

M.Tech. in Textile Technology (Mechanical Processing of Textiles) effective from the year 2013

West Bengal University of Technology

1<sup>st</sup> semester

Theory:							
Code	Subject	Contacts periods per week				Full marks	Credit
		L	T	P	Total		
MTT/MCP 101	Advanced Engg. Math	3	1	0	4	100	4
MTT/MCP 102	Physical Prop of Tex Fibres	4	0	0	4	100	4
MTT 103	Mechanism of Yarn Formation	4	0	0	4	100	4
MTT 104	Mechanism of Fabric Formation	4	0	0	4	100	4
MTT/MCP 105	Elect I: (A)Applied Statistics and Quality Control in Textile industries/ (B)Computational Methods in Textiles	4	0	0	4	100	4
	Total of theory				20	500	20
Practical							
MTT /MCP 191	Lab I: Physical Prop of Tex Fibres Lab	0	0	3	3	100	2
MTT 192	Lab II: Yarn and Fabric Formation Lab	0	0	3	3	100	2
	Total of practical				6	200	4
Sessional							
MTT/MCP 193	Seminar I	0	2	0	2	100	1
	Total credit of 1 <sup>st</sup> semester				28	800	25

2<sup>nd</sup> semester

Theory:							
Code	Subject	Contacts periods per week				Full marks	Credit
		L	T	P	Total		
MTT /MCP 201	Industrial Management	4	0	0	4	100	4
MTT 202	Theory of Textile Structure	4	0	0	4	100	4
MTT 203	Technical Textiles	4	0	0	4	100	4
MTT 204	Elect II: (A) Theory & Design of Yarn forming machineries/ (B) Theory & Design of Fabric forming machineries/ (C) Advanced Fibre Technology (D) Apparel Technology	4	0	0	4	100	4
MTT/MCP 205	Elect III: (A) Electro-active Textiles/ (B) Plasma Technology/ (C) Eco-Textiles (D) Theory of Manmade Fibre Production and Texturising	4	0	0	4	100	4
	Total of theory				20	500	20
Practical							
MTT 291	Lab III: Textile Structure Lab	0	0	3	3	100	2
Sessional							
MTT/MCP 292	Term paper leading to thesis	0	2	0	2	100	1
MTT/MCP 293	Comprehensive Viva-Voce					100	4
	Total credit of 2 <sup>nd</sup> semester				26	800	27

3<sup>rd</sup> semester

Theory:							
Code	Subject	Contacts periods per week				Full marks	Credit
		L	T	P	Total		
Sessional							
MTT/MCP 391	Dissertation (Part-I)				24	100	4
MTT/MCP 392	Defence of dissertation (Part-I)					100	8
	Total credit of 3 <sup>rd</sup> semester:				32	400	20

4<sup>th</sup> semester

Sessional:							
Code	Subject	Contacts periods per week				Full marks	Credit
		L	T	P	Total		
Sessional							
MTT/MCP 491	Dissertation (Completion)				24	100	6
MTT/MCP 491	Post-submission defences of dissertation					100	18
	Total credit of 4 <sup>th</sup> semester:				24	200	24
	Grand Total of credits:						96

**MTT 101 Advanced Engg. Math. (includes numerical methods)**

Unit 1

Fourier series and Transform: Revision of Fourier series, integrals and transforms and their properties. The 2-dimensional fourier transform, convolution theorem, Parseval's formula, discrete fourier transform, fast fourier transform ; (5)

Unit 2

Optimization Technique: Calculus of several variables, Implicit function theorem, Nature of singular points, Necessary and sufficient conditions for optimization, Elements of calculus of variation, Constrained Optimization, Lagrange multipliers, Penalty function, Gradient method, Dynamic programming; (9)

Unit 3

Partial Differential Equations: Solutions of Wave equation, Heat equation and Laplace's equation by the method of separation of variables and their use in problems of vibrating string, one dimensional unsteady heat flow and two dimensional steady state heat flow including polar form. Two Dimensional wave equation; (9)

Unit 4

Graph Theory: Graphs and planar graphs : Basic terminology, multigraphs and weighted graphs, paths and circuits, shortest paths in weighted graphs, Eulerian paths and circuits, Hamiltonian paths and circuits. Trees and cut-sets : trees, rooted trees, path lengths in rooted trees, spanning trees and BFS & DFS algorithms, minimum spanning trees and Prims & Kruskal's algorithms . (9)

Unit 5

Numerical analysis: Cubic spline, B splines Bezier curves and surfaces ;ordinary diff equation Series solution, methods of Milne, Adams-Bashforth, Milne Simpson multistep and Runge-Kutta methods. Difference equations; numerical solution, relaxation method. Solution of partial differential equations by difference methods. Numerical solutions of elliptic, parabolic and hyperbolic partial differential equations. (10)

Books:

1. John B. Conway, Functions of one complex variable, Springer International.
2. James Ward Brown & Ruel V. Churchill, Complex variable and application., Mc Graw Hill International edition .

3. John H. Mathews, Numerical Methods for Mathematics , science and Engineering, PHI
4. D.C. Sanyal and K. Das, A text Book of Numerical analysis, U.N. Dhar & Sons Pvt. Ltd.
5. S.S.Rao., Optimisation theory and application, Wiley Eastern limited
6. E.Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons, 2001
7. Hoffman & Kunze. R, Linear Algebra, PHI

### MTT/MCP 102 Physical Properties of Textile Fibres

Unit	Content
1	Fine structure of textile fibre, Mechanism of deformation in fibres, Principles of elasticity and visco-elasticity, Stress-strain relations, creep, stress-relaxation, time-temperature effect, dynamic mechanical properties, Different model theories of visco-elasticity. Thermodynamic analysis of mechanical deformation and rubber elasticity,
2	Setting of textile fibre, fibre friction, optical properties of fibres, Refractive index and birefringence.
3	Moisture sorption and desorption in fibres, Swelling of fibre.
4	Dielectric properties, effect of frequency and temperature on dielectric constant, Electrical resistance and its measurement, Static electricity and measurement of static charge in fibres.

#### Text Books:

1. Physical properties of fibre, Hearle and Morton;
2. Manufactured fibre Technology, V.B Gupta and V.K Kothari;
3. The Mechanical Properties of Textile Fibers von *R. Meredith.*;
4. Introduction to Polymer, Robert J. Young.

### MTT 103 Mechanism of Yarn Formation

Unit	Content	No of hrs
Unit 1:	Cotton fibre selection through bale management, concept of opening and cleaning, forces on fibres during opening and cleaning processes and it's effect;	4
Unit 2:	Advancement in Carding process, theories of carding, analysis of cylinder load and transfer efficiency, Mechanism of formation of various fibre configurations in carded sliver;	6
Unit 3:	Drafting theories, fibre configuration in drawn sliver; hook removal and it's significance. sliver irregularity, fibre movement in drafting field, suppression of drafting wave, drafting force, roller slip, roller eccentricity and vibration, principles of autolevelling;	6
Unit 4:	Fibre fractionation in comber, combing performance;	3
Unit 5:	Blending of fibres, evaluation of blending efficiency;	2
Unit 6:	Analysis of forces on yarn and traveler, spinning tension in ring and rotor spinning, spinning geometry, twist flow in ring and rotor spinning, end breaks during spinning;	7
Unit 7:	False twisting principles, Friction spinning and mechanism of twisting, Air-jet, Vortex spinning and mechanism of twisting;	7
Unit 8:	Effect of different parameters on structure and properties of yarns; analysis of structure-property relationship of rotor, air-jet and friction spun yarns;	5
Unit 9:	Process control in spinning, control of temperature & humidity, waste control.	5

### Books Recommended:

1. Carl A. Lawrence, "Fundamentals of Spun Yarn technology", CRC Press
2. Carl A. Lawrence, "Advances in Yarn Spinning Technology", The Textile Institute, Woodhead Publishing Limited
3. Peter R. Lord, "Handbook of Yarn Production", The Textile Institute, Woodhead Publishing Limited
4. Grosberg P and Iype C, "Yarn Production-Theoretical Aspects", The Textile Institute
5. Abhijit Majumdar, Apurba Das, Ramasamy Alagirusamy and Vijay Kothari, "Process Control in Textile Manufacturing", The Textile Institute, Woodhead Publishing Limited

### MTT 104 Mechanism of Fabric Formation

#### Unit 1

Mechanism of formation different package in textile, effects of input package on quality of package, Development trends in winding, warping and sizing machines for improving quality of preparation and cost, reduction with specific reference to shuttleless weaving machines. Tension control and automation in winding, warping and sizing. (8)

#### Unit 2

Theoretical analysis of weft insertion in shuttleless looms. effects of weft accumulator, Take-up, let-off. Effects of use of Electronic jacquards on fabric, noise control, waste control. Movement of cloth fell position, beat up force and pick spacing. waste control. Mechanism of woven fabric formation. Effects of warp and weft tension on fabric formation. Mechanism of warp breakage. (10)

#### Unit 3

Fabric formation in Multiphase Weaving, Triaxial Weaving, Weaving of Technical Textiles, Carpet Weaving, Velvet Weaving, Narrow fabric weaving, 3D fabric formation. (4)

#### Unit 4

Knitting: Dynamics of knitted loop formation in weft and warp knitting, Yarn tension and knitting forces, effect of cam shape, increase in number of feeders and increase in linear speed – needle on loop formation of fabric with design. (8)

#### Unit 5

Classification of Braids, Flat braiding, Circular braiding and hollow braiding – production techniques. Knitting of Technical Textiles. (3)

#### Unit 6

Nonwovens: Fibre/filament arrangement in web and its effect on mechanical properties of nonwoven fabrics. Effects of machine, fibre and process variables on properties of nonwoven fabrics. Production of spun bonded and melt blown fabrics. production spunlace fabric. (7)

#### Unit 7

Mechanics of stitching and sewing and problems related to sewn textiles, alongside mechanism sewing machines, and intelligent sewing systems. (2)

**Total 42**

### REFERENCES:

1. Adanur S, "Handbook of Weaving", Technomic Publishing Co, 2001.
2. Allan Ormerod, W S Sondhelm, "Weaving - Technology & Operation", The Textile Institute, 1998.
3. Talukdar M K., Sriramulu P K and Asgaonkar D B, "Weaving Machines, Mechanisms and Management", Mahajan Publishers Pvt. Ltd, 1998
4. Sabit Adanur, "Wellington Sears Handbook of Industrial Textiles", Technomic Publishing Co., Inc, 1995.
5. Horrocks A R and Anand S C, "Handbook of Technical Textiles", Woodhead Publishers and Textile Institute, 2000
6. Seyam A M, "Structural Design of Woven Fabrics", Textile Progress Vol.31, No: 3. Wood Head Publishing Ltd, 2002.
7. Indian Journal of Fibre and Textile Research, "Special issue on Recent Advance in Fabric forming", Publications and Information Directorate (NISCOM) CSIR, Vol. 19, No.3, 1994.
8. Spencer D J, "Knitting Technology", Pergamon Press, 1998.
9. Raz S, "Warp Knitting Technology", Verlag Melliand Textilberchte, GMBH, Heidelberg, 1987.
10. Gottlieb N, "The Production and Properties of Warp knitted fabrics", Textile Progress, Vol.7, No.2, 1975.

11. Wilhelm Albrecht et.al , "Nonwoven Fabrics", Wiley - VCH Verlag Gmbh and Company, 2003.
12. Krcma R, "Manual of Nonwovens", Textile Trade Press, 1993.
13. Russel.S, "Handbook of Nonwovens", The Textile Institute Publication, 2004.
14. Irsak O, "Nonwoven Textiles", Textile Institute, 1999.
15. Mrstina.V and Feigl F, "Needle Punching Technology", Elsevier Science Publishers, 1990.
16. Joining textiles: Principles and applications Edited by I Jones, TWI and G K Stylios,woodhead Publishing 2013.
17. Carl A. Lawrence, "Fundamentals of spun yarn technology", CRC Press, New York, 2003

### MTT 105 Elect I: (A) Applied Statistics and Quality Control in Textile industries

PROBABILITY DISTRIBUTION AND ESTIMATION: Introduction to probability distributions – discrete distributions and continuous distributions; Applications of Binomial, Poisson, Normal, Student's't', Chi-square, and F distributions in textile manufacturing. (5)

TESTS OF SIGNIFICANCE: Concept of hypothesis testing, Errors in hypothesis testing – Type I and Type II errors; Significance tests – t-test, chi-square test and F-test – applicable to textile quality parameters; selection of sample size and significance levels with relevance to textile applications. (5)

Stochastic process, markov chains, poisson process, normal process application in textiles. (3)

ANALYSIS OF VARIANCE: One-way ANOVA, two-way ANOVA, experimental design for ANOVA. (7)

DESIGN AND ANALYSIS OF EXPERIMENTS: Importance of experimental design; Classification of experimental designs – Classical and Taguchi designs; 2k factorial designs – full factorial and fractional factorial designs; 3k factorial designs – design and analysis of second-order composite designs – orthogonal and rotatable designs; fitting regression models; calculation of regression coefficients; adequacy test for the regression equations. Box and Behnken Method applied to textile problem. (8)

EXTREME VALUE MODELLING: Properties of the Weibull model; the characteristic smallest value; two-parameter case and three-parameter case; connections with initial distributions. Application of Weibull distribution in extreme value modelling for yarn strength, fabric strength, etc. (7)

PROCESS CONTROL AND CAPABILITY ANALYSIS: Control charts for variables and attributes-basis, development, interpretation, sensitizing rules, average run length; Capability analysis. Cumulative sum and exponentially weighted moving average control charts, multivariate process monitoring and control (7)

Total 42

#### REFERENCES:

1. Leaf G.A V, "Practical Statistics for the Textile Industry", Part I and II, The Textile Institute, Manchester, 1984, ISBN: 0900739517.
  2. Mayer P L, "Introductory Probability and Statistical Applications", Oxford and IBH Publishing Co., New Delhi, 1970.
  3. Akhnazarova S and Kafarov V, "Experiments Optimization in Chemistry and Chemical Engineering", Mir Publishers, Moscow, 1982.
  4. Bury K V, "Statistical Models in Applied Science", John Wiley & Sons, New York, 1975.
  5. Montgomery D C, "Design and Analysis of Experiments", John Wiley & Sons, New York, 1997.
- Brearely A and Cox D R, "An outline of statistical methods for use in the textile industry", WIRA, 1953

### MTT/MCP 105 Elect I: (B) Computational Methods in Textiles

COMPUTER VISION BASED IMAGE PROCESSING: Elements of Digital Image Processing – Image formation , Pre-processing techniques, image transforms – enhancement- restoration – encoding. image analysis and feature extraction methods – Application of Image processing to textile process/product feature extraction. (7)

ARTIFICIAL NEURAL NETWORKS: Introduction to artificial neural networks, basic models like Hopfield networks, multilayer perceptron and learning vector quantization networks, self-organizing feature maps-their properties and applications ;Basic concept – Inference and Learning – models – supervised & unsupervised learning- Knowledge based Neural Networks. Application of ANN to Fabric defect analysis, pattern recognition –prediction of clothing performance, garment manufacturing – classification of patterns. Support vector machine ,cluster algorithm (9)

ARTIFICIAL INTELLIGENCE AND DECISION SUPPORT SYSTEMS: Scope of artificial intelligence – structures of Expert and Decision support systems – Application – Spinning, weaving and garment unit. (5)

Application of DSS to Fabric defect analysis. Introduction to fuzzy sets and its importance in real life. Definition, basic operators, T-norm , S-norm, other aggregation operators. Fuzzy relation, implications,

cylindrical extension, projection and composition, Approximate reasoning, compositional rule of inference, rule based system, term set, fuzzification, reasoning, defuzzification, different fuzzy models (MA/TS)- some applications of fuzzy rule based system. (6)

An Introduction to Genetic Algorithms, Theoretical Foundations of Genetic Algorithms, Genetic Algorithms in Engineering and Optimization, Genetic Algorithms in Natural Evolution, Simulated Annealing and Tabu Search, Studies of Hybrid (neuro-fuzzy, fuzzy-neutral and fuzzy -GA) systems and applications (6)

Monte Carlo Principle, Simple Simulation Methods, Sequential Monte Carlo Methods, Markov Chain Monte Carlo simulation of univariate and multivariate normally distributed random variables: Box-Muller and Marsaglia methods, variance reduction techniques, generation of Brownian sample paths, quasi-Monte Carlo. Methods. examples (4)

MODELING AND SIMULATION: Introduction – Basic modeling concepts, methods, FEM Technique. Modelling and Simulation of textile structures Basics of computer graphics – graphic input techniques – Two dimensional transformation – 3-D concept. (5)

Total 42

#### REFERENCES:

1. Gonzalez R C and Wintz P, "Digital Image Processing", Pearson Education second edition 2002.
2. Patterson D W, "Artificial Intelligence and Expert System", Prentice Hall of India, 1996.
3. Rajaram V, "Analysis and Design of Information systems", Prentice Hall of India, 1992.
4. Goldberg - Genetic algorithm, Pearson 2003
5. S-Rajasekaran and G-A Vijayalakshmi Pai-'Neural Networks- Fuzzy logic and Genetic Algorithms- Synthesis and Applications'- Prentice Hall of India- New Delhi-2003
6. Nils-J- Nilsson- "Artificial Intelligence- A new synthesis'- Morgan Kauffmann Publishers Inc- San Francisco- California- 1998
7. Freeman - Neural Networks, Pearson 2003
8. Jang - Neuro-fuzzy and soft Computing, Pearson 2003
9. Melanie Mitchell- 'An introduction to Genetic Algorithm'- Prentice-Hall of India- New Delhi- Edition: 2004
10. David-E- Goldberg- 'Genetic algorithms in search- optimization and machine learning'- Addison-Wesley- 1999
11. Min Fu, "Neural Networks in Computer Intelligence", Mc Graw Hill Inc, 1994.
12. Fuzzy Logic with Engineering Applications Timothy J. Ross (Author) 3rd Edition Wiley 2009
13. Monte Carlo Strategies in Scientific Computing, Springer Series in Statistics, by J. S. Liu
14. Monte Carlo Statistical Methods, Springer Texts in Statistics, by C. P. Robert and G. Casella
15. P. Glasserman, Monte Carlo Methods in Financial Engineering, Springer, 2004.

#### MTT /MCP 191 Lab I: Physical Properties of Textile Fibres Lab

Laboratory Experiment	
1	Microscopic studies of fibre structure and swelling
2	Study of Moisture sorption and desorption of different fibres
3	Study of creep behaviour on different fibres
4	Study on Fatigue of different fibres,
5	Study of optical properties on different fibres
6	Thermal analysis such as DSC, TGA, TMA, etc. of fibres.
7	Characterization of fibres by Infrared Spectroscopy.

#### MTT 192 Lab II: Yarn and Fabric Formation Lab

**Part I: Yarn Formation Lab: (At least 6-8 experimental jobs must be attempted from the following list)**

1. Measurement of Different Process parameters (degree of opening, Openness value etc.) related to opening and cleaning of cotton Fibres by suitable methods.
2. Measurement of Transfer co-efficient of carding machine using suitable technique.
3. Analysis of drafting wave as produced in carded and drawing slivers by appropriate methods.
4. Determination of Cutting-Combing Ratio of carded and drawn slivers by Lindsay technique.
5. Establish the relationship between mechanical draft and actual draft on roving preparation.
6. Study on effect of drafting angle on yarn characteristics in ring spinning.
7. Determination of highest standard count by taking trials on ring frame.
8. Optimization of twist in ring-spun yarn preparation.
9. Effect of individual draft and main draft on evenness of ring spun yarn.
10. Determination of doubling twist- single twist ratio for balanced plied yarn preparation in TFO.
11. Study of preparation of different mono fancy yarns, core-spun yarns on ring spinning machine having multiple attachment
12. Study of preparation of different Plied fancy yarns on ring doubling/Fancy doubling/rotor machine
13. Study on fibre configuration in fibre band inside rotor.
14. Effect of different navel guide on rotor-yarn characteristics.
15. Study on fibre breakage on rotor spinning process.
16. Comparison between compact-spun and ring-spun yarn characteristics.

**Part II: Fabric Formation Lab (At least 6-8 experimental jobs must be attempted from the following list)**

- 1) Study of cloth fell movement during nominal movement and actual movement of loom
- 2) Study of weft insertion system shuttle, rapier, air-jet, projectile system,
- 3) Detail study of control mechanism in let off and take up system,
- 4) Study of effect of warp and weft tension on crimp, yarn modular length,
- 5) Study of yarn movement in weft knitting zone,
- 6) Study of yarn breakage in weaving and knitting.
- 7) Study of yarn tension in weaving and knitting.
- 8) Study of effect of yarn and fabric tension on loop length.
- 9) Study of fabric characteristics of needle punched fabric, spun laced, spun bonded fabric, melt-blown fabric, coated fabric, adhesive bonded fabric.

**MCP / MTT 201 Industrial Management**

1. *Classification and importance of Operations Management* 4L  
Operations management in corporate profitability and competitiveness; Types & characteristics of manufacturing systems and service systems
2. *Operations Planning and Control* 10L  
Management and control of cost; Forecasting for operations; Purchases finance marketing and sales; Operation research; EOQ Model, MRP concept and calculation; Inventory planning & control

- |   |     |
|---|-----|
| 3. <i>Quality Assurance</i>   | 5L  |
| The quality assurance system; control of quality; quality standards; Cost of Quality; ISO system  |     |
| 4. <i>Management Information system</i>   | 10L |
| Communication; Motivating personnel; Leadership quality; production planning and control; Concept of Production and Productivity wage and salary structure; concept of Total Productive Maintenance |     |
| 5. <i>Case Study of Textile Industry</i>  | 6L  |
| Concept of machine scheduling: Case Study – I; Concept of Manpower allocation: Case Study – II; Concept of grievance handling: Case Study - III   |     |

## **MTT 202 Theory of Textile Structure**

### Unit 1

Theory of migration of filament and staple yarns. Geometry of Radial migration; Transverse forces and lateral contraction; Comparative analysis of structural characteristics of various types of spun yarns. Influence of fibre characteristics on yarn structure. Tensile behaviour of filament yarn under large extension, consideration of radial stress, theory of tensile properties of spun yarn. (7)

### Unit 2

Energy method applied to calculate stress-strain of filament yarn. Bending and torsion behavior of yarns. Frictional behaviour of yarns. Rupture behaviour of filament and spun yarns. Geometry of plied structure. Tensile properties of plied structures. (5)

### Unit 3

Elastica model for fabric parameters and crimp balance. Concept of fabric relaxation and set. Geometry-mechanical model with setting. Practical application of geometrical (dimensional changes) and elastica models. (4)

### Unit 4

Energy method applied to fabric geometry; Optimal control theory applied to study of fabric mechanics. Uniaxial and biaxial tensile deformation of woven fabric. Bending deformation of woven fabric, bending behaviour of set and unset fabrics and bending in bias direction. (6)

### Unit 5

Bending, Shear and drape properties of woven fabric. Buckling and compressional behaviour of woven fabrics. Mathematical models and their application in the study of tensile, bending, shear, compressional and buckling deformation of woven fabrics. (7)

### Unit 6

Structure and properties of knitted Dimensional properties - Spirality - Relaxation - shrinkage. Dimensional characteristics of warp knits, Warp knitted fabric geometry - relation between loop length and construction - fabric relaxation and shrinkage. and nonwoven fabrics. Arrangement of fibre in Nonwoven fabric: Mechanics of spun bonded fabric.mechanics of adhesive fabric;energy method in stress-strain of nonwoven fabrics ; (6)

### Unit 7

Physics of Porous nature of fabric and liquid absorption; Mechanism of heat and mass transfer through fabrics. Mechanism of Moisture Vapour Transmission. Mechanism of Liquid – Moisture Transmission; Theoretical Consideration of air permeability; Mechanics of Fabric prickliness, Smoothness, Roughness. Mechanics of Tailoring. (7)

## **REFERENCES:**

1. J.W.S Hearle, P Grosberg and S. Backer, Structural Mechanics of Fibres ,Yarns and Fabrics Vol.1 Wiley-Interscience ,New York,1969.
2. R.Poslta,,G.a.Carnaby and S.de.Jong, The Mechanics of wool Structures, Ellis Horwood Limited,Jhon Wiley & Sons1988
3. Carl A. Lawrence, "Fundamentals of spun yarn technology", CRC Press, New York, 2003.
4. Grosberg P and Iype C, "Yarn Production – Theoretical Aspects", The Textile Institute,Manchester,1999.
5. Adanur S , "Handbook of Weaving", Technomic Publishing Co, 2001.
6. Sabit Adanur, "Wellington Sears Handbook of Industrial Textiles ", Technomic Publishing Co., Inc, 1995.
7. Horrocks A R and Anand S C, "Handbook of Technical Textiles", Woodhead Publishers and Textile Institute, 2000
8. J Hu, "Structure and Mechanics of Woven Fabrics", Hong Kong Polytechnic University, Wood Head Publishing Ltd, 2004.



9. Slater K, "Comfort Properties of Textiles", Textile Progress, Vol.9, The Textile Institute, Manchester, 1977. ISBN: 0040-5167.
10. Li Y, "The Science of Clothing Comfort", Textile Progress, Vol.31, No.1/2, The Textile Institute, Manchester, 2001.
11. Saville B P, "Physical Testing of Textiles", Woodhead Pub.Ltd., Cambridge, 1999. ISBN:1-85573-367-6
13. Kothari V K, "Progress in Textiles: Science and Technology Vol.1, Testing and Quality Management", IAFL Publications, New Delhi, 1999.
- 14 Seyam A M, "Structural Design of Woven Fabrics", Textile Progress Vol.31, No: 3. Wood Head Publishing Ltd, 2002.
- 15.Li, "The Science of Clothing Comfort", Textile Progress, Vol., 29/3, 1997.
16. Bishop D L., "Fabrics: Sensory and Mechanical Properties", Textile Progress Vol. 26/3, 1994.
- 17.J.W.S Hearle, The Mechanics of Flexible Fibre Assemblies,Nato advanced study Institute ,Greece,1979
- 18.T.W.Chou and F.K.Ko "Textile Structural Composites",Elsevier,Netherlands,1989.
19. J Hu," 3-D fibrous assemblies: Properties, applications and modelling of three-dimensional textile Woodhead Publishing,UK,2008
20. B K Behera and P K Hari, "Woven textile structure: Theory and applications" Woodhead Publishing,UK,2013

### **MTT 203            Technical Textiles**

Medical Textiles:Main types of nonwovens and technologies for medical applications, Textiles as implants; - Textiles for medicine,Safety evaluation and other regulatory aspect Fabrication and characterization, Application and release technologies of textiles; Thermal comfort of medical textiles:Evaluation and testing of thermal properties for medical textiles,Textile properties influencing skin contact sensations and applications;Lyocell fibers ,SeaCell® textiles for antimicrobial therapy ;Absorbent products for personal health and hygiene; Applications of bio-functional textiles;medical filters ; Application of hollow fiber bioreactors; medical bandages and stockings, superabsorbents in medicine,in hygiene products ;nanofibres in the medical field and Tissue engineering; (9)

Geotextiles:Textile Principles of reinforced soil ,Types of geosynthetics like geotextiles, geogrids, geonets,geocells, geo-composites, their manufacturing method; Different index properties,strength properties, Apparent Opening Size, In-plane and cross-plane permeability tests. Erosion control on slopes using geosynthetics; Drainage and filtration applications of geosynthetics, and criteria for selection of geotextiles, estimation of flow of water in retaining walls, pavements, etc. and selection of geosynthetics. application of different geosynthetics like geonets, geotextiles for drainage in landfills, use of geomembranes and Geosynthetic .(9)

Composite Materials: Constituents - functions of fibre and matrix - Properties of fibres-Critical fibre length - Aligned and random fibre composites - property prediction Rule of Mixtures - Simple problems ; Types of high performance fibers properties - types of matrix materials - Thermoset and Thermo plastics properties - Fibre matrix interface-coupling agents - Concept of interfaces and interfacial reaction in fibre composites - Tensile strength of continuous and discontinuous composites. Fracture mode in fibre composites ; Manufacturing techniques - property requirements- In-plane shear, Biaxial In-plane tension, Compaction. Textile preforms - weaving, knitting and braiding. Application of textile composites. (9)

Material requirement for the design of performance sports wear. Sweat management for sports application. Evaluation methods . (2)

UVProtection, Microorganism protection, Respiratory protection, Chemical and biological protection, protection from electromagnetic radiation, flame resistance, and static hazards. Standards and evaluation methods. (4)

Protective Clothing For Military Textiles: Ballistic protection, Radiation protection and thermal insulation. Environmental protection, surveillance and camouflage, psychological requirements, composites applications. (3)

Intelligent textiles: Applications of smart textiles, sensors, actuators, data processing, storage and communication, phase change material. (2) Nanofibre production: Electrospinning of nanofibres. Continuous yarns from electrospun nanofibres. Production of polyamide nanofibres by electrospinning; application of nano fibres. Bottom-up and top-down approaches and challenges in nanotechnology. (4)

Total 42

#### References

1. Koerner, R.M. "Designing with Geosynthetics", Prentice Hall, New Jersey, USA, 4th edition, 1999.
2. Jewell, R.A., "Soil Reinforcement with Geotextiles", Special Publication, No. 123, CIRIA, Thomas Telford. London, UK, 1996.
3. Geosynthetics - New Horizons, Eds. G.V. Rao, PK Banerjee, J.T. Shahu, G.V. Ramana, Asian Books Private Ltd., New Delhi, 2004
4. Brown P J and Stevens K, "Nanofibres and Nanotechnology in Textiles", Woodhead Pub. Ltd., Cambridge, 2007
5. Yury Gogotsi, "Nanotubes and Nanofibres", CRC Taylor & Francis, Boca Raton, 2006
6. Guazhong Cao, "Nanostructure and nanomaterials", Imperial College Press, USA, 2006
7. Mick Wilson, Kamali Kannangara, Geoff Smith, Michelle Simons and Burkhard Raguse, "Nanotechnology- Basic Science and Emerging Technologies", Overseas Press, New Delhi, 2005.
8. Richard A Scott, "Textiles For Protection Textiles Institute, CRC press & wood head publishing, England, 2005.
9. Adanur S. "Wellington Sears Handbook of Industrial Textiles", Technomic Publishing Co., Ind. 1995
10. Anand S, "Medical Textiles", Textile Institute, 1996.
11. Shishoo R, "Textiles in sport", Textile Institute, 2005.
12. Mattilla H.R. "Intelligent textiles and clothing", Textile Institute, 2006.
13. Tao X., "Smart Fibres, Fabric and Clothing", Textile Institute, 2001.
14. Long A C, "Design and Manufacture of Textile Composites", Woodhead Publishing Ltd., UK, 2005.
15. Gupta L, "Advanced Composite Materials", Himalayam Books, 1998.
16. Mathews F L and Rawlings R D, "Composite Materials Engineering Science", 1994.
17. Bogdanovich A and Pastore C, "Mechanics of Textile and Laminated Composites", Chapman & Hall Due, 1997.
18. Hearle J W S, "High Performance Fibres Composites and Engineering Textile Structures", Journal of the Textile Institute, Special issues, The Textile Institute, 1990.
19. Kostikov V L, "Fibre Science and Technology (Soviet Advanced Composites Technology Series)", Chapman & Hall, 1995.

#### MTT 204 : (A) Theory & Design of Yarn forming machineries

Unit	Content	No of hrs
Unit 1:	Aerodynamic characteristics of blow room machineries; Design principles of modern openers and blenders, feed regulation;	5
Unit 2:	Theories of carding; Technological considerations in the design of high production card; design aspects of high production cards; Card wire geometry;	7
Unit 3:	Developments in roller drafting, design aspects of modern	5

	draw frame, auto leveling;	
Unit 4:	Design development of Modern comber and its preparatory machines;	5
Unit 5:	Design aspects of modern speed frame with respect to drafting, flyer, building mechanism etc.;	4
Unit 6:	Design & development of modern ring frame, developments in the design of spindle, ring and travelers, concept of compact spinning, different systems of compacting, auto piecing & auto doffing, link winding;	8
Unit 7:	Design developments of opening rollers, rotors and navel in rotor spinning;	4
Unit 8:	Developments in the design of friction spinning machines;	3
Unit 9:	Design developments of air jet spinning, design of air jet nozzles, design of vortex nozzle;	4
Total		45

### Books Recommended:

1. Carl A. Lawrence, "Fundamentals of Spun Yarn technology", CRC Press
2. Carl A. Lawrence, "Advances in Yarn Spinning Technology", The Textile Institute, Woodhead Publishing Limited
3. Peter R. Lord, "Handbook of Yarn Production", The Textile Institute, Woodhead Publishing Limited
4. Grosberg P and Iype C, "Yarn Production-Theoretical Aspects", The Textile Institute
5. The Textile Institute Publication - Manual of Textile Technology – Short Staple Spinning Series  
 Vol.I – The Technology of short staple spinning by W. Klein. 1987  
 Vol.-IV – A Practical Guide to Ring spinning by W. Klein. 1987  
 Vol.V – New Spinning Systems – W. Klein.1993  
 Vol.VI - Man-made fibre spinning – W.Klein1994

### MTT 204 Elect II: (B) Theory & Design of Fabric forming machineries

Design trends in winding, warping and sizing machines, Yarn clearer controls - knotter /splicer carriage controls - pre-set length/full cone monitors. Tension control and automation in sizing. Design concepts for warping creels and wrappers beam drive. Design features of creel, sow box, drying system. Warping machine monitors and controls - sizing machine monitors and controls - auto-reaching/drawing-in and knotting machine monitors and controls. Data acquisition system in weaving preparatory and weaving – humidification system Layout of Automatic temperature control Unit In sizing. Drying cylinder construction. Air and condensed water removal from the cylinder. Weavers beam drive. Dust control Units.

(10)

Factors involved in design of Loom structure. requirements for Beat-up mechanism, reed and shuttle. Design limitations in shuttle looms. Kinematics of sley and heald motion with reference to shuttleless looms. Theoretical analysis of weft insertion in shuttleless looms. Drive and Heald shaft design features. cam beat-up -Weft selection device - weft accumulator. Take-up – let-off. Design of multiphase looms. Analysis of let off mechanism, electronic let off and take up. noise reduction and waste control. Electronic data acquisition in a loom shed. design of the electronic dobby, drive arrangement, systems for pattern data transfer. various

electronic jacquard systems, selection system, pattern data transfer CAD for dobby, jacquard, label weaving and carpet. (12)

Design and performance of high speed knitting cams. Developments in knitting machines. Developments in processing machineries for knitted fabrics. Yarn feeding devices on circular knitting machines and design features of positive feeders. Needle Selection Techniques in weft knitting - storage and positive feeding devices - Patterning for multitrack machines, Automation in weft and warp knitting. (8)

Design trends in fibre/filament arrangement in web of nonwoven fabrics. Effects of machine, fibre and process variables on properties of nonwoven fabrics. Production of spun bonded and melt blown fabrics.

(7)

Hydraulic and Pneumatic automation in textile machines - Simple sequential logic circuit design - Programmable Logic Controllers (PLC), Block diagram – programming methods – programs – applications - material handling system (5)

**Total 42**

## REFERENCES:

1. Adanur S, "Handbook of Weaving", Technomic Publishing Co, 2001.
2. Talukdar M K, Sriramulu P K and Asgaonkar D B, "Weaving Machines, Mechanisms and Management", Mahajan Publishers Pvt. Ltd, 1998
3. Sabit Adanur, "Wellington Sears Handbook of Industrial Textiles", Technomic Publishing Co., Inc, 1995.
4. Horrocks A R and Anand S C, "Handbook of Technical Textiles", Woodhead Publishers and Textile Institute, 2000
5. Indian Journal of Fibre and Textile Research, "Special issue on Recent Advance in Fabric forming", Publications and Information Directorate (NISCOM) CSIR, Vol. 19, No.3, 1994.
6. Spencer D J, "Knitting Technology", Pergamon Press, 1998.
7. Raz S, "Warp Knitting Technology", Verlag Melliand Textilberchte, GMBH, Heidelberg, 1987.
8. Gottlieb N, "The Production and Properties of Warp knitted fabrics", Textile Progress, Vol.7, No.2, 1975.
9. Wilhelm Albrecht et.al, "Nonwoven Fabrics", Wiley - VCH Verlag Gmbh and Company, 2003.
10. Krcma R, "Manual of Nonwovens", Textile Trade Press, 1993.
11. Russel.S, "Handbook of Nonwovens", The Textile Institute Publication, 2004.
12. Irsak O, "Nonwoven Textiles", Textile Institute, 1999.
13. Mrstina.V and Feigl F, "Needle Punching Technology", Elsevier Science Publishers, 1990.
14. Berkstresser G A, Buchanan D R and Grady P, "Automation in the Textile Industry from Fibres to Apparel", The Textile Institute, UK, 1995.
15. Textiles Go On-line, The Textile Institute, UK, 1996.
16. Vassiliadis S G, "Automation and the Textile Industry", Eurotex, 1996.
17. Ormerod A, "Modern Development in Spinning and Weaving Machinery", Butterworths, 1993.
18. Gordon A. Berkstresser III et.al, "Automation and Robotics in the Textile and Apparel Industries", Noyers Publication Park Ridge, 1996.
19. Nalura B C, "Theory and Applications of Automatic Controls", New Age International (P) Ltd Pub, 1998.
20. Carl A. Lawrence, "Fundamentals of spun yarn technology", CRC Press, New York, 2003

## MTT 204 Elect II: (C) Advanced Fibre Technology:

### Unit 1

Brief of development of fibre. Definition of 'High Performance Fibre'. Comparative study between Commodity fibre and 'High Performance Fibre'. (3)

### Unit 2

Chemically resistance fibre – production, properties and applications, Thermally resistance fibre - production, properties and applications (7)

### Unit 3

Production, properties, structure and application of para aramid fibres, PBO fibre, Polybenzimidazole fibre, UHMW-PE fibre (by Gel-spinning technique). (12)

### Unit 4

Production, properties, structure and application of Glass fibres, Carbon fibres, Phenolic Fibre, Ceramic fibre, Polyphenylene sulphide fibre, (12)

### Unit 5

Production, properties, structure and application of Micro-denier fibre, Lyocell fibre. (6)

**Book references:**

High-performance Fibre, J W S Hearle, Woodhead Publication; New Fibres, Tatsuya Hongu and Glyn O Philips, Woodhead Publication; Manufactured fibre Technology, V.B Gupta and V.K Kothari.

**MTT 204 Elect II: (D) Apparel Technology**

**Unit -1:** Concept of clothing design and proportion. Fabric properties and their effect on garment properties, production and quality. **Formability and sewability of fabric** ----- 3 Hours

**Unit-2:** Anthropometrics; Clothing sizes. Fundamentals of Pattern making and grading. Concept of Dart , pleats , gathers etc. Principles of marker making, Marker Efficiency Calculation. Principles and Algorithms of Computerized Pattern Making, Grading & Marker Planning -----

8 Hours

**Unit-3:** Spreading and cutting. Cutting methods. Quality control in the cutting room. Principles of Cut planning spread planning, Numerical calculations for Cut planning. Different Algorithms for Computerised Spread Planning and Cut Planning.--- 6 Hours

**Unit-4:** Mechanics of joining of textile materials', Stitch classification, seam types and their applications. Sewing sequence for Shirts, Trousers etc. Basic features and parts of Industrial Sewing Machines. Sewing Mechanism of Lockstich , Chainstich . Basic Mechanics of Sewing Machines. Features of Computerised Sewing Machines----- 9 Hours

**Unit-5 :** Sewing faults, their causes and remedies. Analysis of seam performance , Principles of Choice of sewing needles and threads. --- 3 Hours

**Unit-6 :** Fusing and pressing machines. – 3 Hours

**Unit-7:** Clothing production systems and material handling. Basic principles of Production Planning & Productivity Control in Garment Manufacturing. Planning and control tools, Principles of Apparel Quality Control , AQL concept. ---

5 Hours

**Unit-8 :** Technological advancements in Garment dyeing and functional finishes of Garment. –

3 Hours

**TOTAL 40 HOURS**

**Suggested Books**

1. Carr.H, Latham. B., " The Technology of Clothing Manufacture ", Blackwell Scientific Publications (1988)
2. Jacob Solinger., " Apparel Manufacturing Handbook ", VanNostrand Reinhold Company (1980).
3. Peyton B .Hudson., " Guide to Apparel Manufacturing ", MEDIApparel Inc (1989) ISBN: 0 - 945116-08-X.
4. Glock R.E. and Kunz G.I., " Apparel Manufacturing: Sewn Product Analysis ", Prentice Hall, 1995.
5. Harrison.P ( Editor), " Garment Dyeing: Ready to wear fashion from the dye house", The Textile Institute, U.K (1988) ISBN: 1870812131.
6. Garment wet processing technical manual AATCC/SDC 1994
7. Stephen Gray " CAD / CAM in clothing and Textiles ", Gower Publishing Limited, 1998, ISBN 0-566-07673X.
8. W.Aldrich, " CAD in clothing and Textiles ", Blackwell Science 2nd edition, 1992, ISBN: 0-63 -3893 – 4
9. A.J. Chuter., " Introduction to Clothing Production Management ", Blackwell Scientific Publications
10. David J. Tyler., " Materials Management in Clothing Production ", Blackwell Scientific Publications Professional Books.
11. Laing, R.M. and Webster J., " Stitches and Seams ", The Textile Institute, Manchester, 1998

## **MMP 205 Elect III (A) ELECTRO ACTIVE TEXTILES**

INTRODUCTION: Electric conductivity, metal conductors, ionic conductors, Inherently conducting polymers. (4)

CONDUCTIVE YARNS AND FABRICS: Electro spinning process, process variables, formation of yarns & fabrics. Electro active nano fibres & fabrics, nano composites. (8)

CONDUCTING TEXTILE PREPARATION TECHNIQUES: Extrusion, solution coating, In-Situ polymerization. Electrochemical polymerization. Integration of fibre optic sensors and sensing networks. (8)

TESTING & CHARACTERIZATION: Electrical and Electromechanical characterization, surface resistance, EMI shielding efficiency, morphological Characterisation, Environmental effects. Electroactive fabrics and wearable man-machine Interfaces. (10)

TEXTILE SENSORS: Bio-medical sensors, actuators, wearable bio-feed back systems, motion capture, communication textiles, display of ornamental applications. Textile strain sensors, ECG Electrodes. (12)

Total 42

### REFERENCES:

1. "Intelligent textiles and clothing", Mattila H.R, The Textile Institute, CRC press, New York, & Washington, Woodhead publishing Ltd.,England, 2006.
  2. "Wearable electronics and photonics", Xiaoming Tao, The Textile Institute, Woodhead publishing Ltd.,England,2005.
- "Smart textiles for medicine and healthcare, L.Van Langenhove, Textile Institute & CRC press, wood head publishing limited

## **MMP 205 Elect III (B) PLASMA TECHNOLOGY**

GASES: Masses and Numbers of Atoms, kinetic energy and temperature, mean speed Maxwell – Boltzmann distribution, pressure, Avagadro's Laws, number density of gasses, impingement flux monolayer formation time mean free path, probability of collision, collision frequency, energy transfer during collision, gas flow, types.

GAS PHASE COLLISION PROCESS: Collision cross section, elastic and inelastic collision Ionization, excitation, relaxation, recombination, dissociation, electron attachment, Ion-Neutral collision, Metastable collision.

PLASMA: Electron and Ion temperature, plasma potential, DC discharges - glow - arc - corona - rf - ecr discharges - conduction in ionized gases. Diffusion: Diffusion and mobility - free diffusion - mobility - ambipolar diffusion - transition diffusion - diffusion in magnetic field and fully ionized plasma. General structures and features: V-I characteristics - cathode layer - positive column - discharge in fast gas flow - glow discharge instabilities and their consequences - thermal instability.

ARC DISCHARGE: Definition and characteristics - features of arc discharge, types of arcs, high intensity arcs, classification of arcs, free burning arc, wall, vortex, electrode, forced convection and magnetically stabilized arcs - Non thermal arcs; low pressure and low intensity arcs, initiation of arcs - low pressure arc with externally heated cathode - plasma temperature, V-I characteristics - electron and gas temperatures.

LABORATORY PLASMA SOURCES/DEVICES: Low temperature plasma generation, transferred and non-transferred arc torches and their characteristics, vacuum plasma torches.

PLASMA DIAGNOSTICS: Electrical probe techniques - spectroscopic methods - charged particle methods - energy balance technique.

Total 42

REFERENCES:

1. Brainan Chapman, "Glow Discharge Processes : Sputtering and Plasma Etching", John Wiley and Sons, 1980.
2. Milton O'Ring, "Materials Science of Thin Films", Academic Press, 2002.
3. Lochite W, Holtgrevan" Plasma Diagnostics, , North Holland Publishing Company, 1968.
4. Physics of High Temperature Plasma, George Schmidt., Academic press, New York, 1979.
5. Rossnagel S.M, Cuomo J.J and Westwood W.D. (editors), Handbook of Plasma Processing Technology., William Andrew Publishing, 1990.

**MMP 205 Elect III (C) Eco-Textiles**

INTRODUCTION: Structure and stability of the ecosystem. Health of our planet. Nature of textiles. Textile fibre production. Yarn production. Fabric production. Use of textiles. Garman ban on toxic dyes, chemicals and auxiliaries. Present status of textile industry. Action by Government and other organizations. Precautions to be taken by textile industry. Eco-Auditing and Eco-labelling Eco mark.

(6)

BIO DEGRADABLE AND SUSTAINABLE TEXTILES: Introduction. Bast fibres. Alginate fibres. Cellulosic fibres and fabric processing. Iyocell fibres. Polylactic acid fibres. Poly hydroxyalkanoates and poly caprolactone. Synthetic silks. Biodegradable natural fibre composites. Biodegradable nonwovens. Natural geo textiles. Conversion of cellulose, chitin and chitosan to filaments with simple salt solutions. Soyabean protein fibre.

(9)

ECO TESTING: Toxicology of textile dyes. Eco testing instruments-working of Gas Chromatography, Mass Spectrometry, High Performance Liquid Chromatography, Atomic Absorption Spectrometry/Atomic Emission Spectrometry and Plasma Emission Spectrometry. Eco Standards.

(9)

ECO FRIENDLY TEXTILE PROCESSING: Super critical fluid textile dyeing technology. Pollution abatement and waste minimization in textile dyeing. Decoloration of effluent with ozone and re-use of spent dye bath. Chemical treatment of textile dye effluent. Biotechnological treatment of textile dye effluent

(9)

SUSTAINABILITY AND ECO DESIGN: Building ecodesign in textile and clothing supply chain. Supply chain partnerships for sustainable textile production. Molecular manufacturing for clean and low cost textile production. Use of renewable resource based materials for technical textile applications. Composites made from spinning waste.

(9)

Total 42

REFERENCES:

1. Keith Slater, "Environmental Impact of Textiles", Woodhead Pub. Ltd, Cambridge, 2003. ISBN:1-85573-541-5
2. Blackburn R.S., "Biodegradable and Sustainable Fibres", Woodhead Pub. Ltd, Cambridge, 2005. ISBN:0-84933-484-5
3. Christie R.M., "Environmental Aspects of Textile Dyeing", Woodhead Pub. Ltd, Cambridge, 2007. ISBN:978-1-84569-115-8
4. Miraftab M. and Horrocks R., "Eco Textiles", Woodhead Pub. Ltd, Cambridge, 2007. ISBN-13: 9781-84569-214-8
5. Eco-Textiles'98, Bolton Institute, Bolton, 1998.
6. Eco-Textiles, Special Report, The Bombay Textile Research Association, Mumbai, February, 1996.
7. Eco Friendly Textiles: Challenges to the Textile Industry, Textiles Committee, Mumbai, 1996.
8. Oeko-tex Standard 100, International Association for Research and Testing in the field of Textile Ecology(Oeko-tex), Zurich, Switzerland, January, 1997.
9. Eco-Friendly Textiles, SITRA Focus, Vol.14, No.2, July 1996.

**MTT 205 Elect III: (D) Theory of Manmade Fibre Production and Texturising**

General theoretical fundamentals, spinnability of fluids, behavior of polymer system in elongational flow, elongation of steady state liquid jets, kinetics of orientation in elongational flow, kinetics of crystallization, rheological behavior of fibre forming melts, effect of spinning condition on the take up tension and fibre properties, spinning orientation and crystallization.

Wet and dry spinning, rheological properties of polymer solvent system and their behavior in fibre spinning, solidification of polymer solutions, effect of spinning conditions on structure and properties of solution spun fibre.

Concept of false twist draw texturing with reference to heat setting and drawing, function of machine variables and its impact on fibre properties, causes of defects and their remedies. Concepts of intermingling and their importance

Theoretical fundamentals of Air Texturing, functions of machine parameters, special characteristics of air textured yarn.

1. Fundamentals of Fibre Formation- The science of spinning and drawing, Andrzej Ziabicki,
2. Manufactured Fibre Technology, VB Gupta & V K Kothari
3. Acrylic fibre Technology and Application, James C Masson
4. Man Made Fibre, Moncrieff
5. Guide to Crimping, Gandhi

MTT 291 Lab III: Textile Structure Lab

Yarn structure :Study of yarn frictional property,study of yarn breakage characteristics,study of yarn bending and torsional rigidity, study yarn abrasion characteristics, study of yarn compressional characteristics,study of yarn migration ,study of yarn twist-strength characteriristics,study of yarn creep and relaxation property, study of yarn buckling due to high twisting,study of yarn shrinkage,

Fabric structure :Study of frictional characteristics of fabric; study of fabric compressional behaviour woven,knitted,nonwoven, study of shrinkage of knitted fabric, woven fabric with reference to structural parameters, study of shear of fabric, study of bending rigidity of fabric, study of wetting phenomena of yarn and fabric. study of creep and relaxation of fabric , study of damage of fabric study of fabric buckling.