Properties** Study of fabric appearance in terms of drape, formability, crease recovery, evaluation of fabric properties like flammability, impact resistance, absorbency

Reference Books:

1. Advanced characterization and testing of textiles. Dolez, P. I., Vermeersch, O., & Izquierdo, V. (Eds.). (2017). Woodhead Publishing.
2. Physical testing of textiles. Saville, B. P. (1999). Elsevier.
3. Principles of Textile Testing; an Introduction to Physical Methods of Testing Textile Fibers, Yarns, and Fabrics, Booth, J. (1961). New York, Chemical Pub.
4. Chemical testing of textiles. Fan, Q. (Ed.). (2005). CRC Press.
5. A Practical Guide to Textile Testing. Amutha, K. (2016). CRC Press.

Core 2:

Code	Name of the course	Total Credits	Lectures/week	Practical/ week
KMTC103	**Advances in Bleaching and Finishing**	**3+2**	**3**	**4**

Course Outcomes:

At the end of the Course Contents students will be able to

1. Explain improved preparatory wet processes to save time, energy and chemicals
2. Analyze degradation caused and efficiency accrued during wet pretreatment operations
3. Explain continuous processing and low liquor treatment of textile fabrics
4. Analyse techniques of ecofriendly crease recovery finish and efficient soil release finish
5. Explain newer finishes with their related chemistry

Course Contents :-

Unit I- Emerging bleaching techniques, low temperature scouring and bleaching, solvent scouring, energy conservation by process and machine modification, Combined preparatory processes

Unit II –Chemical and physical changes in mercerization, Ammonia mercerization, Determination of efficiency for various preparatory processes. Methods used to test degradation of cotton during bleaching, Whiteness measurement.

Unit III – Continuous Bleaching Range (CBR), water and heat recovery systems, Minimum application technique, machines for low wet pick up finishing. Foam Finishing Technology .

Unit IV- Developments in anti-crease finish, use of polycarboxylic acids, DP rating, practices and developments in soil release finish, Teflon finish. Energy requirement and conservation in finishing

Unit V – Anti bacterial finish- mechanism and chemistry, Evaluation of antimicrobial finish. Ultraviolet protection finishes, chemistry of UV protectors, Evaluation and trouble shooting.

References Books:

1. Chemical technology in the pre-treatment processes of textiles – S R Karmakar (Textile Science and Technology 12, Elsevier Publication)
2. Functional Finishes for Textiles – edited by R Paul, Woodhead Publication
3. Chemical finishing of Textiles – W D Schindler and P J Hauser, Woodhead Publishing Ltd, England
4. Engineering of Textile Coloration – Edited by C Duckworth, The Dyers Company Publications Trust, England

Practical:

Practical's are to be conducted based on the above Course Contents

Core 3: Semester 2

Code	Name of the course	Total Credits	Lectures/week	Practical/ week
KMTT201	**Characterization of Fibres& Polymers**	**3+4**	**3**	**4**

Course Contents Outcomes: At the end of the Course Contents students will be able to

1. **Characterize physical and chemical structures of textile fibres and polymers by using various instrumentation techniques.**
2. **Determine fibre morphology and its impact on properties**
3. **Evaluation of various properties of textile fibres such as mechanical, optical, and thermal properties.**
4. **Investigate internal and surface morphology of textile fibres**

Course Contents :-

Unit 1:FIBRE STUDY: Basic concept of crystalline regions, and orientation - their effects on fibre properties. Fine structures and models of fibre structures such as, micelle, fibrillar, lamellar, three phase model etc. Sources of elucidation of fibre structure.
Moisture Properties: Significance of moisture in textiles, hysteresis of moisture absorption, Quantitative theory of moisture absorption, effect of temperature, stresses and hydrophilic groups, crystalline and non-crystalline region, calculation of moisture regain,heat absorption and heat of wetting, Swelling.

Unit 2-Refractive index and birefringence - absorption, dichroism, reflection and lustre of fibres. Nuclear Magnetic resonance (NMR): Radiation absorption by the nucleus in a magnetic field, Process of Relaxation , NMR Instrumentation, Fourier transform and continuous wave NMR Instruments, sample preparation of NMR, NMR study of major textile fibres. UV spectrophotometer, sample preparation, instrumentation, UV spectrometry of textile materials, Density Gradient Column. Brief Introduction to mass spectroscopy (11)

Unit-3 Tensile behavior of textile materials, stress strain relations of fibres, Effect of moisture and temperature on stress, strain. Elasticity and elastic recovery of fibres. (6) Dynamic Modulus Analysis**:** Instrumentation Integration for DMA test**,** Axial and Torsional Deformation based DMA, Estimation of Polymeric Thermal Transition by DMA, creep behavior measurement, DMA result analysis (10)

Unit-IV Principle of Spectroscopy, FTIR Spectroscopy, Fundamental of FTIR,FTIR Spectrometer Components,Sequence of Operations to scan a sample on FTIR Spectrometer, **Detectors used in FTIR, FTIR analysis of major textile fibres,**
Mass Spectroscopy, Raman Spectroscopy, Inductively Coupled Plasma—Atomic Emission Spectrometry (ICP-AES):Atomic Emission Spectrometry Theory, major components, ICP-torch, sample preparation for IACP-AES, application of ICP-AES. (11)

Unit-V-Optical microscopy, Scanning Electron Microscope, Transmission Electron Microscope, X-ray Diffractometer, Crystalline structure , Crystal Size, Bravais lattices, Cubic lattices, Bragg's Law of X-ray diffraction X-Ray sample preparation, Developments in X-Ray diffraction Techniques, Crystallinity by X-ray Diffraction, Crystalline Orientation, Herman's Orientation Factor, Differential Scanning Calorimetry, Heat Flux DSC, Power Consumption DSC, DSC Theory, Difference between a heat flow and a heat flux DSC, Sample Preparation for DSC, Crystallinity Measurement by DSC, Heat Capacity, Glass Transition Temperature, Crystallization during melting, Differential Thermal Analysis, Thermo Gravimetric Analysis, Thermo-Balance Principle in TGA, TGA study of measure textile fibres, Dynamic Mechanical Analysis (10)

References Books:

1. Turi E A "Thermal characterization of polymeric materials", Vol I and II, Academic Press, 1997.
2. Gedde, U. L. F. (1995). Polymer physics. Springer Science & Business Media.
3. Billmeyer F W, "Text book of polymer science", John Wiley and Sons, 1984.
4. Singh M K, Singh A, Characterization of Polymers and Fibres, Elsevier and Textile Institute Publications, 2021
5. Morton W E and Hearle J W S, Physical Properties of Textile Fibres, 1st reprint, The Textile Institute, Manchester, 1986.
6. Gupta V B and Kothari V K, "Manufactured Fibre Technology"1st Ed., Chapman and Hall, London, 1997.
7. Hearle JWS, Polymers and their properties, Vol. I, John Wiley and Sons, NY, 1982.

Practical:
Practical's are to be conducted based on the above Course Contents

Core 4: Semester 2

Code	Name of the course	Total Credits	Lectures/week	Practical/ week
KMTC203	**Theory of Coloration of Textiles**	**3+2**	**3**	**4**
	Course Outcomes: 1. **Explain the kinetics of dyeing textile fibres with different dyes** 2. **Analyse the thermodynamics of coloration with different adsorption isotherms.** 3. **Compare different theories of coloration and explore newer explanations for mechanism of dyeing**			

	4. **Analyze theoretical aspects of textile printing and dye-fibre interaction.** 5. **Explain reaction mechanisms and efficacy of newer functionalities in reactive colours.**
	Course Contents :- **Unit 1:** Definition of terms and mathematical equation relevant to physio chemical aspect of dyeing such as diffusion coefficient standard affinity, heat of dyeing. entropy of dyeing, saturation value, adsorption on sites etc. Kinetics of Dyeing: (a) Methods for measurement of diffusion coefficient and different equation used for calculation of diffusion coefficient. (b) Significance of diffusion coefficient in relation of physical structure of fibre. (c) Determination of diffusion coefficient of dyes suitable for natural and synthetic fibres. **Unit 2:** Thermodynamics of dyeing: (a) Adsorption isotherms and experimental design their determination. (b) Classification of adsorption isotherm and their applicability to different dye fibre systems. (c) Standard affinity equation representing different adsorption isotherm. (d) Dye fibre interactions and analytical methods for their investigations. **Unit 3:** Technique of coloration and theories behind them. Recent developments in the mechanism of dyeing of different fibres by various classes of dyes. Quantitative treatment for kinetics as well as equilibrium dyeing state of dye in solution in fibre and dye fibre interactions. **Unit 4:** Physicochemical aspects of printing. Dye –polymer interaction and methods of investigation. Role of fibre structure and other characteristics in dyeing. **Unit 5;** Reaction mechanism for different textile dyes with fibres. Use of improved chromophores. Newer functional groups in reactive colours.
	References Books: 1. The Theory of Coloration of Textiles- 2nd Edition, Edited by Alan Johnson (Published by Society of Dyers and Colourists, UK) 2. Theory of Coloration of Textiles by C L Bird [SDC Publication, UK] 3. Cellulosics Dyeing – Edited by John Shore 4. Journals- Colouration Technology, AATCC Review
	Practical: Practicals are to be conducted based on the above Course Contents

Department Elective 1A: Semester 1

Code	Name of the course	Total Credits	Lectures/week	Practical/ week
KMTC013	**Enzyme Technology for Textile processing**	**3**	**3**	**0**

Course Contents Outcomes: After this course student will be able to:

1. Enumerate the various applications of enzymes on textile and allied materials
2. Explain the alternative environment friendly routes of preparatory wet processing

3. Analyse the bioprocessing of different textile fibres at different stages
4. Compare the conventional Effluent treatment plant with the newer biotreatment plants
5. Understand the care in handling enzymes on industrial scale

Course Contents :-

Unit 1: Introduction: Introduction to Enzyme Technology, Enzymes & their classification, Enzyme structure & catalysis, Enzyme kinetics & their reactions, Present & Future Trends in biotechnology, application of enzymes in detergents, paper,leather & food industries, Demerits of conventional textile processing, Application of Enzymes in Textile Industry and their features

Unit 2: Use of Enzymes in Pretreatments: Desizing and its environmental aspects, Bioscouring- concept and industrial practice, bleaching and its eco-aspects, conventional and enzyme based peroxide killers, factors affecting efficiency of enzyme treatment. Enzyme retted flax using different formulations, Enzymatic degumming.

Unit 3: Bioprocessing of different fibres: Combined bio-treatment of cotton, Bioprocessing of Jute, flax & their characteristics, Bioprocessing of protein fibres like wool and silk, possible use of enzymes on synthetics, Biodegradability

Unit 4: Enzymes in Textile Effluents: Textile processing Operations, Textile Effluent Characteristics, Present technology in Treating Effluents, Treatment of textile effluents by various methods, Newer Technologies in effluent treatment practices, Role of Enzymes in decolourisation, Prospects and future research.

Unit 5: Safety & Precautions in Handling Enzymes: Introduction, Enzyme safety Program, Safe handling of enzymes, Symptoms of Enzyme exposure, Practical aspects and possible controls.

Biotechnology and Biomaterials for hygienic & Health care Textiles: Introduction, Medical Textiles, Modern Wound Dressing, Enzymes in medical application, advanced biopolymer materials, future trends in medical textiles

References:

1 Advances in Textile Biotechnology by V.A. Nierstrasz and A. Cavaco-Paulo

2 Wastewater Microbiology by Gabriel Bitton

3 Handbook of Sustainable Textile Production by Marion I. Tobler-Rohr

4 Bioprocessing of Textiles by Dr. C. Vigneswaran, Dr. M. Ananthasubramanian&Dr. O. Kandhavadivu

5 Biotechnology in Textile Processing by Georg M. Guebitz, ArturCavaco-Paulo &Ryszard Kozlowski

6 Biodegradable and sustainable fibres by R.S. Blackburn

7 Advances in the Dyeing & Finishing of Technical Textiles by M. L. Gulrajani

Department Elective 1B

Code	Name of the course	Total Credits	Lectures/week	Practical/ week
KMTT012	**Advances in Knitting & Nonwoven**	**3**	**3**	**0**

Course Outcomes:

1. Enumerate recent advances in the field of knitting and nonwoven technology.
2. Explain mechanism of knitting and action of various knitting elements.
3. Explain structure property relationship between knitted and nonwoven fabrics.
4. Distinguish various nonwoven manufacturing technology, machines and mechanisms.
5. Find suitable applications of knitted and nonwoven fabrics.

Course Contents :-

Unit 1: Concepts of loop formation in weft and warp knitting. Different forces acting on the needle butt and mechanics of loop formation. Study of dynamics of knitting process. Study of different machines, process and yarn parameters affecting the yarn tension in knitting zone and loop length.

Unit-I2I: Concept of 'Robbing Back' of yarn in loop. Study of design and performance of high sped knitting cam and increase in machine production. Yarn feeding devices on circular knitting machines.

Unit-3: Geometry and properties of weft knitted fabrics –k-values and Pierce's geometry. Outlines of process control in knitting. Use of electronics and computers and other developments in knitting. Features of warp knitted fabrics and their uses.

Unit 4-Classification and areas of application of nonwoven fabrics. Different methods of production of nonwoven fabrics. Effect of machines, fibre and process variables on properties of nonwoven fabrics. Failure mechanism of nonwoven fabrics.

Unit-5: Prediction of needle punched nonwoven fabric behavior. Designing of nonwoven for engineering applications. Development in nonwoven machineries. Developments in various nonwoven manufacturing techniques.

References:

1. Lunenschloss J and Albrecht W, "Non-Woven Bonded Fabric", Ellis and Horwood Ltd., UK, 1985.
2. Russell, S. J. (2006). Handbook of nonwovens. Woodhead Publishing.
3. Kellie, G. (Ed.). (2016). Advances in technical nonwovens. Woodhead Publishing.
4. Spencer, D. J. (2001). Knitting technology: a comprehensive handbook and practical guide. Woodhead Publishing.
5. Au, K. F. (Ed.). (2011). Advances in knitting technology. Elsevier.
6. Ray, S. C. (Ed.). (2012). Fundamentals and advances in knitting technology. CRC Press.

Department Elective 2A

Code	Name of the course	Total Credits	Lectures/week	Practical/ week
KMTT021	**Selected Topics in Technical Textiles**	**3**	**3**	**0**

Course Outcomes:

1. **Classify and explain various sectors of technical textiles.**
2. **Explain features, merits, demerits, types and applications oftextile structural composites.**
3. **Describe the applications of textiles in various sectors of technical textiles.**
4. **Explain the technology of industrial tapes and narrow weaving for technical textiles.**
5. **Find applications of carpet and home textiles.**

Course Contents :-

Unit-1: Composites: Basic concepts, classification, manufacturing techniques-from fibre to composite, textile composites, composite applications, reuse & recycling;

Geotextiles: Geotextiles: basic classification, main functions of a geotextiles, applications; Architectural textiles, concepts of tensegrity structures.

Unit-2: Automotive Textiles: requirements on automotive textiles including tyre cords, air bags, seat belts and seat fabrics, carpets, trims.

Filtration: Principles of filtration, industrial filtration in textile, chemical, food and metallurgical applications.

Unit-3: Medical Textile: Medical textile materials and structures; application of compression bandage technology for medical care; integrating electronic sensors into medical textiles; knitted electro-textiles.

Protective Textiles: Bullet proof, stab proof vests. Impact protection: impact mechanism and cellular textile composites. Ballistics and body armour.

Technical clothing, sportswear, spacewear, sailing equipment. Medical and Smart Textiles

Unit-4: Industrial Tapes: Slide fastener tapes - Insulating tapes – Book binder's tapes - Labeling Tapes – Border Tapes – Elastic- Pleated lingerie ribbing. Classification of braids – Trimmed braids – Flat braids – Circular Braids - Hollow braids. Production techniques. Properties and applications.

Unit-5: Carpet and Home Textiles: Non-pile carpet weaves and their looms. Pile surfaced carpet weaves and their looms. Needle felt floor coverings. Definition of home textiles-requirements. Kitchen linen, Bedlinen, Furnishing, Floor coverings, Wall coverings, Decoration fabrics.

References:

1. Horrocks, A. R., &Anand, S. C. (2000). Handbook of Technical Textiles: Technical Textile Applications (Vol. 2). UK: Woodhead Publishing.
2. Horrocks, A. R., &Anand, S. C. (Eds.). (2015). Handbook of Technical Textiles: Technical Textile Processes. Woodhead Publishing.
3. Paul, R. (2019). High Performance Technical Textiles. John Wiley & Sons, Incorporated.
4. Sabit Adanaur, Wellington Sears Handbook of Industrial Textiles, Technimic Publishing Company, Inc., Pennsylavania, USA, 1995.
5. P.K. Mallick, (2007) Fiber-Reinforced Composites Materials Manufacturing and Design-CRC Press.
6. Kumar, R. S. (2013). Textiles for industrial applications. CRC Press.

Department Elective 2B

Code	Name of the course	Total Credits	Lectures/week	Practical/ week
KMTT022	**High Performance Fibres & Composites**	**3**	**3**	**0**

Course Outcomes:

1. Classify various high performance fibres and role of its phases.
2. Describe manufacturing process of various high performance fibres.
3. Use the high performance fibres for various applications including structural composites.
4. Explain nano-composites and its applications.
5. Evaluate properties of high performance fibres and composites**.**

Course Contents :-

Unit 1: Aramids & Co Polyesters: Fibres formation – Fibre & structure properties, performance and Application. **Carbon and Graphite**: Classification and Types, manufacturing Processes from Polyacrylonitride (PAN) and Rayon structured pitch based fibres, properties.

Unit-2: **Glass Fibres**: Types and Composition, Manufactures Processes, Fibre structures, Properties and Applications. **Poly Ethelene Fibres: Types**- UHMWPE, HDPE, Manufacturing process, properties and applications **Ceramic Fibres**: Classification and fibre formation, composition, structure, properties and application

Unit-3: **Polyurethane Elastomeric Fibres**: Manufacturing Processes, Fibre Properties, Application and future trends **Metallic Compound Fibres**: Aluminium Oxide fibres and lead oxide fibres – Preparation and processes, Fibre structure, properties and Application.

Unit 4: **Optical Fibres**: Light Propagation. Silica Fibres- Fibre manufacture and Application, **Definition of composite**. General introduction to fibres and resins for composites. Composite fabrication techniques. Matrices and interphase. Applications of natural fibres and technical fibres in composite.

Unit 5: Nano-composite: Introduction, advantages and different nanomaterials commonly used as fillers (Carbon nanotubes, carbon nanofibres and Nano clay).

References:

1. Horrocks, A. R., &Anand, S. C. (2000). Handbook of Technical Textiles: Technical Textile Applications (Vol. 2). UK: Woodhead Publishing.
2. Horrocks, A. R., &Anand, S. C. (Eds.). (2015). Handbook of Technical Textiles: Technical Textile Processes. Woodhead Publishing.
3. Paul, R. (2019). High Performance Technical Textiles. John Wiley & Sons, Incorporated.
4. SabitAdanaur, Wellington Sears Handbook of Industrial Textiles, Technimic Publishing Company, Inc., Pennsylavania, USA, 1995.
5. P.K. Mallick, (2007) Fiber-Reinforced Composites Materials Manufacturing and Design-CRC Press.
6. Kumar, R. S. (2013). Textiles for industrial applications. CRC Press.

Department Elective 3A

Code	Name of the course	Total Credits	Lectures/week	Practical/ week
KMTT031	**Nano Technology in Textiles**	**3**	**3**	**0**

Course Outcomes:

1. Explain the concept of nanotechnology and manufacturing of some nano materials
2. Elucidate electrospinning in nanofibre production and applications of these fibres
3. Describe fabrication and usage of nanocomposites in textiles
4. Explain the mechanism of nano finishing on properties of textiles.

Course Contents :-

Unit 1: Fundamentals of nanotechnology, Basic properties of nanomaterial, Fabrication of nanomaterial, Top down and Bottom up approaches. Outline of Various methods of synthesis of nanomaterial.

Unit 2: Different methods of production of Polymer Nanofibres, comparison of the methods namely Drawing, Electrospinning, Self-assembly, Template synthesis, and Thermal-induced phase separation. Polymer nanofibres: Properties of polymer relevant to electrospinning, Polymer Crystallinity, Polymer Molecular Weight, Glass Transition Temperature (Tg), Solution properties - Surface tension and Viscosity, polymer solubility, evaporation, basics of electrostatics and conductivity of solutions.

Unit 3: Parameters affecting nanofibres production by electrospinning and other methods. Controlling structure and properties of nanofibres by different ways. Various applications of Nanofibres and nanofibre coated textile fabrics such as in filtration, scaffolds, composites, dye sensitised solar cells, catalysis etc. Outline of the characterization methods

Unit 4: Nanocomposites, polymers with CNTs: synthesis and their application, Polymer – nanoclay composites fabrication and application, Principles of Polymer/Inorganic-inorganic nano composites in various Textile applications

Unit 5: Classification of nano finishing on textile, use in preparatory processes of the textile fabrics. Nano-coating of textiles: electroless deposition, layer-by-layer deposition, CVD and PVD Organic and Inorganic Atomic Layer deposition techniques on textiles, Nano finishing of textiles by sol-gel methods,smart Nano coating of textiles. Nanofinishes such as antimicrobial finishes, soil release finishes, flame retardants, antistatic, flouro chemical, Nanotechnology based finishes for personal protection, such as bacteria, virus, toxic gas and chemicals, chemical warfare agents (CWA) etc.

References:

1. Brown, P., & Stevens, K. (Eds.). (2007). Nanofibers and nanotechnology in textiles. Elsevier.
2. Mishra, R., &Militky, J. (2018). *Nanotechnology in Textiles: Theory and Application*. Woodhead Publishing.
3. Smith, W. C. (Ed.). (2010). *Smart textile coatings and laminates*. Elsevier.
4. Noor-Evans, F., Peters, S., &Stingelin, N. (2012). Nanotechnology innovation for future development in the textile industry. In *New Product Development in Textiles* (pp. 109-131). Woodhead Publishing.
5. Shabbir, M., & Mohammad, F. (2017). Insights into the functional finishing of textile materials using nanotechnology. In *Textiles and clothing sustainability* (pp. 97-115). Springer, Singapore.

Department Elective 3B

Code	Name of the course	Total Credits	Lectures/week	Practical/ week
KMTT032	**Advances in Fibre Production**	**3**	**3**	**0**

Course Outcomes

1. Judge raw material quality for manufactured fibres and parameters needed for their spinning process.
2. Explain rheology and kinetics of Melt and solution spinning processes.
3. Illustrate the mechanism of dry and wet spinning and control the spinning processes.
4. Identify the control parameters affecting fibre morphology.
5. Explain the process and effects of drawing and heat setting on fibre structure and properties.

Course Contents

Unit 1: Manufacture and specifications of raw materials and monomers. Types, methods of manufacture, mechanism of polymerisation and production techniques of viscose, nylon 6 and 66, PET, PAN and PP.

Unit 2: Introduction to new developments. Other fibres including PU, PVA, PE, PVC and polyvinylidene chloride. General definition of manmade or manufactured fibres, introduction to general principles of spinning and spinning processes,

Unit 3: Melt spinning: Basic principles of fluid flow during fiber spinning, Primary and secondary variables and their effect on melt spinning, factors affecting shear viscosity. Melt Rheology,Elongational flow, spinnability and flow instabilities. Extruder design, spin head, spinneret, quench chamber. Spin finish application, wind up mechanism.

Unit 4: Solution spinning: Wet and dry spinning, various variants of wet solution spinning, Rheology, Spinnability in solution spinning, kinetics, Mechanism for development of fibre morphology, Effect of polymer modification on morphology,

Unit 5: Drawing: Concept, Drawing Machines, drawing parameters, Structure development during drawing

High speed spinning, spinning of microfibre, Heat-setting of fibres.

Reference Books

1. Vaidya A A, “Production of Synthetic Fibres”, 1st Ed., Prentice Hall of India, New Delhi,1988.
2. Gupta V B and Kothari V K, “Manufactured Fibre Technology”, 1st Ed., Chapman and Hall, London, 1997
3. Mark H F, Atlas S M and Cernia E, “Man Made Fibre Science and Technology”, Vol. 1, 2, 3, 1st Ed., Willey Inter Science Publishers, New York, 1967.
4. Macintyre J E, “Synthetic Fibres”, WoodheadFibre Science Series, UK, 2003.
5. Fourne F, “Synthetic Fibres: Machines and Equipment, Manufacture, Properties”, Hanser Publisher, Munich, 1999.

Department Elective 4A

Code	Name of the course	Total Credits	Lectures/week	Practical/ week
KMTC044	**Selected topics in Textile Chemical Processing**	**3**	**3**	**0**

Course Outcomes: The students will be able to-

1. Describe textile dyes with newer and multiple functionalities.
2. Elucidate waterless dyeing and application of ultrasonography in textile processing.
3. Analyse the practices of wet processing for speciality fabrics and their blends.
4. Explain the concept of ink jet printing technology and application of different dye classes by using it.
5. Explain the hazards of restricted substances and the techniques to manage them.

Course Contents :-

Unit I - Dyeing and its ecological attributes, novel chromophores in reactive dyeing. Polyfunctional and neutral fixing reactives, Low and no salt reactive dyes. Eco-friendly dyeing with sulphur & vat dyes. Sodium sulphide substitutes and electrochemical vat dyeing, Photo chromic dyes, thermo chromic dyes, fluorescent dyes.

Unit II - Supercritical CO_2 dyeing – concept, mechanism, pressure-temperature phase diagram for CO_2 sorption, setup for supercritical dyeing. Merits and demerits. Ultrasound application in wet treatment - Concept, mechanism, methods of application in various processes like pretreatment and coloration.

Unit III - Processing of specialty fabrics: Processing of Lyocell- General properties and uses of lyocell (Tencel). Pretreatment, dyeing profile and finishing of lyocell. Concept of fibrillation, its causes and remedies. Processing of Fabric containing spandex- Properties and uses of spandex fibres and blends. Wet processing of Cotton / Spandex, polyester / Spandex fabrics.

Unit IV – Digital printing - Inkjet printing of textiles – principle of ink drop formation and deposition. Concept of print heads, working and salient features of Inkjet printing machines. Digital techniques for printing pigment, reactive and disperse colours. Printing inks and their specifications. Recent developments in Inkjet printing and market trends.

Unit V - Carbon and water footprint – Techniques to reduce carbon footprint, Restricted substances in Textiles, chemical management in wet processing, compliances. Water treatment and recycling for ZLD (Zero Liquid Discharge), novel techniques of effluent treatment.

Reference Books:

1. Dyeing – Processes, Techniques and Applications – Edited by Jie Fu, 2014, Nova Science Publishers Inc., New York, USA
2. Textile Ink Jet Printing – Edied by T L Dawson & B Glover, 2004, The Society of Dyers & Colourists Publication
3. Advances in the dyeing and finishing of technical textiles, Edited by M L Gulrajani, 2013, Woodhead Publishing Ltd
4. Journals – Indian Journal of Fibre and Textile Research (CSIR Publication), Review Progress In Coloration (SDC, UK Publication)

Department Elective 4B

Code	Name of the course	Total Credits	Lectures/week	Practical/ week
KMTT043	**Testing of Technical and Functional Textiles**	**3**	**3**	**0**

Course Objectives:

1. Explain performance properties and functions of technical textiles
2. Evaluate various functional properties of technical textiles.
3. Identify various parameters affecting performance of functional and technical textiles.
4. Find applications of the functional and technical textiles.

Course Contents :-

Unit 1: Testing of Low Stress Mechanical Properties of Textile Fabrics: fabric handle, bending length, flexural rigidity, cantilever principle, hanging loop method, Kawabata Evaluation System KES, Fabric Assurance by Simple Testing FAST.

Testing of Transmission Characteristics of Textile Fabrics: air, moisture and heat transmission, air permeability, evaluation of liquid water transmission, wetting, wicking, tensiometry and goniometry, evaluation of liquid water transmission, wicking: Test methods of transplanar or transverse wicking, in plane wicking, vertical wicking, moisture management tester, evaporative dish method, upright cup method, Upright cup method, sweating guarded hot plate method, PERMETEST method, Measurement of thermal transmission. Tog and Clo,togmeter, guarded hot plate, KESF thermo-lab. Testing of Thermal transmission characteristics for extreme heat condition, Flame exposure test, Radiant heat, stream, hot water splash exposure test, etc.,

Unit 2: Testing of Fibre Reinforced Composite Materials: Characterization and test for thermoset and thermoplastic matrix, get time evaluation, moisture content, melt flow index, density, thermal characteristics, reinforced material fibre characterization, fibre surface characterization, FTIR, testing of mechanical properties: tensile, compression, impact, dynamic test, fibre-matrix interfacial strength test, Various methods of void test,

Unit 3: Testing of Filter Fabrics: woven, nonwoven and composite filters, liquid filtration, surface and depth filtration, particle capture mechanisms, variables of particle capture mechanism, various properties of filter fabric, filtration efficiency, particl;e collection efficiency, penetration efficiency, permeability, filter life, air filtration: apparatus, parameters, cleaning efficiency, capillary flow porometry, tensile and bursting strength of filter fabrics, various types of filters, air quality, N95 mask,

Unit 4: Testing of Geo-textiles: Functions of geotextiles, laboratory and filed tests, In-isolation test, performance tests, physical, mechanical, hydraulic, endurance and degradations tests.

Testing of Ballistic Protective Clothing: bulletproof test, dynamic impact test weapon test, back face signature test.

Testing of UV Radiation Protective Textiles: Measurement of Ultraviolet Protection Factor, Erythema Weighted Transmittance, sun protection factor, UV index, Parameters affection UV protections of fabrics.

Unit 5: Testing of Compression Bandages: compression therapy, Oedema, filtration and reabsorption, measurement of bandage pressure and stiffness, parameters e\affecting bandage pressure.

Testing of Electromagnetic Shielding Textiles: Concept of electromagnetic waves, its effects, EMI shielding efficiency, measurement, co-axial transmissions, wave-guide principle, s-parameters, various EMI shielding materials and their performance.

Reference Books

1. Prof. Apurba Das, Testing of Functional and Technical textiles, NPTEL course.
2. Horrocks, A. R., &Anand, S. C. (2000). Handbook of Technical Textiles: Technical Textile Applications (Vol. 2). UK: Woodhead Publishing.
3. Horrocks, A. R., & Anand, S. C. (Eds.). (2015). Handbook of Technical Textiles: Technical Textile Processes. Woodhead Publishing.
4. Paul, R. (2019). High Performance Technical Textiles. John Wiley & Sons, Incorporated.
5. SabitAdanaur, Wellington Sears Handbook of Industrial Textiles, Technimic Publishing Company, Inc., Pennsylavania, USA, 1995.
6. P.K. Mallick, (2007) Fiber-Reinforced Composites Materials Manufacturing and Design-CRC Press.
7. Kumar, R. S. (2013). Textiles for industrial applications. CRC Press.

Department Elective 5A

Code	Name of the course	Total Credits	Lectures/week	Practical/ week
KMTT051	**Statistics & Controls for Textile Industry**	**3**	**3**	**0**

Course Outcomes:

1. Calculate all central tendencies, variations, and their confidence intervals using statistical probability distributions.
2. Test significance difference between mean, difference between means, variance, ratio of variance by using statistical technique.
3. Design an experiment accounting all parameters and analyse the effect of all parameters on response.
4. Derive empirical relationship between all independent and dependent variables using theory of regression and ANOVA and interpret goodness of fit.
5. Control and monitor the quality of product and process by applying the concepts of variable and attribute control charts.

Course Contents :-

Unit 1: STANDARD PROBABILITY DISTRIBUTIONS: Mean and variance of Probability distribution, Geometric distribution, Binomial distribution, Poisson distribution, Normal approximation to Binomial and Poisson.

Unit 2: STANDARD SIGNIFICANCE TESTS: Hypothesis, significance level, interpretation of significance test, single and double tail tests. Errors and choice of sample size. Test for single mean, two means – test for single variance, two variances and single proportion. Rejection of outliers.

Unit 3: ANALYSIS OF VARIANCE: ANOVA for different models, test of significance – comparison with a control, global comparisons. Rank test.**: DESIGN OF EXPERIMENTS**: Introduction. Random variation in experiments – randomization, 2n full-factorial designs – Yate's algorithm, fractional replication. Optimization techniques using composite designs.

Unit 4: LINEAR REGRESSION: Introduction. Method of least squares – linear regression equation – correlation coefficient. Regression through origin – multiple regression. Confidence limits.

Unit 5: CONTROL CHARTS: General principle of control charts – action and warning limits – interpretation of control charts. Control charts for defectives, defects, averages, ranges. Cusum charts. Process capability analysis.

References:

1. Leaf G A V, "Practical Statistics for the Textile Industry", The Textile Institute, Manchester, 1984.
2. Leaf G A V, "Practical Statistics for the Textile Industry", The Textile Institute, Manchester, 1987.
3. J. R. Nagla, "Statistics for Textile Engineers", Woodhead Publishing India Pvt. Ltd., 2014
4. Meloun M and Militky J, "Statistical Data Analysis: A Practical Guide", Woodhead Publishing Ltd. UK, 2011.
5. Hayavadana J, "Statistics for Textile and Apparel Management", Woodhead Publishing Ltd., UK, 2012.
6. Montgomery D C, "Design and Analysis of Experiments", John Wiley & Sons, New York, 1997
7. Ronald D moen, Thomas W Nolan and Lloyd P Provost, "Quality Improvement Through Planned Experimentation", McGraw Hill, 1998.

Department Elective 5B

Departmental Elective-				
Code	**Name of the course**	**Total Credits**	**Lectures/week**	**Practical/ week**
KMTT052	**Elective: Smart & Functional Textiles**	**3**	**3**	**0**

Course Outcomes

1. Describe general introduction of smart textiles and modelling of intelligent materials.
2. Elucidate temperature sensitive shape memory polymers.
3. Explain solar textiles and introduction to conductive materials.
4. Describe applications of smart / intelligent textiles.

Course Contents

Unit I - General introduction: Definition, classification, intelligent systems and general applications.

Unit II - Modelling of intelligent materials: Background, underpinnings of interdisciplinary, scientific practices and research strategies for intelligent garments

Unit III - Phase change materials: Heat balance and thermo-physiological comfort, Phase change technology, PCM in textiles, Future prospects of PCM in textiles and clothing Intelligent textiles with PCMs: Basic information of phase change materials, Phase change properties of linear alkyl hydrocarbons, Textiles

Unit IV - Temperature sensitive shape memory polymers: A concept of smart materials, Shape memory polymer and smart materials, Some examples of shape memory polymer for textile applications, Potential use of shape memory polymer in smart textile, General field of application, Challenges and opportunities. Study of shape memory polymer films for breathable textiles: Breathability and clothing comfort, Breathable fabrics, Water vapor permeability (WVP) through shape memory polyurethane Chromic and conductive materials: Photo chromic materials, Thermochromics materials, Color changing, Electro chromic materials

Unit V - Solar textiles: production and distribution of electricity coming from solar radiation: Solar cells, Textiles as substrates, Technological specifications, Challenges to be met, Suitable textile constructions. Introduction to conductive materials: Electric conductivity, Metal conductors, Ionic conductors, inherently conducting polymers, Application technologies for conducting fibre materials Multipurpose textile based sensors: Introduction, Conductive polymer textile sensors, Conductive polymer composites (CPCs) textile sensors Textile micro system technology: Textile micro system technology, Textiles are inherent microstructures, Textile-based compliant mechanisms in micro-engineering and mechatronics

Unit VI - Applications: Intelligent textiles for medical and monitoring applications, Context aware textiles for wearable health assistants, Intelligent garments in prehospital emergency care, Intelligent textiles for children, Wearable biofeedback systems, Applications for woven electrical fabrics

Reference Books

1. Smart fibres, fabrics and clothing edited by Xiaoping Tao, Wood head publishing Ltd., England.
2. Intelligent Textile and clothing edited by H. R. Mattila, Wood head Publishing, England.
3. Clothing bisensory Engineering edited by Y. L. and A. S. W Wang, Wood head publishing ltd. England.

Department Elective 5C

Departmental Elective-				
Code	**Name of the course**	**Total Credits**	**Lectures/week**	**Practical/ week**
KMTC053	**Environmental practices in Textiles**	**3**	**3**	**0**

Course Outcomes

1. Explain the concept of healthy environment and the role of textile industry
2. Describe ways of waste management from textile wet processing plant
3. Enumerate characteristics of textile effluent and steps for their treatment
4. Explain techniques of environment friendly textile processing and various standards for compliance

Course Contents

Unit1: Environment - Definition, scope and importance of environmental study - composition of atmosphere. Particles, ions and radicals in the atmosphere. Thermochemical and photochemical reactions in the atmosphere.

ECOSYSTEM: Structure and stability of the ecosystem. Health of our planet. Nature and role of textiles. Ban on toxic dyes, chemicals and auxiliaries. Present status of textile industry.

Unit 2: ENVIRONMENTAL POLLUTION: Definition. Causes, effects and control measures of air pollution, water pollution, soil pollution, marine pollution, noise pollution and thermal pollution in textile industry. Solid waste management - causes, effects and control measures. Land fills and concept of electromagnetic pollution.

Unit 3: EFFLUENT TREATMENT: Introduction. Characteristics and treatment of Textiles processing effluents. Flow chart of effluent treatment processes. Primary, Secondary and Tertiary treatments. Evaporation and Reverse osmosis, ultra filtration, membrane filtration, advanced oxidation techniques.

Unit 4: ECOFRIENDLY PROCESSING: Brief note on dry processing techniques, low liquor applications, use of biodegradable auxiliaries, use of natural resources in textile preparatory, dyeing and finishing processes.

Unit 5: ENVIRONMENTAL STANDARDS: Sustainable textiles, role of nongovernmental organizations like Green peace. Manufacturing Restricted Substances List. Process of EIA(Environmental Impact Assessment) - ISO 14000 - Environment protection act – Air (prevention and control of pollution) act, Water (prevention and control of pollution) act. SA8000 certification process.

Reference Books

1. Gilbert M Masters, “Introduction to Environmental Engineering and Science”, Printice Hall, India, 2004.
2. Tobler-Rohr M I, Handbook of sustainable textile production, Woodhead Publishing Ltd, 2011.
3. Benny Joseph, “Environmental Science and Engineering”, Tata McGraw-Hill, New Delhi, 2010.
4. Keith Slater, “Environmental Impact of Textiles”, Woodhead Pub. Ltd, Cambridge, 2003. ISBN:1-85573-541-5
5. Koteswara Rao M V R, “Energy Resources: Conventional & Non-Conventional “, BSP Publications, India, 2006.
6. Cunningham W P, Cunningham M A, “Environmental Science: A Global Concern”, McGraw-Hill, Boston, 2008.
7. De A K, “Environmental Chemistry”, New Age International P Ltd, New Delhi, 2006.

Research Methodology and IPR: Lectures: 2 hrs/week

Course Outcome:

At the end of this course, students will be able to

- Formulate research problem.
- Analyze research related information and data.
- Follow research ethics
- Explain Computer applications, Information Technology ruled by ideas, concept, and creativity.
- Explain IPR for thegrowth of individuals & nation.
- DescribeIPR protection that provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

Syllabus Content:

Unit 1: Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

Unit 2: Effective literature studies approaches, analysis Plagiarism, Research ethics,

Unit 3: Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

Unit 4: Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

Unit 5: Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

Unit 6: New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IIT.

References:

- Stuart Melville and Wayne Goddard, "Research methodology: an introduction forscience& engineering students'"
- Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
- Ranjit Kumar, 2 ndEdition, "Research Methodology: A Step by Step Guide for beginners"
- Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd,2007.
- Mayall, "Industrial Design", McGraw Hill, 1992.
- Niebel, "Product Design", McGraw Hill, 1974.
- Asimov, "Introduction to Design", Prentice Hall, 1962.
- Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Property in New Technological Age", 2016.
- T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008

Audit 1 & 2

A) ENGLISH FOR RESEARCH PAPER WRITING:

Course Outcomes: Students will be able to:

1. Explain the methods of improving your writing skills and level of readability
2. Write in each section
3. Write a good quality of paper at very first-time submission

Syllabus

Units	Contents	Hours
1	Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness	**4**
2	Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction	**4**
3	Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check	**4**
4	key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature,	**4**
5	skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions	**4**
6	useful phrases, how to ensure paper is as good as it could possibly be the first- time submission	**4**

Suggested Studies:

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2. . Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman'sbook .
4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

B) Audit 1 & 2: Disaster Management

Course Objectives: -Students will be able to:

1. Demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.
2. Evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
3. Develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.

4. Analyse the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in

Syllabus

Units	Contents	Hours
1	Introduction Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude.	**4**
2	Repercussions Of Disasters And Hazards: Economic Damage, Loss Of Human And Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.	**4**
3	Disaster Prone Areas In India Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics	**4**
4	Disaster Preparedness And Management Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness.	**4**
5	Risk Assessment Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global And National Disaster Risk Situation. Techniques Of Risk Assessment, Global Cooperation In Risk Assessment And Warning, People's Participation In Risk Assessment. Strategies for Survival.	**4**
6	Disaster Mitigation Meaning, Concept And Strategies Of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs Of Disaster Mitigation In India.	**4**

SUGGESTED READINGS:

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal book Company.
2. Sahni, PardeepEt.Al. (Eds.)," Disaster Mitigation Experiences And Reflections", Prentice Hall Of India, New Delhi.
3. Goel S. L. , Disaster Administration And Management Text And Case Studies" ,Deep &Deep Publication Pvt. Ltd., New Delhi.

C) AUDIT 1 and 2: SANSKRIT FOR TECHNICAL K NOWLEDGE

Course Objectives

1. Culture illustrious Sanskrit, the scientific language in the world
2. Apply Sanskrit to improve brain functioning

3. Apply Sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power
4. Explore the huge knowledge from ancient literature.

Syllabus

Units	Contents	Hours
1	• Alphabets in Sanskrit, • Past/Present/Future Tense, • Simple Sentences	**8**
2	• Order • Introduction of roots • Technical information about Sanskrit Literature	**8**
	• Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics	**8**

Suggested reading

1. "Abhyaspustakam" – Dr.Vishwas, Samskrita-Bharti Publication, New Delhi
2. "Teach Yourself Sanskrit" Prathama Deeksha-VempatiKutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. "India's Glorious Scientific Tradition" Suresh Soni, Ocean books (P) Ltd., New Delhi.

Course Output

Students will be able to

1. Understanding basic Sanskrit language
2. Ancient Sanskrit literature about science & technology can be understood
3. Being a logical language will help to develop logic in students

D) AUDIT 1 and 2: VALUE EDUCATION

Course Objectives Students will be able to

1. Explain value of education and self- development
2. Imbibe good values in students
3. Know about the importance of character

Syllabus

Units	Contents	Hours
1	• Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism. • Moral and non- moral valuation. Standards and principles • Value judgments	**4**
2	• Importance of cultivation of values. • Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness. • Honesty, Humanity. Power of faith, National Unity. • Patriotism.Love for nature ,Discipline	**6**
3	• Personality and Behavior Development - Soul and Scientific attitude. Positive Thinking. Integrity and discipline. • Punctuality, Love and Kindness.	**6**

	• Avoid fault Thinking. • Free from anger, Dignity of labour. • Universal brotherhood and religious tolerance. • True friendship.• Happiness Vs suffering, love for truth. • Aware of self-destructive habits. • Association and Cooperation. • Doing best for saving nature	
4	• Character and Competence –Holy books vs Blind faith. • Self-management and Good health. • Science of reincarnation. • Equality, Nonviolence ,Humility, Role of Women. • All religions and same message. • Mind your Mind, Self-control. • Honesty, Studying effectively•	**6**
	Suggested reading 1. Chakroborty, S.K. "Values and Ethics for organizations Theory and practice", Oxford University Press, New Delhi	

Course outcomes

Students will be able to

1. Get knowledge of self-development
2. Learn the importance of Human values
3. Developing the overall personality

E) AUDIT 1 and 2: CONSTITUTION OF INDIA

Course Objectives:

Students will be able to:

1. Explain the premises informing the twin themes of liberty and freedom from a civil rights perspective.
2. Address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.
3. Address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution

Units	Contents	Hours
1	• History of Making of the Indian Constitution: • History Drafting Committee, (Composition &Workin	**4**
2	• Philosophy of the Indian Constitution: • Preamble Salient Features	**4**
	• Contours of Constitutional Rights & Duties: • Fundamental Rights • Right to Equality • Right to Freedom • Right against Exploitation • Right to Freedom of Religion • Cultural and Educational Rights	**4**

	• Right to Constitutional Remedies • Directive Principles of State Policy • Fundamental Duties.	
	• Organs of Governance • Parliament • Composition • Qualifications and Disqualifications • Powers and Functions • Executive • President • Governor • Council of Ministers • Judiciary, Appointment and Transfer of Judges, Qualifications • Powers and Functions	**4**
	• Local Administration: District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation. Pachayati raj: Introduction, PRI: Zila Pachayat. Elected officials and their roles, CEO Zila Pachayat: Position and role. Block level: Organizational Hierarchy (Different departments), Village level: Role of Elected and Appointed officials, Importance of grass root democracy	**4**
	• Election Commission: • Election Commission: Role and Functioning. • Chief Election Commissioner and Election Commissioners. • State Election Commission: Role and Functioning. • Institute and Bodies for the welfare of SC/ST/OBC and women	**4**

Suggested reading

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

Course Outcomes: Students will be able to:

1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
3. Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
4. Discuss the passage of the Hindu Code Bill of 1956.

F) AUDIT 1 and 2: PEDAGOGY STUDIES

Course Objectives: Students will be able to:

1. Review existing evidence on the review topic to inform programme design and policy making undertaken by the DfID, other agencies and researchers.
2. Identify critical evidence gaps to guide the development.

Syllabus

Units	Contents	Hours
1	• Introduction and Methodology: • Aims and rationale, Policy background, Conceptual framework and • terminology • Theories of learning, Curriculum, Teacher education • Conceptual framework, Research questions. • Overview of methodology and Searching•	**4**
2	• Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries. • Curriculum, Teacher education.	**2**
	• Evidence on the effectiveness of pedagogical practices • Methodology for the in depth stage: quality assessment of included studies. • How can teacher education (curriculum and practicum) and the schoo • curriculum and guidance materials best support effective pedagogy? Theory of change. • Strength and nature of the body of evidence for effective pedagogical practices. • Pedagogic theory and pedagogical approaches. • Teachers' attitudes and beliefs and Pedagogic strategies.	**4**
	• Professional development: alignment with classroom practices and follow-up support. • Peer support Support from the head teacher and the community. • Curriculum and assessment • Barriers to learning: limited resources and large class sizes	**4**
	• Research gaps and future directions • Research design • Contexts • Pedagogy • Teacher education • Curriculum and assessment • Dissemination and research impact.	**2**

Suggested reading

1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2): 245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361-379.
3. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272–282.
5. Alexander RJ (2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.
6. Chavan M (2003) Read India: A mass scale, rapid, 'learning to read' campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf.

G) AUDIT 1 and 2: STRESS MANAGEMENT BY YOGA

Course Outcomes

1. Achieve overall health of body and mind
2. Overcome stress
3. Learn to perform yoga

Syllabus

Units	Contents	Hours
1	• Definitions of Eight parts of yog. (Ashtanga)	**8**
2	• Yam and Niyam. Do`s and Don't's in life. • i) Ahinsa, satya, astheya, bramhacharya and aparigraha • ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan	**8**
3	• Asan and Pranayam i) Various yog poses and their benefits for mind & body ii) ii)Regularization of breathing techniques and its effects-Types of pranayam	**8**

Suggested reading

1. 'Yogic Asanas for Group Tarining-Part-I" : Janardan Swami YogabhyasiMandal, Nagpur
2. "Rajayoga or conquering the Internal Nature" by Swami Vivekananda, AdvaitaAshrama (Publication Department), Kolkata

Course Outcomes: Students will be able to:

1. Develop healthy mind in a healthy body thus improving social health also
2. Improve efficiency.

H) AUDIT 1 and 2: PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS

Course Outcomes

1. Learn to achieve the highest goal happily
2. Become a person with stable mind, pleasing personality and determination
3. Awaken wisdom in students

Syllabus

Units	Contents	Hours
1	• Neetisatakam-Holistic development of personality • Verses- 19,20,21,22 (wisdom) • Verses- 29,31,32 (pride • & heroism) Verses- 26,28,63,65 (virtue) • Verses- 52,53,59 (dont's) • Verses- 71,73,75,78 (do's)	**8**
2	• Approach to day to day work and duties. • ShrimadBhagwadGeeta : Chapter 2-Verses 41, 47,48, • Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,17, • 23, 35, Chapter 18-Verses 45, 46, 48	**8**
3	• Statements of basic knowledge. • Shrimad Bhagwad Geeta: Chapter2-Verses 56, 62, 68 • Chapter 12 -Verses 13, 14, 15, 16,17, 18 • Personality of Role model. Shrimad Bhagwad Geeta: • Chapter2-Verses 17, Chapter 3-Verses 36,37,42, Chapter 4-Verses 18, 38,39 • Chapter18 – Verses 37,38,63	**8**

Suggested reading

1. "Srimad Bhagavad Gita" by Swami Swarupananda Advaita Ashram (Publication Department), Kolkata
2. Bhartrihari's Three Satakam (Niti-sringar-vairagya) by P.Gopinath, Rashtriya Sanskrit Sansthanam, New Delhi.

Course Outcomes Students will be able to

1. Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life
2. The person who has studied Geeta will lead the nation and mankind to peace and prosperity
3. Study of Neetishatakam will help in developing versatile personality of students.

Open Elective: 1. Business Analytics, 2. Industrial Safety, 3. Operation Research, 4. Cost Management of Engineering Projects, 5. Composite materials, Waste to Energy

A) Business Analytics

Teaching Scheme: 3 Hr/week

Total Number of Lectures: 48

Course Outcomes:

1. Describe the role of business analytics within an organization.
2. Analyze data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization.
3. Gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making.
4. Familiar with processes needed to develop, report, and analyze business data.
5. Use decision-making tools/Operations research techniques.
6. Mange business process using analytical and management tools.

7. Analyze and solve problems from different industries such as manufacturing, service, retail, software, banking and finance, sports, pharmaceutical, aerospace etc.

Syllabus

Units	Contents	Hours
1	Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics. Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview	9
2	Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression. Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.	8
3	Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes. Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.	9
4	Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models. Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model.	10
5	Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making	8
6	Recent Trends in : Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.	8

Reference:

1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.
2. Business Analytics by James Evans, persons Education.
3.

B) OPEN ELECTIVES: Industrial Safety

Teaching Scheme: 3h/week

Syllabus

Units	Contents	Hours
1	Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.	9
2	Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.	9
3	Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.	9
4	Fault tracing: Fault tracing-concept and importance, decision treeconcept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic,automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.	9
5	Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance	9

Reference:

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

C) OPEN ELECTIVES Operations Research

Teaching Scheme: 3h/week

Course Outcomes: At the end of the course, the student should be able to

1. Apply the dynamic programming to solve problems of discreet and continuous variables.
2. Apply the concept of non-linear programming
3. Carry out sensitivity analysis
4. Model the real world problem and simulate it.

Syllabus Contents:

Units	**Contents**	**Hours**
1	Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models	9
2	Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming	9
3	Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT	9
4	Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.	9
5	Competitive Models,Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation	9

References:

1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009
5. Pannerselvam, Operations Research: Prentice Hall of India 2010
6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010

D) Open Elective: Cost Management of Engineering Projects

Teaching scheme: 3 h/week

Syllabus Contents:

Units	**Contents**	**Hours**
1	Introduction and Overview of the Strategic Cost Management Process	4
2	Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.	10
3	Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process	11
4	Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.	11
5	Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.	8

References:

1. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
2. Charles T. Horngren and George Foster, Advanced Management Accounting
3. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
4. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher
5. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

E) Open Elective Composite Materials

Teaching Scheme: 3 h/week

Syllabus Contents:

Units	Contents	Hours
1	INTRODUCTION: Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.	9
2	REINFORCEMENTS: Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.	9
3	Manufacturing of Metal Matrix Composites: Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.	9
4	Manufacturing of Polymer Matrix Composites: Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.	9
5	Strength: Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.	9

TEXT BOOKS:

1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.

2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.

References:

1. Hand Book of Composite Materials-ed-Lubin.

2. Composite Materials – K.K.Chawla.

3. Composite Materials Science and Applications – Deborah D.L. Chung.

4. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi.

F) Open Elective Waste to Energy

Teaching Scheme: 3h/week

Syllabus Contents:

Units	Contents	Hours
1	Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors	8
2	Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.	8
	Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.	9
	Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors	10
	Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.	10

References:

1. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.