

CURRICULUM

B. TECH. (Textile Technology)

3rd – 8th Semester

July 2018 admission onwards

BOARD OF STUDIES (BOS)

5th MEETING, February 27th, 2019

B. TECH. (Textile Technology)

(Revised Teaching Scheme)



DEPARTMENT OF TEXTILE TECHNOLOGY

**Dr B R AMBEDKAR NATIONAL INSTITUTE OF TECHNOLOGY,
Jalandhar**

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Mission and Vision of the Department

Vision

‘To offer quality education in the field of textile technology and serve the textile industry through applied research and collaborative activities for the benefit of society.’

Mission

- To disseminate knowledge in the field of textile technology by offering state of the art undergraduate, postgraduate and doctoral programmes
- To undertake research and consultancy on a globally competitive basis
- To provide continuing and informal education for developing human potential to the fullest extent.
- To emphasize on multidisciplinary work and sustainability for the dynamic needs of the textile industry

Programme Educational Objectives (PEO) for B. Tech (Textile Technology)

- To incubate professionals capable to develop new textile manufacturing processes and textile products with novel features and functionality for the benefit of society.
- To inculcate managerial skills for improving efficiency and better shop floor management
- To motivate the students to apply their knowledge and skills to become successful professionals and entrepreneurs.
- To apply their knowledge and skills with academic integrity and rationality.

Teaching Scheme for B. Tech (Textile Technology)**III Semester**

Course Code	Subject	L	T	P	Contact hours	Credits
TTPC-201	Fundamentals of Textile Machines & Processes	3	0	0	3	3
TTPC-203	Natural Fibres	3	0	0	3	3
TTPC-205	Yarn Formation-I	3	1	0	4	4
TTPC-207	Preparatory and Basic Fabric Formation	3	0	0	3	3
TTPC-209	Unit Operation	3	1	0	4	4
MACI-201	Probability and Statistics	3	1	0	4	4
TTPC-211	Textile Fibre Laboratory	0	0	2	2	1
TTPC-213	Yarn Formation Laboratory -I	0	0	2	2	1
TTPC-215	Fabric Formation Laboratory -I	0	0	2	2	1
Total		18	3	6	27	24

IV Semester

Course Code	Subject	L	T	P	Contact hours	Credits
TTPC-202	Man-made Fibres	3	0	0	3	3
TTPC-204	Yarn Formation- II	3	1	0	4	4
TTPC-206	Fabric Formation Systems	3	0	0	3	3
TTPC-208	Preparatory and Coloration of Textiles	3	0	0	3	3
TTPC-210	Fabric Structure and Design Analysis	3	0	0	3	3
TTPC-212	Yarn Formation Laboratory -II	0	0	2	2	1
TTPC-214	Fabric Formation Laboratory -II	0	0	2	2	1
TTPC-216	Textile Chemical Processing Laboratory - I	0	0	3	3	2
TTPC-218	Fabric Structure and Design Analysis Laboratory	0	0	2	2	1
Total		15	1	9	25	21

V Semester

Course Code	Subject	L	T	P	Contact hours	Credits
TTPC-301	Properties of Fibres	3	0	0	3	3
TTPC-303	Printing and Finishing	3	0	0	3	3
TTPC-305	Textile Testing	3	0	0	3	3
TTPC-307	Knitting Technology	3	0	0	3	3
HMCI-204	Human Resource Management	3	0	0	3	3
TTPE-3XX**	Departmental Elective - I	3	0	0	3	3
TTPC-309	Textile Chemical Processing Laboratory – II	0	0	3	3	2
TTPC-311	Knitting Technology Laboratory	0	0	2	2	1
TTPC-313	Textile Testing Laboratory	0	0	2	2	1
TTCI-300	Minor Project, Phase -I	0	0	2	2	0*
Total		18	0	9	27	22

VI Semester

Course No.	Subjects	L	T	P	Contact hours	Credits
TTPC- 302	Process Control in Textiles	3	0	0	3	3
TTPC- 304	Nonwoven Technology	3	0	0	3	3
TTPC- 306	Garment Manufacturing Technology	3	0	0	3	3
TTPE-3XX**	Departmental Elective - II	3	0	0	3	3
TTPE-3XX**	Departmental Elective - III	3	0	0	3	3
	Open Elective-I	3	0	0	3	3
TTPC-308	Garment Manufacturing Technology Laboratory	0	0	2	2	1
TTPC-310	Data Analysis Laboratory	0	0	2	2	1
TTPC-312	Seminar	0	0	2	2	1
TTCI-300	Minor Project, Phase-II	0	0	4	4*	2
Total		18	0	10	28	23

* Minor Project will be allotted in 5th Semester, will be evaluated at the end of 6th Semester.

** Subject will be offered from the list of Department Elective of third year.

VII Semester

Course No.	Subjects	L	T	P	Contact hours	Credits
TTPC 401	Theory of Textile Structure	3	1	0	4	4
TTPC-403	Statistical Quality Control in Textile	3	1	0	4	4
TTPC-405	Mill Management and Maintenance	3	0	0	3	3
TTPC-407	Sustainable Textile Technologies	3	0	0	3	3
TTPE-4XX**	Departmental Elective - IV	3	0	0	3	3
	Open Elective-II	3	0	0	3	3
TTCI- 401	Industrial Practical Training	0	0	0	0	2*
TTCI- 400	Major Project (Phase-I)	0	0	4	4	0***
Total		18	2	4	24	22

* Industrial Practical Training will be held during summer vacation after sixth semester.

** Subject will be offered from the list of Department Elective of fourth year.

VIII Semester

Course No.	Subjects	L	T	P	Contact hours	Credits
TTPC-402	Technical Textiles	3	0	0	3	3
TTPC- 404	Mechanics of Textile Processes	3	1	0	4	4
TTPE-4XX**	Departmental Elective - V	3	0	0	3	3
TTPE-4XX**	Departmental Elective - VI	3	0	0	3	3
	Open Elective-III	3	0	0	3	3
TTCI- 402	Industrial Lecture	1	0	0	1	1
TTCI- 400	Major Project (Phase-II)	0	0	8	8	4***
Total		16	1	8	25	21

*** Major Project will be allotted in 7th Semester, will be evaluated at the end of 8th Semester

Detail distribution of credits of common Institute core, programme core, programme elective and open course offered in B.Tech. Textile Technology

S. No.	Course Category	No. of Courses	No. of Credits
1.	Common Institute Core [1 st Year (credits: 47); 3 rd Semester - Mathematics course (credits:04); 5 th Semester-Human Resource Management (credits:03); 6 th Semester- Minor Project (credits: 02); 7 th Semester- Industrial Practical Training (credits: 02); 8 th Semester- Major Project (credits: 04); 8 th Semester- Industrial lecture (credit: 01)		63
2.	Programme Core (PC)	23 Theory + 12 Lab + 1Seminar	90
3.	Programme Elective (PE)	6	18
4.	Open Elective (OE)	3	9
5.	Other Cognate Department	-	-
	Total		180

Semester Wise Credits Distribution

Semester	No. of Credits
I & II	47
III	24
IV	21
V	22
VI	23
VII	22
VIII	21
Total	180

Departmental Electives:**5th and 6th Semesters (TTPE-3XX)**

S.No.	Name of Subject with Code	L-T-P-C
1	Post Spinning Operations (TTPE-321)	3-0-0-3
2	Multi-fibre Process (TTPE- 322)	3-0-0-3
3	Marketing Management in Textiles (TTPE-323)	3-0-0-3
4	Costing and its application in Textiles (TTPE-324)	3-0-0-3
5	Product Design (TTPE- 325)	3-0-0-3
6	Advances in Chemical Processing (TTPE- 326)	3-0-0-3
7	Chemical Processing of Manmade Fibres and Blend Textiles (TTPE- 327)	3-0-0-3
8	Financial Management in Textiles (TTPE- 328)	3-0-0-3
9	Advances in Yarn Manufacturing (TTPE- 329)	3-0-0-3
10	Advances in Fabric Manufacturing (TTPE- 330}	3-0-0-3

7th and 8th Semesters (TTPE-4XX):

S.No	Name of Subject with Code	L-T-P-C
1	Characterization of Fibre and Polymers (TTPE- 421)	3-0-0-3
2	Production Management (TTPE- 422)	3-0-0-3
3	Textile Structural Composites (TTPE- 423)	3-0-0-3
4	Waste Management and Pollution Control in Textile Industry (TTPE- 424)	3-0-0-3
5	Apparel Marketing and Merchandising (TTPE- 425)	3-0-0-3
6	Project Formulation and Appraisal (TTPE- 426)	3-0-0-3
7	Textile Process Simulation and Modeling (TTPE- 427)	3-0-0-3
8	Woollen Technology (TTPE- 428)	3-0-0-3
9	Intelligent and Functional Textile (TTPE- 429)	3-0-0-3
10	Quality Control in Chemical Processing (TTPE- 430)	3-0-0-3
11	Advancement in Manmade fibres (TTPE- 431)	3-0-0-3
12	Application of Operations Research in Textiles (TTPE- 432)	3-0-0-3
13	Clothing Science and Engineering (TTPE- 433)	3-0-0-3
14	High Performance Fibres (TTPE- 434)	3-0-0-3
15	Advances in Knitting Technology (TTPE- 435)	3-0-0-3
16	Advancement in Textile Testing (TTPE- 436)	3-0-0-3
17	Bioprocessing of Textiles(TTPE- 437)	3-0-0-3

Open Electives (TTOE-4XX)

S.No	Name of Subject with Code	L-T-P-C
1	Polymer and Fibre Science (TTOE-451)	3-0-0-3
2	Properties of Polymer and Fibre (TTOE-452)	3-0-0-3
3	Textile Machines and Processes (TTOE-453)	3-0-0-3
4	Textile Design (TTOE-454)	3-0-0-3
5	Fashion and Textiles (TTOE-455)	3-0-0-3
6	Fashion Designing (TTOE-456)	3-0-0-3
7	Geotextiles (TTOE-457)	3-0-0-3
8	Design of Experiments (TTOE-458)	3-1-0-4
9	Application of Nanotechnology on Polymers and Fibres (TTOE- 459)	3-0-0-3
10	Environmental Science and Management (TTOE-460)	3-0-0-3
11	Industrial Textiles (TTOE-461)	3-0-0-3
12	Marketing and Merchandising of Products (TTOE-462)	3-0-0-3
13	Clothing Science (TTOE- 463)	3-0-0-3
14	High Performance Fibres (TTOE-464)	3-0-0-3

Six Theory Courses for “Minor degree in Textile Technology for other Department students”;

S No	Course No	Course Title	L	T	P	Credits	Semester
1.	TTMI- 201	Fundamentals of Textile Machines & Processes	3	0	0	3	III
2.	TTMI-202	Fibre Science	3	0	0	3	IV
3.	TTMI-301	Yarn Formation	3	0	0	3	V
4.	TTMI-302	Fabric Manufacture	3	0	0	3	VI
5.	TTMI-401	Chemical Processing of Textiles	3	0	0	3	VII
6.	TTMI-402	Textile Structures & Applications	3	0	0	3	VIII

TTMI: Textile Technology Institute Minor

B.Tech. 3rd Semester**TTPC-201 Fundamentals of Textile Machines and Processes [3 0 0 3]****Course Outcomes**

CO1	Fundamental knowledge of different textile product
CO2	Study of product specifications and their quality parameters
CO3	Classification of textile industries
CO4	Basic concept of textile fiber, filament, yarn and fabric
CO5	Basic concept of conversion from fibre to garment

Basic characteristics of textile materials; Concept of dimensional characteristics of textiles; Applications of textiles in diversified fields; Variations in textile structure and properties based on applications; Role of different structure and material constituents for fulfilment of target requirements; Different machine sequences for processing textile materials differing in structure; Product properties and their measurement; Understanding the significance of parameters characterizing product properties; Need for process control and use of statistics; Improvement in product quality; Current trends in research and development of textile machines and processes.

Books Recommended:

1. Rose Sinclair, Textiles and Fashion: Materials, Design and Technology, Woodhead Publishing Ltd., Cambridge, 2015
2. Gohl E P G and Vilensky L D, Textile Science, CBS Publishers and Distributors, New Delhi.
3. Corbman Bernard P., "Textiles Fiber to Fabric", McGraw-Hill International Editions, Singapore, 1983.
4. "Handbook of Technical Textiles", Ed. A R Horrocks and S C Anand, Woodhead Publication Ltd., Cambridge, 2000.
5. Textile Design: Principles, Advances and Applications, Edited by A Briggs-Goode and K Townsend, Woodhead Publishing Series in Textiles No. 112, 2011.
6. Handbook of Nonwovens, Edited by S Russell, Woodhead Publishing Series in Textiles No. 58, 2006, UK.
7. Morton W E and Hearle J W S, "Physical Properties of Textile Fibres", Woodhead Publishing Series in Textiles No. 68, 2008, UK.

TTPC-203 Natural Fibres [3-0-0-3]**Course Outcomes**

CO1	Develop the concept of fibre
CO2	Understanding various natural source of fibres
CO3	Knowledge about common natural fibres
CO4	Understanding structure and Properties of Common natural Fibres
CO5	Application or use of natural fibres

Fibres and polymers: Introduction to fibres; Introduction to polymers; Requirements of fiber forming polymers; Essential and desirable properties of textile fibers; Essential properties of fiber forming polymers; Classification of textile fibers.

Micro structure: Difference between conventional and polymeric material; Features of polymer structures, e.g. regularity and irregularity, molecular weight and size; Configuration

and conformation of polymers; Effect of molecular arrangement and molecular weight on properties of polymers/fibres; Determination of molecular weight; Introduction to various methods of molecular weight determination, i.e. end group analysis, osmometry, GPC and viscosity method; Orientation and crystallinity of fibres; Effect of orientation and crystallinity on the physical and chemical properties of fibres; Concept of thermoplastic and thermoset material; Concept of rubbery state and rubber elasticity; Transition from glassy to rubbery state; Melting of polymers.

Natural fibres: Natural cellulosic and lingo cellulosic fibres, i.e. cotton, jute, flax; Micro and macro structure of fibres; Effect of oxidizing agent, reducing agent, acid, alkali and water on the structure, physical and chemical properties of fibres; Assessment of degradation in fiber structure; Properties and uses of cotton, jute and flax; Correlation of structures with properties; Natural protein fibres i.e. wool and silk; Properties and uses of wool and silk; Introduction to ramie, hemp, coir and pineapple fiber. Sustainability aspect of fibre cultivation/ production ie Organic cotton, BT cotton, Bamboo or fibres based on agricultural waste.

Polymerization: Introduction to polymerization methods and kinetics of condensation and addition polymerization.

Books Recommended:

1. Gohl E P G and Vilensky LD, "Textile Science", CBS Publishers, Delhi, 1983.
2. Cook Gordon J, "Hand Book of textile fibre", Vol. I and II, Woodhead Fibre Science Series, UK, 1984.
3. "Hand Book of Fibre Chemistry", Ed. M Lewin and E M Pearce, Mercel Dekker Inc., 1998.
4. Shenai V A, "Technology of Textile Processing", Vol. 1, Sevak Publications, Mumbai,
5. Gowariker V R, Viswanathan N V and Sridhar J, "Polymer Science", New Age International Ltd., New Delhi, 1996.

TTPC-205 Yarn Formation-I [3-1-0-4]

Course Outcomes

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|-----|---|
| CO1 | Introduction to the important fibre characteristics for yarn production |
| CO2 | To study Opening and cleaning process of blow room |
| CO3 | To study Objective and working of carding machine |
| CO4 | To study basic principles of doubling and drafting |
| CO5 | Numerical problems , norms , performance assessment; Latest development |

Ginning - Classification and importance; Introduction to the important fibre characteristics for yarn production.

Opening and cleaning in blow room–Introduction, Methods, Recent developments.

Mixing and blending-Definition; Compatibility requirements; Perfect blend; Blending deficiencies; Index of blend irregularity; Blending methods and techniques; Mixing and blending machines.

Carding-Objectives; Revolving flat card; Card clothing; Operating regions of the card; Forces acting on the fibres; Carding disposition and doffing disposition; Centrifugal forces; Action between feed roller and licker-in, Cylinder and Flats, Transfer zone at doffer, Numerical problems, norms, performance assessment, Developments in carding machine.

Doubling and Drafting- Basic principles; drafting operation in the drafting arrangement; behavior of fibres in the drafting zone; fibre friction field; numerical problems; norms; performance assessment; Latest developments

Books Recommended:

1. Klein W, "Manual of Textile Technology", Vol. I – III, The Textile Institute, UK, 1987.
2. Oxtoby E, "Spun Yarn Technology", Butterworth and Co. Ltd., 1987.
3. Lawrence C A, "Fundamental of Spun Yarn Technology" CRC Press, USA, 2003.
4. Lord P R, "Handbook of Yarn Production", The Textile Institute, Woodhead Publication Limited, Cambridge, 2003.

TTPC 207 Preparatory and Basic Fabric Formation [3-0-0-3]

Course Outcomes

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|-----|---|
| CO1 | Quality of yarn requirements for weaving |
| CO2 | Importance of winding and warping with basic parameters |
| CO3 | Sizing machine and variable |
| CO4 | Basic concept of weaving |
| CO5 | All kind motions in weaving machine |

Winding: Objectives, types of packages, types of winding machines, uniform build up of cones, Mechanical and electronic type yarn clearer. Yarn tensioners: Additive, multiplicative, combined and compensating type. Patterning: Reasons and remedies. Yarn fault classifying systems. Basic features of auto winders like Autoconer, Barbar colman, Murata etc. Latest developments. Machine and labour productivity. Norms. Performance assessment and calculations.

Pirn winding: Objectives, types of pirns, yarn traversing system, different automation and standard winding parameters.

Warping: Objectives, conditions for warping, comparison of beam warping with sectional warping, basic features of warping machine, different types of creels, reeds, leasing systems. Latest developments. Machine and labour productivity. Norms. Performance assessment and calculations.

Sizing: Objectives, classification of sizing methods and sizing machines. Features of sizing machine, machine elements, sizing ingredients, size preparation, control points, principle of different non conventional sizing techniques. Latest developments. Machine and labour productivity. Norms. Performance assessment and calculations.

Drawing in: Importance, different ways to do it, standard norms. Latest developments.

Weaving: History of weaving with manual and automatic loom, and modern loom revolutions. Overall concept about looms and its elements. Different motions of looms: Primary, secondary and auxiliary motions.

Shedding: Different types of shedding with advantage and disadvantages, geometry of shedding, importance of bending factor, reed and reed counting systems, tappet shedding and its limitations, positive and negative shedding.

Picking: Types of conventional picking: over picking, under picking and parallel picking. Calculation of shuttle velocity and energy of picking, picking force. Different picking accessories and their functions. Picking timing such as late picking and early picking, reasons of false picking and shuttle fly.

Sley: Movement of sley, beat up, sley eccentricity and the factors which influence it, calculation related to sley eccentricity, effects of sley eccentricity on beat up force and timing available for shuttle passage.

Calculations: Production, efficiency and balancing of machine, Calculations related to winding, warping and sizing. Numerical based on shedding, picking and sley movement.

Books Recommended:

1. 'Winding', BTRA Monograph Series, Bombay Textile Research Association, Bombay, 1981.
2. 'Warping and Sizing', BTRA Monograph Series, Bombay Textile Research Association, Bombay, 1981.
3. Mark R, Robinson A T C, "Principles of Weaving", The Textile Institute, Manchester, 1986.
4. Talukdar M K, Sriramulu P K and Ajgaokar D B, "Weaving – Machine, Mechanism and Management", Mahajan Publisher Private Ltd., Ahmedabad, India, 1998.
5. Booth J E, "Textile Mathematics", Part III, Textile Institute, Manchester, 1977.
6. Goswami B C, Anandjiwala R D and Hall D M, 'Textile Sizing', Marcel Dekker, USA, 2005

TTPC-209 Unit Operations [3-1-0-4]

Course Outcomes

CO1	Deals with fluid flow, heat transfer and mass transfer
CO2	Fluid flow through porous channel of textile material
CO3	Heat flow through porous media
CO4	Heat flow through porous multilayer fabrics
CO5	Moisture flow through fabric

Fluid flow: Unit operations, basic equations, Hydrostatic equilibrium, Hydrostatic equilibrium in a centrifugal field, Manometer, Newtonian and non-Newtonian fluid, viscosity, Reynold number, Bernoulli equation and its application on pump work. Fluid flow through tube, fluid flow through bed packed with solid, fluid flow through textile porous media. Filtration, cake filter and clarifying filter mechanism, textile as filter media.

Transportation and Metering of Fluid: Pipe, fittings and valves, different type of pumps venture meter, orifice meter, Rota meter.

Conduction: Basic law of heat conduction- Fourier's law, thermal conductivity, its dependence on temperature, steady state heat conduction through a composite solid and its electric analogue, steady state heat conduction through cylinders, different insulating materials. Thermal conductivity of textile materials and its applications.

Convection: Convection heat transfer and the concept of heat transfer coefficient, individual and overall heat transfer coefficient, heat transfer between fluids separated by plane wall critical/ optimum insulation thickness. Design of heat exchanger and related problems.

Radiation: Basic principle of radiation from a surface, blackbody radiation, Planck's law Wein's displacement law, the Stefan Boltzmann law, Kirchoff's law, gray body, radiation exchange between black bodies and gray bodies. Radiative heat transfer coefficient. Applications of radiative heat transfer in different industries.

Evaporation: Type of evaporators, single and multiple effect evaporators, boiling point elevation

Mass Transfer Operations: Classification of mass transfer operation, Fick's law of diffusion, Mass transfer coefficients. Application in textiles.

Drying: Equilibrium in drying, batch drying, and time of drying, continuous drying, and equipment of drying. Application in textile Industry.

Books Recommended:

1. Geankopolis C J "Transport Processes and Separation Process Principles", Prentice Hall of India, 4th Edition, Eastern Economy Edition (2004)
2. Treybal R E, "Mass Transfer Operations" 3rd Ed., McGraw Hill (1980)

3. McCabe W L and Smith J C, "Unit Operations of Chemical Engineering". McGraw Hill (2001)
4. Coulson J M and Richardson J F, "Chemical Engineering, Vol 2,5", McGraw Hill (1999)
5. Walter L, Badger and Julius T, Banchemo, "Introduction to Chemical Engineering", McGraw Hill (1997)

MAIC-201 Probability and Statistics [3-1-0-4]

Course Outcomes

CO1	Concept of statistics, collection and representation of data
CO2	Different approaches to probability
CO3	Discrete and Continuous Probability Distribution
CO4	Correlation analysis, Regression analysis, Curve fitting
CO5	Sampling and sampling distribution

Section A

Concept of statistics, collection and representation of data, frequency distribution, graphical Representation of data, measure of central tendency and dispersion, coefficient of dispersion, Moments, factorial moments, skewness and kurtosis. Different approaches to probability, addition and multiplication theorem of probability, Boole's inequality, conditional probability, Bayes theorem and applications, Moment generating functions.

Section B

Random variables – discrete and continuous, distribution function, probability mass function, Probability density function, two dimensional random variables, mathematical expectation, Expectation of discrete and continuous random variables, properties of expectation, conditional expectation. Discrete and Continuous Probability Distribution: Binomial, Poisson, Normal, Exponential.

Section C

Correlation analysis, Regression analysis, Curve fitting using least square method. Sampling and sampling distribution: chi-square, student-t and F-test.

Books recommended:

1. Bhattacharya G.K. and Johnson R.A.: Statistical Concepts and Methods, John Wiley, New Delhi, 2002.
2. Hogg R. V. And Elliot A.T, "Probability and Statistical Inference", Pearson Education, 6th Edition.
3. Hogg R V, Craig A T, "Introduction to Mathematical Statistics", Sixth Edition, Pearson Education, Delhi

TTPC-211 Textile Fiber Laboratory [0-0-2-1]

Course Outcomes

CO1	Practical exposure to different textile fibres
CO2	Knowledge of Physical techniques of identification of fibres

CO3	Knowledge of Chemical techniques for identification of fibres
CO4	Knowledge of Blend analysis
CO5	Development of ability of identification and analysis of unknown sample

Physical and Chemical identification of following textile fibres

1. Identification of cotton
2. Identification of wool
3. Identification of silk
4. Identification of Bast fibres
5. Identification of polyester
6. Identification of nylon
7. Identification of Acrylic
8. Identification of Polypropylene

Identification of fibers and their ratio in blended textile

9. Analysis of P/C blended fabric
10. Analysis of P/V blended fabric
11. Analysis of P/W blended fabric
12. Estimation of fiber/filament fineness using projection microscope.

TTPC-213 Yarn Formation Laboratory- I [0-0-2-1]

Course Outcomes

CO1	To study of Blow room machine line
CO2	To study the Trash analyser machine
CO3	To study the different parts of carding machine
CO4	To study drafting system of Draw frame
CO5	To study the maintenance & overhauling of Draw Frame

At least 10 experiments are to be performed by each student:

1. Study of general outline of opener and clearer machine employed in B/R line process.
2. Study of following in Shirley trash analyses machine.
 - i. Chief organs.
 - ii. Gearing arrangements.
 - iii. Teeth inclination and teeth per inch
3. Determination of trash content and analysis of waste by using Trash Analyser Machine.
4. Study of carding machine with technical details.
5. Study of gearing mechanism, calculation of the speed of different organs of carding machine.
6. Calculation of draft between different zones of carding machine and its production.
7. Study of card settings for different fibre lengths and types.
8. Maintenance and overhauling of carding machine.
9. Study of distribution of fibrous waste in a carding machine.
10. Study of the 'NEP -COUNT' in a card.
11. Study of drafting arrangement and top roller weighting system of draw frame machine.

12. Calculation of the total draft and its distribution in draw frame machine.
13. Effects of break draft and roller settings on sliver uniformity.
14. Measurement of nip-load pressure, roller eccentricity and shore hardness of top roller drafting rollers.
15. Maintenance and overhauling of draw frame machine.

TTPC-215 Fabric Formation Laboratory-I [0-0-2-1]

Course Outcomes

CO1	Aquaintance with all kind of preparatory and shuttle weaving machine
CO2	Yarn path in winding machine with all technical details
CO3	Yarn path in pirn winding machine with all technical details
CO4	Yarn path in shuttle weaving machine
CO5	Shedding, picking, beat-up, take-up, let-off and other motions of shuttle weaving machine

At least 10 experiments are to be performed by each student

1. Study of the motion transmission system in winding machine.
2. Study of the effect of slub catcher, yarn tensioner and yarn guide on package formation.
3. Study of Package stop motion in cone winding machine.
4. Calculation of winding speed on grooved drum winding system and study of anti-patterning system incorporated to it.
5. Study of precision winding machine and mechanism of package building.
6. Study of the motion transmission system in Pirn winding machine.
7. Calculation of winding speed and traversing speed of Pirn winding machine.
8. Study of the direct warping machine.
9. Study of the sectional warping machine and planning the width of a section according to pattern of the given striped fabric.
10. To study the passage of yarn on a sizing machine and the features of various parts/mechanism of the sizing machine.
11. To select the proper reed and heald for a weaver's beam keeping in mind the beam, loom size and fabric construction.
12. Study of shedding mechanism of shuttle loom and cam positioning with respect to loom cycle.
13. Study of picking mechanism, Picker movement in relation with crank shaft rotation and calculation of average velocity of shuttle.
14. Study of sley movement, construction and calculation of sley eccentricity.

4th Semester

TTPC- 202 Man Made Fibres [3-0-0-3]

Course Outcomes

CO1	Develop the concept of manmade fibre
CO2	Understanding various manufacturing process of manmade fibres
CO3	Understanding structure development and structure property relation
CO4	Knowledge about common manmade fibres
CO5	Application or use of manmade fibres

Introduction to man- made fibres: Definition of made fibres. Brief history of manmade Fibres. Relative merits and demerits of manmade fibres and natural fibres.

Conversion of polymers into fibres: Basic production systems of the man- made fibre. Melt spinning, solution dry spinning and solution wet spinning. Factors influencing selection of a Particular process for fiber formation, Relative merits and demerits of melt, dry and wet spinning processes, Variables of spinning, Different components of spinning process, i.e., extruder, gear pump, filters, manifold, spinning head, quenching chamber, winders. Different Quenching/ solidification techniques, spinning of staple fibres and filaments. POY, MOY and FDY. High speed spinning.

Melt spinning: Raw material, technology of polymerization and extrusion of polyester, nylon 6, nylon 66 and polypropylene. Effect of process parameters on structure and properties of melt spun filament.

Solution dry spinning: Dry spinning of cellulose acetate. Acetylation of cellulose, Dope Preparation and spinning of cellulose diacetate and triacetate, Dry spinning of acrylic. Significance and types of co-monomers used during polymerisation of acrylic, Polymerisation. Dope preparation, extrusion and solidification of filaments. Effect of process parameters on Structure and properties of solution dry spun filament.

Solution wet spinning: Process flow diagram and significance of each step for solution wet spinning of viscose rayon. Chemistry of viscose rayon formation process, Influence of various additives and temperature of the regeneration bath and their influence on the process and properties of viscose rayon, Various types of rayons, i.e. high wet modulus, Ten-X, etc. Introduction about alternative routes of regenerated cellulosic fibre formation, Properties and Use, Wet spinning of acrylic, Different solvents and parameters of regeneration bath for wet Spinning of acrylic, Effect of process parameters on structure and properties of acrylic.

Drawing and heat setting of fibres: Object of drawing. Concept of neck drawing, Effect of drawing conditions on the structure and properties of fiber. Object of heat setting. Effect of heat setting parameters on the structure and properties of fiber.

Spin finish: Objective, properties and application of spin finish.

Developments in Manmade Fibres: Fundamentals of high performance fibres such as Nomex, Kevlar, Carbon, Spandex, etc. their properties and applications. Developments in fibres production such as microdenier, bicomponent, hollow fibres, etc. Sustainability aspects of Manmade fibres.

Books Recommended:

1. Vaidya A A, "Production of Synthetic Fibres", 1st Ed., Prentice Hall of India, New Delhi, 1988.
2. "Manufactured Fibre Technology", 1st Ed. V B Gupta and V K Kothari, 1st Ed., Chapman and Hall, London, 1997.
3. Mark H F, Atlas S M, Cernia E, "Man Made Fibre Science and Technology", 1st Ed., Vol.1, 2, 3, Science Publishers, New York, 1967.
4. Macintyre J E, "Synthetic Fibres", Wood head Fiber Science Series, UK, 2003.
5. "Hand Book of Fibre Chemistry", Ed. M Lewin and E M Pearce, Marcel Dekker Inc., 1998.

TTPC-204 Yarn Formation II [3-1-0-4]

Course Outcomes

CO1	Brief idea about short staple spinning technology
CO2	To study objectives, working and process parameters of comber
CO3	To study objectives, working and process parameters of speed frame
CO4	To study function and mode of operation of ring frame, role of drafting system
CO5	To study Non-conventional spinning processes

Introduction to short staple spinning: Brief idea about short staple spinning technology.

Combing process: Objectives, combing for shorter and medium varieties of cotton, cottons suitable for combing, preparation of stock for combing, combing cycle, role of machine components and settings, noil extraction at backward feed and forward feed comber, mathematical problems, norms, performance assessment. Recent developments.

Process related to roving formation: Objectives, functions of different machine components and high drafting system, roving twist in speed frame, winding principles and equations related to bobbin leading and flyer leading, building motion, cone profile, numerical problems, norms, performance assessment.. Developments in speed frame.

Ring spinning Process: Function and mode of operation of ring frame, role of drafting system, yarn guiding devices, forces acting between ring and traveler, yarn tension variation, balloon tension at maximum diameter, tasks of traveller, limiting speed, classification, form of traveler, traveler mass and material, different ring-traveller combinations, fiber lubrication, running on new-ring, winding process, cop structure, spinning geometry, causes of end breaks, numerical problems, norms, performance assessment, Latest developments including compact spinning.

Non-conventional spinning processes: Principle of open end spinning, rotor spinning, chief organs and their functions, yarn properties in comparison with ring-spun yarn, principle of friction spinning, function of chief organs, yarn properties and comparison of Dref-II and Dref-III friction spinning machines, basic principle to air jet spun yarn, functions of chief organs, yarn properties, numerical problems, norms, performance assessment.

Books Recommended:

1. Klein W, "Manual of Textile Technology", The Textile Institute, Manchester, Vol.1 and 3, 2002.
2. Klein W, "A Practical Guide to Ring Spinning", The Textile Institute, Manchester, Vol 4, 2002.
3. Klein W, "New Spinning Process", The Textile Institute, Manchester, Vol.5, 2002.
4. Lawrence C A, "Fundamental of Spun Yarn Technology" CRC Press, USA, 2003.
5. Lord P R, "Handbook of Yarn Production", The Textile Institute, Woodhead Publication Limited, Cambridge, 2003.

TTPC-206 Fabric Formation Systems [3-1-0-4]

Course Outcomes

CO1	Concept on dobby and jacquard shedding
CO2	Automatic pirn changing, let-off and take-up devices
CO3	Concept of non-conventional weft insertion system
CO4	Basic mechanism of projectile, air-jet and rapier weft insertion
CO5	Merits and demerits of the process

Let-off System: Warp and cloth control, different types of let-off systems, control of tension variation.

Take-up: Types of take-up and their mechanisms, control of pick density, calculation related to it.

Warp Stop: Types of warp stop motions and their functioning.

Weft Stop: Weft stop mechanisms with advantages and disadvantages.

Weft Replenishment System: Pirn replenishment mechanism and its limitations. Different types of feelers used for it.

Box changing motion: Working mechanism of multiple box motions (2x1 and 4x1).

Dobby and Jacquard: Scope of dobby, different types of dobby and their mechanism pegging system as per design of weave, paper dobby, Scope of jacquard, working of different types of jacquards and card punching methods.

Concept of Quick style change

Shuttle-less Weaving: Problem of shuttle weaving, Development of shuttle less weaving, an elementary idea on Projectile, Air-jet, Water-jet, Rapier weaving machine, Special features of these machines. Calculation related to weaving process

Nonwoven: An Introduction to Non-woven Technology.

Books Recommended:

1. Mark R, Robinson A T C, "Principles of Weaving", The Textile Institute, Manchester, 1986.
2. Talukdar M K, Sriramulu P K and Ajgaokar D B, "Weaving – Machine, Mechanism and Management", Mahajan Publisher Private Ltd., Ahmedabad, India, 1998.
3. Aswani K T, "Fancy Weaving mechanism", Mahajan Publisher Private Ltd., Ahmedabad, India 1990.
4. Talavasek and Svaty V, Shuttleless Weaving machine, Elsevier Scientific Publishing Co, Amsterdam, 1981.
5. Lord P and Mohamad.M.H., " Weaving Conversion of Yarn to fabric", Merrow Technical Library, UK,1988
6. Krcma R, "Mannual of Non wovens", Textile Trade Press, UK,1971

TTPC-208 Preparatory and Colouration of Textiles [3 0 0 3]**Course Outcomes**

CO1	To study the nature of pretreatments are to be imparted in the shop-floor level to various textiles
CO2	To study process parameters and methods for pretreatment of textiles as well as study of process efficiency
CO3	To study dye-fibre interaction and related colour fastness
CO4	To study dye chemistry based on application and suitability for a specific fibre
CO5	To study application parameters for various textiles

Introduction: Process line for pretreatment, colouration and finishing of textiles. Objectives of each process. Optimized of process line for specific end use

Singeing: Object of the process, types of singeing, details of various singeing methods, drawbacks and advantages. Process and quality control aspects involved. Evaluation of efficiency of singeing.

Desizing: Objectives of desizing. Hydrolytic and Oxidative desizing: Rot, acid and enzyme, chlorine, chlorite, peroxide and bromite desizing; methodology adopted, parameters involved, mechanism of removal of starch and advantages and drawbacks in each method. Efficiency of desizing. Process and quality control.

Scouring: Objectives, mechanism of removal of impurities, recipe and controlling parameters involved. Kier, J Box, pad-roll and V loc P loc methods. Scouring of coloured textiles. Scouring of wool, manmade and blended textiles. Bioscouring with enzymes. Evaluation of scouring efficiency: Absorbency, copper number, Methylene Blue absorption, fluidity test. Degumming of silk

Bleaching: Objectives of bleaching: Hypochlorite, peroxide, chlorite and peracetic acid bleaching methods. Suitability and effectiveness of each method for various textiles. Controlling parameters, and mechanism involved in each method, Efficiency of bleaching. Concept of bio-bleaching with enzymes.

Mercerization: Objectives, mechanism related to various physical and chemical changes in cotton. Process parameters and operation details for fabric and hank. Causticization. Wet and hot mercerization, Ammonia treatment of cotton. Performance of various mercerization / alkali treatment processes. Assessment of efficiency of mercerization: Barium activity number, its determination and interpretation.

Heat setting: Objectives and mechanism. Different methods of heat setting and their effectiveness on various manmade textiles and blends. Influencing factors of heat setting. Changes in properties of textiles during heat setting. Heat setting of polyester, nylon, acetate and their blends. Performance assessment of heat setting.

Concept of colour: Visible spectrum, wavelength and blindness of colour. Metamerism/ isomerism.

Theories of colour: Additive and subtractive theories. Primary, secondary, tertiary, complementary and contrasting colours. Tristimulus values of colour. Computer colour matching, Kubelka-Munk equation, reflectance factor, colour-co-ordinates, CIELAB values. Surface colour strength and dye uptake on textiles.

Theory of dyeing: Various forces responsible for dye-fibre interaction and related colour fastness properties. Related chemistry involved, free volume theory.

Dyeing of textiles: Dyeing technology of natural and manmade textiles with direct, reactive, vat, insoluble azoic, sulphur, solubilised vat, acid, metal-complex, basic and disperse dyes. Colouration with Pigments. Auxiliaries used in dyeing.

Books Recommended

1. V A Shenai, Technology of Bleaching and Mercerising, Vol 2, Sevak Publication, Mumbai (1991).
2. Peters R. H, "Textile Chemistry", Vol - II, Elsevier Publishing Company, London (1967).
3. Shore J, "Cellulosics dyeing", Society of Dyers and Colourists, Bradford, UK (1979).
4. Mittal R M and Trivedi S S, "Chemical Processing of polyester / cellulosic Blends", Ahmedabad Textile Industries Research Association, Ahmedabad, India (1983).
5. Karmakar S R, "Chemical Technology in the pretreatment processes of Textiles", Textile Science and Technology Series, Vol-12, 1st Edition, Elsevier (1999).

TTPC- 210 Fabric structure and design analysis [3 0 0 3]

Course Outcomes

CO1	To understand the concept of fabric designing
CO2	To analyse the fabric structure for modification or reproduction
CO3	To represent the fabric structure graphically along with the design specifications
CO4	To learn about the method of construction, features and derivatives of simple and compound structures
CO5	To estimate the raw material requirement for a particular fabric design and specifications

Introduction: Different types of yarn such as spun, filament, textured and fancy yarns and their impact on textile design, Concept of fabric designing through fabric structure and textile printing, Fabric cover and crimp; importance of fabric structure and analysis, detection of directions of warp and weft; classification of woven fabrics, method of fabric presentation, weaving plans.

Basic Weaves: Method of construction, features and uses of plain weave and its derivatives, twill weave and its derivatives, Satin and sateen weaves and their derivatives.

Absorbent Fabrics: Method of preparation features and uses of Diamond and Diaper Weaves, Honey comb weaves, Huck-a-back and mock -leno weaves.

Crepe Weave: Special feature, construction of the weave, method of preparation of its derivatives and uses.

Bedford cord weaves: Method of construction, features, cross-sectional view, derivatives and uses.

Stripe and Check Weaves: Features, criteria for selection of weaves for combination, rules governing the joining of different weaves, Method of preparation and uses.

Color and Weave Effect: Weave and color combinations, features, method of preparation of Continuous line effect, Hounds tooth, Birds eye, Crows foot, Hair lines and Step pattern.

Terry Weaves: Definition, classification, process of formation of pile, graphical representation of terry weaves, loop sprouting, extra attachments.

Backed fabrics: Definition, features, classification and usage. Graphical representation, warp backed and weft backed cloth, reversible backed fabric, wadded backed fabric.

Double Cloth: Definition, features, classification and uses. Method of preparation of self stitched and center stitched double cloths, their salient feature and uses, Wadded double cloth.

Calculations: Raw material calculations to produce different weaves. Technical specifications of important fabrics.

Books Recommended:

1. Groszicki Z J, “Watsons Textile Design and Colour”, NewnesButtersworth, 1988.
2. Groszicki Z J, “Watsons Advanced Textile Design”, NewnesButtersworth, 1989.
3. J. Hayavadana, “Woven Fabric Structure Design and Product Planning”, 1st Edition, WPI Publishing
Published January 14, 2015, ISBN 9789380308241
4. Klibbe J W, “Structural Fabric Design”, revised edition, 1965, North Carolina State University.
5. Nisbeth H, “Grammer of Textile Design”, 3rd edition, D B Tarapore Wala sons and Co., 1994.

TTPC-212 Yarn Formation Laboratory-II [0021]

Course Outcomes

CO1	To estimate head to head difference in noil level
CO2	To study the drafting, twisting and winding zone of speed frame.
CO3	To study the building motion in speed frame.
CO4	To study the drafting, twisting and winding zone in ring frame
CO5	To study the influence of spindle speed and traveller weight on hairiness

At least 10 experiments are to be performed by each student

1. To estimate head to head difference in noil level (mill based study).
2. To study the effect of feed per nip on percentage in nep level during combing (mill based study).
3. To study the drafting, twisting and winding zone of speed frame.
4. To study the building motion in speed frame.
5. To study the differential motion of speed frame and calculation of bobbin speed.
6. Calculation of break draft constant, draft constant and twist constant and production of speed frame.
7. To study the influence of machine and process parameters on roving unevenness (mill based study).
8. To study the drafting, twisting and winding zone in ring frame.
9. To study the building motion in ring frame.
10. Calculation of draft constants, twist constant, coils per inch and production of ring frame.
11. To ascertain the effect of break draft and total draft on yarn unevenness and strength (mill based study).
12. Estimation of spinning tension as a function of traveller weight, yarn count and balloon height (mill based study).
13. To perform various settings and maintenance operation on ring frame such as:

- ◆ Ring rail leveling
- ◆ Spindle gauging
- ◆ Spindle eccentricity
- ◆ Lappet eccentricity

14. To study the effect of shore hardness on yarn quality (mill based study).
15. To study the influence of spindle speed and traveller weight on hairiness.
16. Study the chief organs, mechanism and calculations of open end and friction spinning machines.
17. To study the timing diagram of a comber.
18. To study the function of top comb and its depth of penetration with reference to noil extraction and fractionating efficiency (mill based study).
19. To study the nature of movement of nipper assembly.
20. To study the mechanism of detaching roller drive and the nature of its motion.
21. To study the effect of type of feed and detachment setting on noil percentage and fractionating efficiency.

TTPC-214 Fabric Formation Laboratory-II [0021]

Course Outcomes

- | | |
|-----|---|
| CO1 | Acquaintance with shuttle-less weaving |
| CO2 | Work on pirn changing system |
| CO3 | Yarn path in shuttle-less weaving machine |
| CO4 | Air- jet picking system study |
| CO5 | Rapier picking system study |

At least 10 experiments are to be done:

1. Study of take up motion and calculation of loom take up constant.
2. Study of positive let-off system.
3. Study of Warp protection motion (both loose reed and fast reed).
4. Study of warp stop motion.
5. Study of Beating up system in Terry towel loom.
6. Study of temple motions.
7. Study of pirn changing mechanism.
8. Study of side/centre weft fork mechanism.
9. Study of (4x1) multiple box motion.
10. Study of let-off and take-up of shuttle less weaving machine.
11. Study of weft insertion mechanism of Air-jet and Rapier weaving machine.
12. Study of selvedge formation technique of Air-jet weaving machine.
14. Identification of fabric faults by fabric inspection machine.

TTPC-216 Textile Chemical Processing Lab I [0 0 3 2]

Course Outcomes

- | | |
|-----|--|
| CO1 | To develop knowledge on calculation of dyes and chemicals for specific pretreatment and colouration processes. |
| CO2 | To develop practical knowledge on application of various processes on |

	various textiles
CO3	To develop knowledge on unevenness on textiles during a specific processes.
CO4	To learn knowhow of carrying out pretreatment and colouration processes
CO5	To learn remedial measures and correction of faulty results

At least 10 experiments are to be performed by each student

1. Scouring of cotton
2. Scouring of polyester
3. Scouring of blend
4. Scouring of wool
5. Degumming of silk
6. Bleaching of cotton with NaOCl
7. Bleaching of cotton with H₂O₂
8. Bleaching of cotton with NaClO₂
9. Bleaching of polyester
10. Bleaching of blend
11. Bleaching of jute yarns / fabric
12. Dyeing of cotton with direct dye and after treatment
13. Dyeing of cotton with reactive dye
14. Dyeing of cotton with Sulphur dye

TTPC- 218 Fabric structure and design analysis laboratory [0 0 2 1]

Course Outcomes

CO1	To analyse various weaves for their structure
CO2	To graphically represent different weaves
CO3	To analyse the yarn and fabric parameters of various weaves

At least 10 experiments are to be performed by each student

To analyze the yarn and fabric particulars of the different weave structures along with their graphical presentation and weaving plans.

- | | |
|------------------------|----------------------------|
| a. Plain weave | h. Stripe and check weaves |
| b. Twill weave | i. Crepe weaves |
| c. Satin/sateen weave | j. Huck a back weaves |
| d. Diamond weave | k. Double fabrics |
| e. Honeycomb weaves | l. Backed fabrics |
| f. Perforated weaves | m. Terry weaves |
| g. Bedford cord weaves | |

5th Semester

TTPC-301 Properties of fibers [3-0-0-3]

Course Outcomes

CO1	Concept of fibre structure and its characterisation
CO2	Understanding various properties of fibres
CO3	Concept of structure–property correlation
CO4	Understanding various mathematical models of fibre structures and properties
CO5	Effects of different factors on fibre properties

Fiber structure: Traditional view of fiber structure. Chemical structure and physical Structure, Degree of order and degree of orientation.

Structure investigation: Methods of investigation of fiber structure. Basic understanding of IR spectroscopy, X-ray, SEM and TEM.

Moisture absorption: Definitions of humidity, moisture regain, and moisture content. Relation between regain and relative humidity, Effect of stress and temperature on regain. Heat of sorption, swelling of fibres, Quantitative theory of moisture absorption.

Tensile properties: Factors influencing results of tensile experiment, expressing results, Different experimental methods; effect of variability. Elastic recovery. Effect of test conditions on recovery. Cyclic loading and fatigue. Fibre fracture and fatigue. Time effect. Creep and stress relaxation. Introduction to dynamic testing. Concept of models. Kelvin and Maxwell model. Bending and torsional rigidity of fibre.

Dielectric properties: Definition and effect of different parameters on dielectric properties. Electric resistance and effect of different factors on the electrical resistance of fibres.

Static electricity: Introduction and significance. Measurement of static electricity. Explanation of static phenomena.

Optical properties: Refractive index and birefringence. Birefringence and orientation of fiber. Reflection and lustre.

Thermal properties: Structural changes on heating. Thermal transitions. Concept Heat setting of fibres.

Fibre friction: Technological importance. Measurement of friction. Effect of load and area of contact. Static and kinetic friction. General theory of friction and application to fiber.

Books Recommended:

1. Meredith R, “The Mechanical Properties of Textile Fibres”, North Holland Publishing Co; Amsterdam 1959.
2. Morton W E and Hearle J W S, “Physical Properties of Textile Fibres”, 1st reprint, The Textile Institute, Manchester, 1986.
3. Gupta V B and Kothari V K, “Manufactured Fibre Technology”, 1st Ed., Chapman and Hall, London, 1997.
4. Hearle JWS, “Polymers and their properties”, Vol. I, John Wiley and Sons, NY, 1982.
5. Gedde U W, “Polymer Physics”, Chapman Hall, London, 1995.

TTPC- 303 Printing and Finishing [3 00 3]

Course Outcomes

CO1	To manipulate knowledge of dyeing single textile for implementation in dyeing of blended textiles
CO2	To learn composition of print paste and function of various components in it
CO3	To learn properties and types of thickeners and their suitability for various printing processes as well as various printing machines and styles
CO4	To know application and perspective of various finishing processes
CO5	To identify dyes from dyed textiles

Dyeing of blends: Classification of blends and fancy shades, Methods for dyeing of blends. Suitability of each method for dyeing of specific blend. Possibility of developing fancy shades on blends with related technology.

Pretreatment and dyeing machineries: Working Principle, construction and functioning of singeing m/c, J-box, kier, mercerizing machine, loose fibre, yarn and package dyeing machines. Jigger, winch, jet and HTHP beam dyeing machines. Padding mangles.

Carbonization: Objectives, selection of chemical, process parameters, trouble shoots, precautionary measures and efficiency of carbonization.

Printing methods: Hand block, roller and screen printing processes, Construction and working of roller printing machine, photoelectric method of screen preparation, Drawback and advantage of each method.

Print Paste: Constituent and characteristics of print paste, classification and mechanism of working of thickeners.

Printing after treatments: Importance of steaming, curing, ageing of prints, Mechanism of each process.

Printing Styles: Direct, discharge and resist styles of printing on natural, manmade and blended textiles.

Transfer Printing: Classification, mechanism of transfer in each type. Transfer printing of natural, man-made and blended textiles. Transfer printing machines..

Mechanical Finishes: Calendering: Influence of working parameters, construction and function of various calendering machines. Physical and chemical softening processes, selection of chemical and evaluation of softening. Sanforizing: Method, mechanism and machineries involved, Evaluation of sanforizing.

Functional finishes: Problem of creasing and anti-crease finish on cotton, Choice of chemical, catalyst and process parameters. Drawback and advantages associated with use of various anti-crease chemicals, Measures to reduce release of formaldehyde, Water repellency and water repellent finishes on cotton, Evaluation of water repellency. Soil release finish: Classification of soil and mechanism of their adherence on cotton. Soil releases finishes. Flame retardant finish: Burning cycle and its importance to hypothesis for flame retardants. Limiting Oxygen Index (LOI), various proposals for application of flame retardants on various textiles.

Identification of dyes: Identification of dye on dyed natural and manmade textiles.

Books Recommended:

1. Miles L W C, "Textile Printing", Dyers Company Publication Trust, Bradford, England, 1981.
2. Shenai V A, "Technology of Printing", Sevak Publications, Mumbai, 1990.
3. Hall A J, "Textile Finishing", Haywood Books, London, 1996.
4. Shenai V A and Saraf, N M, "Technology of Textile Finishing", Sevak Publications, Mumbai, 1990.
5. Nunn D M, "The Dyeing of Synthetic Polymer and Acetate Fibres", Dyers Company Publication Trust, London, 1979.

TTPC- 305 Textile Testing [3 1 0 4]

Course Outcomes

- CO1 Develop the concept of testing of fibres, yarns and fabrics
CO2 Understanding of the basic principles and procedures of testing
CO3 Knowing the various methods of testing and study of their results.
CO4 Discuss the advanced and latest sophisticated testing instruments
CO5 Understanding of the applications and result/data analysis of products.

Introduction: Aim and scope of testing, Sample and Population, Sampling techniques for fibre, yarn and fabrics.

Testing of Fibres and Yarn intermediates: Cotton fibre testing such as length, fineness, crimp, maturity, neps, strength, elongation, trash-content, grading of different cotton, fibre contamination measurement, application of HVI and AFIS. Testing of wool and man-made staple fibers, measurement of fiber friction and crimp. Evenness testing of silvers, rovings.

Testing of Yarn: Yarn numbering and conversion system, twist in continuous filament, spun and plied yarns, tensile properties, various type of measuring instruments and their working principles, factors affecting tensile properties, elastic recovery, effect of impact loading and fatigue behavior, yarn friction, evenness testing of yarns, nature and causes of irregularities, principles and methods of evenness testing, evaluations and interpretation of evenness results, concept of index of irregularity. Analysis of periodic variations in mass per unit length. Variance - length curves and spectrogram analysis, yarn faults classification, Uster Classimat and Classifault. Yarn hairiness, principle of measurement, measuring instruments. Test for filament and textured yarn.

Testing of Fabric: Measurement of fabric dimensions and other physical properties such as thickness, weight, yarn crimp, fabric shrinkage, air-permeability, thermal properties, wettability, water proof-ness, and flame resistance, Fabric low stress mechanical properties such as smoothness, stiffness, softness and shear, drape behaviour. Test related to fabric appearance such as pilling, crease and wrinkle recovery, fabric handle and factors influencing it, fabric comfort. Air-water and water-vapor transmission through fabrics, thermal resistance of fabrics. Serviceability testing parameters such as abrasion resistance, fabric strength, tear strength, bursting strength and snagging test, assessment of barre and other form of fabric defects.

Chemical Testing of Textiles: Color fastness, rubbing fastness, laundering fastness.

Books Recommended:

1. Saville B P, "Physical Testing of Textiles", Woodhead Publishing Ltd, Cambridge, 2002.
2. "Testing and Quality Management", Ed. V. K. Kothari, IAFL Publications, New Delhi, 1999.
3. Booth J E, "Principles of Textile Testing", CBS Publishers and Distributors, New Delhi, 1999.
4. Angappan P and Gopalakrishnan R, "Textile Testing", SSM Institute of Textile Technology, Komarapalayam, 2002.
5. Basu A, "Textile Testing", SITRA Coimbatore, 2002.

TTPC-307 Knitting Technology [3 0 0 3]

Course Outcomes

CO1	To differentiate between the characteristics of fabrics made from different techniques
CO2	To understand the various techniques of manufacturing knitted fabrics
CO3	To appreciate the use of knitted fabrics in different areas of application
CO4	To understand the warp and weft knitting processes & structure of fabrics
CO5	To study the latest developments in the knitting processes

Knitting: Process, comparison of weaving and knitting, warp and weft knitting, classification of weft knitting machines.

Weft Knitting Elements: Knitting needles, sinkers, cam systems, type of feeding systems, Tensioning devices, stop motions.

Weft Knitted Structures: Properties and uses of basic weft knitted structures- Plain, Rib, Interlock and Purl along with their derivatives. Different types of stitches, Production calculations, fabric faults in weft knitting.

Flat Knitting Machines: Process of loop formation, cam track, features and structures produced.

Patterning: Devices for patterning in circular knitting machine, Electronic needle selection.

Science of Knitting: Concept of loop length, knitting tension, spirality, Relation between geometry and properties of weft knitted loop

Warp Knitting: Machines and mechanism. Study of let-off and take up mechanism, lapping diagrams, Production calculations, Warp knit structures.

Books Recommended:

1. Spencer D J, "Knitting Technology", 2nd edition, Pergamon Press, 1989
2. Warp knitting production : S Raz; Published by MelliandTextilberichte.
3. Flat Knitting : S Raz; Published by MelliandTextilberichte.
4. Circular knitting :Iyer, Mammel and Schach; Published by Meissenbach GmbH.
5. Ray S C, "Fundamentals and advances in knitting Technology", Woodhead publishing limited, 2001.
6. Booth J E, "Textile Mathematics", Vol. 3, Textile Institute, Manchester, 1977.

TTPC- 309 Textile Chemical Processing Lab-II [0 0 3 2]

Course Outcomes

CO1	To practice on Dyeing of cotton with vat, naphthol and soluble vat dyes
CO2	To do practice on dyeing of manmade textiles
CO3	To do practice on direct printing of cotton with reactive dyes
CO4	To apply anti-crease finish on cotton
CO5	To identify dye on coloured textiles

At least 10 experiments are to be performed by each student

1. Dyeing of cotton with Insoluble azoic colours
2. Dyeing of cotton with vat dyes
3. Dyeing of cotton with solubilised vat dyes
4. Dyeing of wool fiber with: a) Reactive dyes, b) Acid dyes, and c) Metal complex dyes
5. Dyeing of silk with acid dyes, mordant dyes, and metal-complex dyes
6. Dyeing of polyester with disperse dyes
7. Dyeing of nylon with acid dyes and metal complex dye
8. Dyeing of acrylic with basic dyes
9. Printing of cotton fabric in direct style
10. Printing of cotton fabric in discharge style
11. Printing of cotton fabric in resist style
12. Identification of dyes on dyed textiles
14. To finish cotton fabric with: a) Anti-crease finish, and b) Water repelling agent

TTPC- 311 Knitting Technology Laboratory [0 0 21]

Course Outcomes

CO1	To understand the knitting cycle of various weft knitting machines (circular/flat)
CO2	To learn the process of manufacturing fundamental structures on weft knitting
CO3	To evaluate the effect of yarn and machine parameters on quality of knitted fabrics
CO4	To analyse the basic weft knitted structures

At least 10 experiments are to be performed by each student

1. To study the path of yarn through plain knitting machine.
2. To study the different knitting elements including the cam system.
3. To study the driving mechanism of plain knitting m/c.
4. To study the cloth take-up mechanism of plain knitting m/c.
5. To study the rib knitting m/c including arrangement of dial and cylinder needles, cam system and driving mechanism.
6. To study the Interlock knitting m/c including arrangement of dial and cylinder needles, cam system and driving mechanism.
7. To study cam system of V - bed rib knitting m/c.
8. To study driving mechanism of V - bed rib knitting m/c.
9. Preparation of Fabric sample (rib, circular, half cardigan and full cardigan) in V-bed rib knitting machine.
10. To study the effect on loop length with the change in cam setting in flat knitting machine.
11. To study the effect of variation in yarn input tension on the loop length in V-bed rib flat knitting machine.
12. To study plain, rib and Interlock knitted fabrics (course per inch, wales per inch, loop length etc.)

TTPC- 313 Textile Testing Laboratories [0 0 2 1]

Course Outcomes

CO1	Aim and scope of textile testing.
CO2	Testing of fibres, yarns and fabrics
CO3	Knowing the various methods of basic test and their comparison of results.
CO4	Discuss in detail the testing standard of ASTM and norms of other international organisation.
CO5	Role and uses of textile testings in quality control, characterisation of products.

At least 10 experiments are to be performed by each student

1. To prepare and analyze Baer Sorter diagram. and determine the following:
2. Determine moisture content/regain of a fibre sample by hot air oven method.
3. Determine the micronaire value of a given cotton sample by Air-Flow method. Convert the result into SI units and give a suitable rating to the fibre sample.
4. Determine maturity coefficient and maturity ratio of a given sample by caustic soda method. Give appropriate rating to the fibre sample.
5. Determine Pressley Index of a cotton sample by Pressley Tester at zero and 3mm gauge length and convert result into tenacity. Compare and comment on the results at different gauge lengths.
6. Determine the bundle strength and elongation of a given manmade fibre using Stelometer. Analyze the effect of rate of loading on tensile properties of the fibre.
7. Cotton fibre testing by HVI.
8. Determine crimp (crimp %) of a given manmade fibre sample.
9. Determine fibre fineness of a manmade fibres/filaments by:
10. Tensile properties of a staple fibre by UTM
11. Determine stress relaxation and creep recovery of fibre.
12. Study evenness and imperfection in the given yarn and compare the results with USTER statistics. Study the spectrogram and irregularity trace to determine type of irregularity present. Study the imperfections at different sensitivity level for different yarn samples.
13. Prepare yarns Appearance Boards and compare with ASTM standards.
14. Study the hairiness of a given yarns using Hairiness Tester. Compare the results of Evenness Tester and Hairiness Tester with ASTM grade.
15. Determine coefficient of friction of a spun yarn and indicate the effect of waxing on coefficient of friction.
16. Determine bending rigidity by (HEART) loop method.
17. Determine the Lea C.S.P by Lea CSP Tester and Autosorter and compare the results of various yarn.
18. Determine the percentage crimp and corrected count with the help of crimp Tester.
19. Determine the crimp rigidity by using hot crimp contraction method.
20. Classimat fault analysis (yarn fault classifying system).
21. Determine the tensile properties of yarn by single thread strength tester.
22. Determine twist of yarn using different principle of measurement.
23. Characterize a woven fabric with respect to its dimensional properties.
24. Determine the tensile strength and elongation of a woven fabric and compare the Load-elongation curve with non-woven and knitted fabric.
25. Determine the tear resistance of a fabric using Elmendorf Tear Tester.

26. Determine the bursting strength of a fabric on a hydraulic bursting tester.
27. Determine the abrasion resistance and pilling resistance of a fabric.
28. Determine the crease recovery of fabric and observe effect of loading time and recovery time on crease recovery.
29. Determine the Drape coefficient of a fabric sample.
30. Determine the compression property of a fabric (thickness).
31. Determine the Air permeability, water permeability and water repellency of a fabric.
32. Determine the thermal resistance of a fabric.
33. Determine the stiffness of a fabric.

6th Semester

TTPC- 302 Process Control in Textiles [3 0 0 3]

Course Outcomes

CO1	Concept of research and managerial decision making
CO2	Optimization technique, primarily LPP
CO3	Exposure of operations research in textile in textile operations
CO4	Transportation and assignment problems and the optimization techniques
CO5	Concept of inventory management

System of process control in spinning: Role and scope, key variables, establishing norms or standards, Collection and interpretation of data and corrective action.

Mixing quality and Cost: Instrumental evaluation of cotton, control of mixing quality through fiber characteristics control of mixing cost and quality, linear programming for cotton mixing and its formulation and approach.

Yarn realisation: Records and estimation of yarn realization and waste in spinning mill, norms for yarn realisation.

Waste and cleaning in Blow room and carding: Calculation of Trash content and cleaning efficiency, Norms for waste and cleaning efficiency, assessing the performance of Blow room and card.

Comber waste control: Technological conditions, optimization of comber waste extraction, norms and procedures for control of comber waste.

Control of yarn quality: Measurement, assessment and control of count, strength, unevenness and imperfections of yarn.

System of process control in weaving: Scope and approach to process control in weaving. Establishing and standards schedule of checks and machinery audit.

Quality Control and Productivity in winding warping and sizing: Approach, scope, control and optimization.

Control of productivity in Loom shed: scope and approach, control of loom speed, efficiency and stops. Quality of yarn. Expected loom efficiency, loom allocation.

Fabrics Quality in Weaving: Scope and approach, control of some specific fabric defects, grey fabric imperfection.

System of Process Control in Chemical Processing: Scope and approach, norms and standards.

Quality control and Productivity: Quality control and productivity in Bleaching, dyeing, printing and finishing. Control of damages in chemical processing.

Books Recommended:

1. Garde A R and Subramanian T A, "Process Control in Cotton Spinning," ATIRA, Ahmedabad, 2nd Ed., 1978.
2. Paliwal M C and Kimothi P D," Process Control in weaving", ATIRA, Ahmedabad 2nd Ed, 1978.
3. Gokhale S V and Modi J R, " Process and Quality Control in Chemical Processing of Textiles", ATIRA, Ahmedabad, 1992
4. Ratanam T V, "Quality control in spinning", SITRA, Coimbatore, 1994.
5. Salhotra K R, Chattopadhyay R and Ishtiaque S M, "Process control in spinning", IIT, Delhi, CD cell, 2001

TTPC- 304 Nonwoven Technology [3 0 0 3]

Course Outcomes

CO1	Understanding the techniques of manufacturing nonwoven fabrics
CO2	Relate the structure and properties of nonwoven fabrics produced by different techniques
CO3	Analyze the effect of various process parameters on the properties of nonwoven fabrics
CO4	Application of fabrics produced by different techniques.
CO5	Understanding the advancements in the nonwoven technology

Raw materials: Natural and Synthetic fibres, Bonding agents, Types of bonding agents, Basic structure of bonding agent formulation, Characteristic properties of polymer dispersions, Adhesive fibres, Soluble fibres.

Web formation techniques: Fibre preparation, Dry laying, wet laying, Spunlaying, Melt blowing, SM, SMS fabrics.

Mechanical Bonding: Needle punching technology, oblique needle punching, Hyperpunch and H1 technology, Developments in needle punching technology, Factors affecting the tensile and bulk properties of needle punched fabrics, Spunlacing technology, factors affecting the properties of spunlaced fabric, Stitch bonding techniques like, Malimo, Malliwatt, Malivlies, Voltex, Kunit, Multiknit and KSB

Chemical Bonding: Adhesive Bonding, Methods of bonding agent application, Cohesive bonding, Drying by convection, conduction, radiation, infra red drier and high frequency driers.

Thermal bonding: Thermal bonding techniques, Area bonding, Point bonding and their properties.

Spunbonding and Meltblowing: Techniques, structure and properties of fabrics.

Finishing of nonwoven fabrics: Shrinkage, Calendaring, Pressing, Splitting, Grinding Washing, Dyeing, Printing, Softening, Coating and Laminating.

Applications: Medical and Hygiene, Apparel, Household and Home Textiles, Geotextiles, Filtration, automotive textiles, agriculture, leather industry

Books Recommended:

1. Russell, S J, "*Handbook of Nonwovens*", Woodhead Publishing Limited, Cambridge, UK, 2007
2. Lunenschloss J and Albrecht W, "Non-Woven Bonded Fabric", Ellis and Horwood Ltd., UK, 1985
3. Albrecht W, Fuchs H and Kittelmann, "Nonwoven Fabrics", Wiley-VCH Weinheim, 2003.
4. Mrstina V and Fejgal F, "Needle punching textile technology", Elsevier, 1990.
5. Krcma Radco, "Manual of nonwovens", Textile Trade Press, UK, 1971

TTPC- 306 Garment Manufacturing Technologies [3 0 0 3]

Course Outcomes

CO1	Growth and global scenario of garment industries
CO2	Types, size and production-layout of garment industries
CO3	Detailed study of the various methods of basic production stages of garment
CO4	Discuss in detail the production and quality control of garment production
CO5	Seam quality and their characterisation

Garment Manufacturing: Introduction, present scenario and future of Indian apparel industry. **Raw material:** Woven and knitted fabrics with their characteristics and applications for different uses, Garment manufacturing from woven and knitted fabrics.

Designing and Pattern making: Introduction to designing, Pattern making – draft construction, advanced Pattern making, grading of pattern, marker planning, fabric spreading, laying methods, Factors affecting spreading, 3D body scanner for measurements, fabric cutting, computerized cutting machines, easy match system, automatic ticketing and bundling, garment size and size charts.

Garment Sewing: Introduction to sewing m/c and its parts and working details, Different types of sewing m/c, driving system of sewing machines, Various attachments of sewing m/c, high speed sewing, LAN in Sewing machine and sewing room planning, Preparation of seamless garments and its applications.

Stitches and seams types: Stitch formation, types of stitches, seam classification, seam geometry, seam strength and slippage, seam puckering. Thread calculation and its consumption, seam quality.

Sewing Needles and Threads - Needle – functions, special needles, Needle size, Needle points; sewing thread – construction, material, thread size and packages.

Trimming and Garment accessories: linings, interlinings, wadding, lace, braid, elastic, hock and loop fastening shoulder pads, eyelets and laces, Zip fasteners and buttons.

Garment finishing: Fasteners, thread tucking, care and size labeling system, checking, pressing, folding and packing, packaging standards for domestic and export markets.

Quality Control in Garment manufacturing: Quality control in pattern making, grading, fabric laying, marking, sewing and finishing, control of garment defects.

Manufacturing systems and Planning – Various production system with their characteristics, lay out planning, Work study methods, motion and time study, computer Integrated production planning and management systems. Concepts of CAD, computer aided embroidery designs, computer integrated manufacturing (CIM) in the garment manufacturing and technological advancement in garment manufacturing.

Books Recommended:

1. Carr H and Lantham B, “The Technology of Clothing Manufacture”, Om Book Service, Delhi.
2. Mehta P V and Bhardwaj S K, “ Managing Quality in apparel industry”, Om Book Service, New Delhi.
3. Aldrich W, “Metric Pattern Cutting”, OM Book Service, New Delhi, 1998.
4. Cooklin Gerry, “Garment Technology for Fashion Designers”, OM Book Service, New Delhi, 1997.
5. Eveleyn M and Ucas, “Clothing Construction”, 2nd Edition Hughton Mifflin Co, Boston 1974.

TTPC 308 Garment Manufacturing Technology Lab [0 0 2 1]

Course Outcomes

CO1	Aim and scope of garment production
CO2	Study of raw materials and their quality in garment
CO3	Study of sewing machine , its parts and also construction of hand stitches
CO4	Study and development of patterns for simple designs using basic blocks
CO5	Skill of the designer to convert a design sketch into a three dimensional form of garments

(15 practical are given below at least 10 are to be performed by students)

1. Study of sewing machine and its parts (01 Lab).
2. Study and construction of hand stitches - Basting, Running, Hemming, Back stitch and its variations (01 Lab).
3. Study and construction of seams - Plain, French, Lapped, Flat fell, Hongkong, eased and top stitched (01 Lab).
4. Study and construction of Gathers, Pleats and Tucks (01 Lab).
5. Study and development of patterns for simple designs using basic blocks (01Lab).
6. Study and construction of basic blocks to assemble a garment (01 Lab).
7. Garment stitching and finishing (03 Lab).
 - Darts
 - Waist bands
 - Pockets
 - Placket - slit and seam
 - Neckline finish
 - Sleeve attachments
8. To explain important skill that enables the designer to convert a design sketch into a three dimensional form (01 Lab).
9. Study and applications of various type of software used in apparel manufacturing processes (based on tuka-tech and all reach software) (01 Lab).
10. Designing of T –shirts, Skirts, Pant and shirt using garment software (02 Lab).
11. Design wedding dresses for women / man using fashion studio (CAD) software (01 Lab).
12. Design dresses for women / man sport player using fashion studio (CAD) software (01 Lab).

TTPC - 310 Data Analysis Laboratory [0 0 2 1]

Course Outcomes

CO1	Calculate Mean, Median, Mode, Range, Mean Deviation, PMD and CV% using MS excel
CO2	Draw scatter plot, histogram, bar chart, line plot, 3-D surface and contour plot using MS excel/other software
CO3	Do regression analysis and curve fitting with the equations
CO4	Do statistical analysis such as ANOVA and Significance test using MS excel/other software
CO5	Design the experiment using statistical software

At Least 10 experiments are to be performed by each student

1. Analysis of given data to find Mean, Median, Mode, Range, Mean Deviation, Percent Mean Deviation, Standard Deviation and Coefficient of Variation in MS excel/any other software.
2. Presentation and analysis of data: scatter plot, histogram, bar chart, line plot, variability plot, box plot and table in MS excel/any other software.
3. Study and use of logical functions (If, AND, OR, XOR, NOT) in MS excel.
4. Application and use of significance test in MS excel.
5. Study and use of linear programming in MS excel.
6. Application and use of ANOVA in MS excel/any other software.
7. Study of curve fitting using regression equation.
8. Study of curve fitting with customized equation in MATLAB.
9. Finding area under curve in MATLAB.
10. Regression analysis of raw data using MATLAB.
11. Producing 3-D surface and contour plot in MATLAB/any other software.
12. Application and use of design of experiment using statistical software.

7th Semester

TTPC- 401 Theory of Textile Structure [3 1 0 4]

Course Outcomes

CO1	Deals with structure of yarn and fabric
CO2	Modeling of yarn structure
CO3	Relation of yarn structure with properties
CO4	Modeling of fabric structure
CO5	Relation of fabric structure with properties

Basic geometry of twisted yarns, The idealized helical yarn structure, Deviation from real yarn. Twist contraction and retraction, Packing of fibres in yarn. Forms of Twisting. Migration and its importance in yarn mechanics. Ideal migration, Parameters affecting migration, characterization of migration behavior, mechanism of migration in single and plied structure. Extension of yarn under small load. Analysis of tensile forces of yarn under stress. Prediction of breakage, Nature of rupture for continuous filament yarn. Extension and breakage of spun yarn: Traditional view and approach by Hearle and El-Sheikh. Blended yarn structure, Humburger's Theory. Structure property relationship of ring, rotor, air-jet, friction spun yarn.

Engineering approach to the analysis of fabric, Ashenhurst theory and its application. Fabric cover and fractional cover. Cover factor in SI unit. GSM and cover factor relationship. Concept of similar cloth. Design of similar cloth. Pierce geometrical model relationship between h, p, c, Crimp interchange, Jammed Structure. Minimum possible cover factor. Race track geometry, close limit of weaving concept of pierce elastic thread model, Geometry of plain knitted fabric. Knitted fabric tightness factor and GSM. An elementary idea about tensile, tear, bending, shear and drape behavior of fabric. An elementary idea about fabric objective measurement technology.

Books Recommended:

1. Hearle J W S, Grosberg P and Backer S, "Structural Mechanics of Fibres Yarns and Fabrics", Wiley Interscience, New York, 1969.
2. Goswami B C, Martindale J G and Scardino F, "Textured yarn technology, structure and applications", Wiley Interscience Publisher, New York, 1995.
3. Peirce F T and Womersley J R, "Cloth Geometry", reprint, The Textile Institute, Manchester 1978.
4. Hearle J W S, Thwaites J J and Amirbayat, "Mechanics of Flexible Fibre Assemblies", Sijthff and Noordhoff International Publishers BV, Alphen aan den Rijn, Netherlands 1980.
5. Journals: Textile Research Journal, Princeton, USA and Journal of Textile Institute, Manchester, UK

TTPC- 403 Statistical Quality Control in Textiles [3 1 0 4]

Course Outcomes

- CO1 Understanding of textile parameters and quality management
- CO2 Some basic concept of Analysis of Variance & Regression
- CO3 Apply basic statistical tools for data analysis
- CO4 Statistical process control process
- CO5 Utilize techniques for process improvement

Quality Management: Definition of quality and its importance, different approaches to quality, Description of Deming's fourteen points and Ishikawa's seven tools of quality, utility of statistical method for quality control and improvement, concept of Total Quality Management (TQM), ISO 9000 Standards, Quality Function Deployment (QFD) and Quality Costs.

Basic Approaches to Statistical Quality Control: Population and sample, descriptive and inductive statistics, discrete and continuous variables, subjective tests, collection and classification of data, frequency distributions, measures of central tendency, measures of dispersion, random variables and probability distribution, differences and applications of normal, binomial, Poisson's and other form of distribution.

Statistical Analysis for Continuous Function: Population and sampling distribution of mean, statistical estimation theory, points estimates, concept of single tail and double tail test, Student's t distribution, confidence limit, statistical decision theory, tests of hypotheses and significances, type I and type II errors, difference between two sample means. Test for single variance, Chi-square test, the F distribution, test for the difference between two variances, confidence limits for variance and ratio of two variances, choice of sample size.

Statistical Analysis for Discrete Function: Application of binomial and Poisson's distribution, normal approximation, test for a single proportion and difference between two proportions, application of χ^2 distribution, contingency table.

Subjective Tests: Rank correlation, tied rank, coefficient of concordance.

Acceptance Sampling: Basic idea about acceptance sampling, OC curve, producer's risk and customer's risk.

Control Charts: Advantages using quality control charts, random and assignable causes, action and warning limits, \bar{X} , R, \bar{p} , $n\bar{p}$ and \bar{c} chart, Process Capability Ratio (C_p and C_{pk}), concept of 6 sigma process control, brief idea about CUSUM and EWMA chart.

ANOVA and Regression: Some basic concept of Analysis of Variance, method of least squares, linear regression methodology, correlation and standard error.

Books Recommended:

1. Leaf G A V, "Practical Statistics for the Textile Industry", Part-I and II, The Textile Institute, U.K, 1984.
2. Montgomery D C, "Introduction to Statistical Quality Control", Fourth Ed., John Wiley and Sons (Asia) Pte. Ltd., Singapore, 2004.
3. Mehta P V, "Quality Management: An Overview", in 'Testing and Quality Management', Vol. 1, Ed. V K Kothari, IAFL Publication, New Delhi, 1999.
4. Spiegel M R and Stephens L J, "Schaum's Outlines Statistics", Third Ed., Tata McGraw Hill, New Delhi, 2000.
5. Walpole R.E. and Myers R.H., "Probability and Statistics for Engineers and Scientists", McMillan Publishing Company, New York, 1985.

TTPC-405 Mill Management and Maintenance [3 0 0 3]

Course Outcomes

CO1	Study of Plant location and site selection & layout
CO2	Humidification systems used in Textile Mills
CO3	Calculations of Machine balancing
CO4	Energy consumption in textile machines
CO5	To study measures of working environment & Maintenance management

Location and Layout: Plant location and site selection, Factors affecting location, Plant layout, Different types of layouts, Layout plan for spinning, weaving and process house.

Air conditioning and humidification: Psychrometric chart, various psychrometric processes, Humidification systems used in Textile Mills, Developments in humidification systems, Heat load, Calculations of total heat, air circulation required.

Machine Balancing: Calculation for different machines required for carded and combed yarns, weaving, preparatory and chemical processing.

Costing: Elements of cost, Cost sheet, costing the products, conversion cost, cost reduction techniques, impact of end breaks in ring spinning on productivity and cost.

Power consumption: Energy consumption in textile machines, Measures to reduce power consumption.

Working environment: Measures of good working environment, Different types of noise and remedial measures to minimize noise of different departments, terms related to lighting, illumination level required for different departments, lighting plan for different departments, Material handling equipments, Classification of material handling equipments, work load, work assignment, Time and Motion study, Accidents and safety engineering, Fire prevention and protection., Lean Manufacturing

Maintenance Management: Maintenance systems, Maintenance cost, Maintenance schedules, Maintenance scheduling, down time management, down time analysis, Total productive maintenance (TPM)

Books Recommended:

1. Dudeja V D, "Management of Textile Industry", Textile Trade Press, Ahmedabad, 1981.
2. Ormerod A, "Textile Project Management", The Textile Institute, ManchesterUK, 1992.
3. Talukdar M K, Sriramulu P K and Ajgaokar D B, "Weaving – Machine, Mechanism and Management", Mahajan Publisher Private Ltd., Ahmedabad, India, 1998.
4. Garde A R and Subramanian T A, "Process Control in Spinning", ATIRA Ahmedabad, 3rd edition, 1987.
5. Higgins, "Handbook of Maintenance Management", Prentice Hall New York, 1999.

TTPC- 407 Sustainable Textile Technology [3 0 0 3]

Course Outcomes

CO1	Understanding the importance of sustainable solutions for protecting the environment
CO2	Utilising the energy efficient processes to optimally utilize the scarce resources
CO3	Analyzing the need of the society to recycle and reuse the textile materials
CO4	Acquiring knowledge about effluent treatment techniques (ZDHC) for protecting the water sources

Introduction: Present scenario in various sectors of textile industries and its consequences on growth of industry. Sustainability and its significance in the pretext of textile industries Approaches to different forms of sustainable procedures, logistics systems, value chains and Green technology in textiles

Energy efficient processes: Various techniques to reduce wastage of energy. Ascertaining boiler capacity with production volume, Precautions to reduce wastage of steam and electrical energy.

Modified technologies for chemical processes: Modified technologies of colouration, Processing with low liquor ratio, Mass colouration of textiles, Continuous application techniques, Dyeing of blends, Bioprocessing of textiles, Controlled application techniques, Combination of various processes like, desizing - scouring, scouring – bleaching etc., Dyeing at room temperature, viz. vat, reactive and direct dyeing of cotton.

Waste reduction techniques: Need for solid and hazardous waste management in textile industry, types and sources of solid and hazardous waste management in textile industry Waste water management, Norms of using water in processing and discharge to public sewage. Various technical approaches to reduce waste water load. Analysis of effluent, Zero Discharge of Hazardous Chemicals (ZDHC)

Recycling of textiles and its waste: Life cycle of textile products, Recycling of polymer and fibre waste, Recycling of waste fibres and fabrics for nonwoven fabric production,

References

1. Youjiang Wang, “Recycling in Textiles”, Woodhead Publishing Limited, Cambridge 2006.
2. Sabit Adanur, “Wellington Sears Handbook of Industrial Textiles”, Technomic Publications Co. Inc., Lancaster, 2006.
3. Miraftab M and Horrocks R, “Eco-Textiles”, Woodhead Publishing Limited, Cambridge 2007.
4. Schindler W D and Houser P J, Chemical finishing of textiles, Woodhead Publishing Co, Chembridge, 2004
5. Smethwurst G, “ Basic water treatment”, IBT Publications, Delhi, 1989
6. Cavaco-Paulo A and Gubitz G M, *Textile processing with enzymes*, Woodhead Publishing, Cambridge, UK. 2003,
7. Nierstrasz V A and Cavaco-Paulo, *Advances in textile Bio-technology*, Woodhead Publishing, Cambridge, 2010
8. Gardetti, M.A., Torres, A.L. Sustainability in fashion and textiles: Values, Design, Production and Consumption, Greenleaf Publishing (latest edition). Pal, R.Managing fashion apparel value chains (latest edition).

8th Semester

TTPC- 402 Technical Textiles [3 0 0 3]

Course Outcomes

CO1	Identify diversified fields of application of Technical Textiles
CO2	Understanding factors influencing product performance of various technical textiles; Learn product design specific to fabric filter, geo-textiles, medical textiles and textiles in sports
CO3	Characterize products and their performance
CO4	Innovation in textile products

Introduction: Definition and scope for technical textiles, brief idea about technical fibres, role of yarn and fabric construction, composite material.

Filtration textiles: Definition of filtration parameters, theory of dust collection and solid liquid separation, filtration requirements, concept of pore size and particle size, role of fiber, fabric construction and finishing treatments.

Geotextiles: Brief idea about geosynthetics and their uses, essential properties of geotextiles, geotextile testing and evaluation, application examples of geotextiles.

Medical textiles: Classification of medical textiles, description of different medical textiles.

Protective Clothing: Brief idea about different type of protective clothing, functional requirement of textiles in defence including ballistic protection materials and parachute cloth, temperature and flame retardant clothing, chemical protective clothing, water proof breathable fabrics.

Sports and recreation textiles: Functional requirement of different type of product and their construction.

Automotive Textiles: Application of textiles in automobiles, requirement and design for different tyres, airbags and belts, methods of production and properties of textiles used in these applications.

Sewing threads, cords and ropes: Types, method of production and applications, functional requirements, structure and properties.

Other uses of technical textile: Functional requirements and types of textiles used for paper making, agricultural, electronics, power transmission belting, hoses, canvas covers and tarpaulins.

Books Recommended:

1. "Handbook of Technical Textiles", Ed. A R Horrocks and S C Anand, Woodhead Publication Ltd., Cambridge, 2000.
2. "Wellington Sears Handbook of Industrial Textiles", Ed. Sabit Adanaur, Technimic Publishing Company, Inc., Pennsylvania, USA, 1995.
3. "Geosynthetics in civil engineering", Ed. R W Sarsby, Woodhead Textiles Series No. 57, 2006,UK.
4. "Modern Textile Characterization Methods", Ed. M Raheel, Marcel Dekker, Inc., 1996.
5. Mukhopadhyay S K and Partridge J F, "Automotive Textiles", Textile Progress, Vol. 29, No. ½, 1999, Textile Institute, Manchester, UK.
6. Ukponmwan J. O, Mukhopadhyay A. and Chatterjee K. N., "Sewing Threads", Textile Progress, Vol. 30, No. 3/4, 2000, Textile Institute, Manchester, UK.

TTPC- 404 Mechanics of Textile Processes [3 1 0 4]

Course Outcomes

CO1	Mechanics of yarn preparatory processes
CO2	Mechanics of different machineries in a spinning line
CO3	Mechanics of different weaving preparatory processes
CO4	Mechanics of weaving processes
CO5	Design and developments of machines and process improvement based on textile process mechanics

Role of friction in textile processing: Elementary ideas of tuft opening; dust and foreign matter separation. Evaluation of Blow Room performance: Mechanisms of contaminant removal.

Theories of carding: Mechanics of fibre entanglement and hook formation during carding. Transfer mechanism of fibres, Cylinder load and transfer efficiency, Fibre configuration and estimation of degree of disorder, Effect of different parameters on hook formation, evaluation of carding performance.

Role of draw frame on yarn quality and process parameters: Hook straightening in roller drafting, Theories of roller drafting, Evaluation of draw frame performance.

Theoretical aspects of combing: Fractionation in combing, Parameters affecting combing performance and quality, evaluation of combing performance.

Mechanism of package building and twisting in speed frame: Evaluation of roving frame performance, Yarn tension in ring spinning, Balloon theory in spinning.

Mechanics of package building during winding, Performance of sensors, Splicing and yarn tension during unwinding, Yarn tension controlling devices, Cone angle and traverse in sectional warping, Stretch control in sizing, Weft package sloughing and its control. Kinematics of sley and heald motion, Shed depth and interference factor, Shedding cam design, Mechanism of picking, Shuttle retardation and its importance, Causes of pick variation, Cloth fell equation, Bumping condition.

Books recommended:

1. Booth J E, Textile Mathematics vol. 3 1st ed, The Textile Institute, Manchester 1975.
2. Chattopadhyay R, Advances in Technology of Yarn Production, 1st Ed, NCUTE, IIT Delhi 2002.
3. Winding, BTRA Monograph series, The Bombay Textile Research Association, Bombay, 1981.
4. Warping and Sizing, BTRA Monograph Series, The Bombay Textile Research Association, Bombay, 1981.
5. Marks R and Robinson A T C, Principle of Weaving, The Textile Institute, Manchester, 1986.

Departmental Electives (TTPE-XXX)

5th and 6th semester (TTPE-3XX)

TTPE-321 Post Spinning Operation [3 0 0 3]

Course Outcomes

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|-----|--|
| CO1 | Objective of post spinning operation |
| CO2 | Understanding operations involved in post spinning |
| CO3 | Concept of drawing and heat-setting |
| CO4 | Understanding process of production of bulk yarn |
| CO5 | Properties and applications of bulk yarn. |

Introduction: Introduction and objective of post spinning operation. Operations involved in post spinning.

Drawing: Introduction of drawing filament/fibre: Theoretical considerations of drawing, Concept of neck drawing, Prediction of neck formation, Significance and stabilization of neck, drawing unit, draw behavior of thermoplastic polymers. Influence of drawing parameters on structure and properties of fibres. High speed spinning and spin draw process, drawing of pre-oriented yarns and draw-warping.

Heat-setting: Introduction and concept of heat-setting, Objective of heat-setting, Different nature of set, Heat-setting behavior of fibres, Methods of heat-setting, Influence of heat-setting parameters on structure and properties of fibres, Settability and measurement of set.

Tow conversion: Introduction of Tow to Top conversion, Different methods for tow to top conversion.

Bulk yarn: Introduction of bulk yarn. Objectives of producing bulk yarns. Different methods of producing bulk yarns. Principles of manufacturing acrylic high bulk yarn. Concept and classification textured yarns. Different texturing methods and brief working principles of different texturing methods. Principles of false twist texturing. Material and Machine variables and their influence on the structure and properties of false twist textured yarn, Concept of air-jet texturing. Material and process variables in air-jet texturing and their influence on the structure and properties of air-jet textured yarns, Testing and evaluation of textured yarns, recent developments in texturing, Air entanglement process.

Books Recommended:

1. Gupta V B and Kothari V K, "Manufactured Fibre Technology", Chapman and Hall, London, 1999.
2. Vaidya A A, "Production of Synthetic Fibres" 1st Ed., Prentice Hall of India, New Delhi, 1988.
3. Hearle J W S, Hollick L and Wilson D K, "Yarn Texturing Technology", Woodhead Publishing Ltd., UK, 2002.
4. Goswami B C, Martindle J G and Scardino F L, "Textile Yarns Technology, Structure and Applications", Wiley-Interscience Publication, New York, 1976.
5. Mark H F, Atlas S M, Cernia E, "Man Made Fibre Science and Technology", 1st Ed., Vol. 1, 2, 3, Science Publishers, New York, 1967.

TTPE-322 Multi fiber Processes [3 0 0 3]

Course Outcomes

CO1	Processing of fibres of varying origin
CO2	Change on machine and process parameters in the existing line to process other fibres
CO3	The changes required to process blend in existing
CO4	Specific requirement to process a fibre other than cotton
CO5	Specific changes in the preparatory stage to process man-made fibres and their blends

Survey of the established practices for spinning of man-made fibres, Present practices and assessment of available methods of contaminant removal. Spinning line for short and long staple spinning. Fibre quality requirements for spinning. Humburger's theory. Assessment of blending at different stages of a spinning line. Development in bending machines. Conventional spinning system. Detailed study of the changes required in processing short and long staple man made fibres on cotton system. Spinning of dyed fibres. Aspects of Spinning of man- made fibres and wool on rotor spinning system. Spinning of micro fibres. Mellaenge and fancy yarn production. Processing of long fibres on woollen/worsted system. Silk reeling. Introduction and process sequence for jute spinning. Blending of jute. End use of jute and jute blended yarns and fabrics. End use of linen blended and linen yarn and fabrics. Production of manmade and their blends with modern spinning systems.

Books Recommended:

1. Salhotra K R, "Spinning of Manmades and blends on cotton system", 2nd Ed; The textile Association, India, 1989.
2. Lawrence C A, Fundamentals of Spun Yarn Technology, 1st Ed; CRC Press LLC, Florida, USA (2003)
3. Richards R T D and Sykes A B, "Manual of Textile Technology: Woollen Yarn Manufacture", The Textile Institute, Manchester 1994.
4. Chattopadhyay R, "Advance in Technology of yarn Production", 1st Ed; Nodal Centre for Upgradation of Textile Education, IIT, Delhi, 2002.
5. Atkinson R R, "Jute fibre to Yarn", 1st Amercian Edition; Chemical Publishing Co., INC., New York, 1965.

TTPE- 323 Marketing Management in Textiles [3 0 0 3]

Course Outcomes

CO1	Need, want, demand, production, product, selling, marketing and societal concepts of marketing
CO2	Analyzing marketing opportunities
CO3	Understanding the factors affecting consumer behaviour
CO4	Concept of Organizational Buying
CO5	Study of price, distribution & promotion mix of a product

Introduction: Need, want, demand, production, product, selling, marketing and societal concepts of marketing, types of goods. Various Textile Industry marketing practices in fibres, yarns, grey fabrics, finished fabrics and garments.

Marketing Process: Analyzing marketing opportunities, researching and selecting target markets, positioning the offer, designing marketing strategies, planning marketing program, organizing, implementing and controlling marketing efforts.

Consumer Behavior: Factors affecting consumer behavior, Buyer black box, stages in purchasing, buying roles

Marketing Research: Basic concepts, Marketing research process, market segmentation, target market selection, product research, Advertisement Research.

Organizational Buying: Salient features, factors affecting organizational purchase marketing mix, product, product levels, product hierarchy, product line, product mix, product life cycle, procedure for new product development, branding and packaging.

Price: Pricing objectives, price elasticity of demand, methods of pricing, discounts, discriminatory pricing.

Distribution: Need for middleman and their functions, vertical marketing system. Types of distributions, Channel management decisions, Frame work of Retailing in Textiles, career in retailing, types of retailers, and trends in retailing

Promotion Mix: Advertising, media selection, frequency and timing of advertisement, steps in developing effective communication, sales promotion, personal selling, publicity, Recruitment, training and motivating sales representatives, controlling and evaluating.

Books Recommended:

1. Kotler P, "Marketing Management", Prentice Hall of India, Delhi, 9th Edition, 2002.
2. Dudeja V D, "Management of Textile Industry", Textile Trade Press, Ahmedabad, 1981.
3. Barry Band Joel R.E. "Retail Management" Metmiiam Publishing Co., New York 1989.
4. Winer Russel S, "Marketing Management", Prentice Hall of India, 1998.
5. Guilitinan Joseph P, Gordon W Paul and Thomas J Maddaen, "Marketing Management: Strategies and Programs", Mc Graw Hill Publication, 1996.

TTPE-324 Costing and its Application in Textiles [3 0 0 3]

Course Outcomes

CO1	To understand the concept of elements of cost
CO2	To study the methods of cost estimation
CO3	To study various methods of valuing materials and labour
CO4	To understand the concept of overhead allocation and apportionment
CO5	To study various techniques for cost analysis and control

Costing as an aid to management-Elements of cost, treatment of stock, Cost terms related to income measurement, profit planning and cost control for textile industry.

Material cost - Costing of materials, Methods of valuing materials : FIFO, LIFO, Average cost method, Inflated price method, identification method, base stock method, HIFO, Market price method, Techniques of material control: Economic order quantity, Just in Time inventory system, stock control through ABC Analysis, VED analysis,

Labour cost – Types of labour, control of labour cost, labour turnover and turnover cost, Time and motion study, job analysis and job evaluation, Remuneration and Incentives, time wage system, Piece wage system

Overheads – Importance and classification of overheads, Allocation and apportionment of overhead to cost centres

Methods of costing – Job, Batch and contract costing, Process costing; waste cost and its control in a textile mill, Joint and by-product costing, Unit cost; costs of yarns and fabrics, fabric processing cost.

Techniques of cost analysis and control - Absorption and marginal costing, cost-volume-profit-analysis, break-even point, contribution margin, margin of safety, standard costing, budgetary control, productivity and value analysis,

Books Recommended:

1. Jain S P, Narang K L and Dhingra T R, “Cost Accounting”, 6th Ed., Kalyani publishers, N Delhi, 2000.
2. Khan M Y and Jain P K, “Cost Accounting and Financial Management”, Tata McGrawhill, Delhi, 2008.

TTPE- 325 Product Design [3 0 0 3]

Course Outcomes

CO1	Basic concepts and critical factors for textile product design
CO2	Basic elements and tools for conceptualization of textile product design
CO3	Textile product design analysis
CO4	Material selection for textile product design
CO5	Design requirement for specific textile product

Introduction, Characteristics of successful product design, Product development process tools, Understanding customer needs, Establishing product function and product specification, Concept generation, Concept selection, Concept testing, Product architecture. Design for manufacturing, Analytical and Numerical model solutions, Physical models and experimentation, Product design economics.

Book Recommended:

1. Otto Kevin, and Wood Kristin, Product Design Techniques in Reverse Engineering and New product Development Pearson Education publication, 1st Ed, 2006.

Ulrich K T, Product Design and Development, TMG, 3rd Ed, 2004.

TTPE-326 Advances in Chemical Processing[3 0 0 3]**Course Outcomes**

CO1	Study on Pretreatment of blends and Fastness determination of coloured textiles
CO2	To achieve knowhow on Controlled application techniques
CO3	Reduction in wastage of energy and waste water load
CO4	Process and quality control
CO5	Automation in dye houses

Combined pretreatment methods: Concept and basic criteria for combining pretreatment methods, combined desizing and bleaching, scouring and bleaching, desizing, scouring and bleaching of natural, manmade and blended textiles.

Controlled application techniques: Concept and importance of short liquor processing: advantages and limitations, Short liquor pretreatment, dyeing and finishing of textiles. Critical application value (CAV). Saturation removal and topical application methods. Performance assessment of each method.

Fastness determination: Significance of assessment of colourfastness. Fastness criteria of dyed and printed textiles. Grading and methods to determine fastness relating to washing, light, perspiration, sublimation and chlorine treatment.

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

Reduction in wastage of energy: Cold, low temperature and closed processes. Combined and short liquor methods. Continuous and batch machines as well as modified processes. Wet to wet methods without drying. Working with least liquor ratio.

Reduction in waste water load: Specification of water for use in industries and its discharge to public sewage, bio-degradation of chemicals. Waste water load generated from different sections of textile processing. Assessment of waste water load, Preventive measures to reduce this load.

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

Thermodynamic study of dyeing: Kinetic study of vat dye on cotton, acid dye on wool and nylon, Dyeing equilibrium and Langmuir isotherm. Concept of half time dyeing.

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

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

Shade reproduction and repetition: Theory and tristimulus values of colour, colour co-ordinates, Primary, secondary and tertiary colours. Surface colour strength, Analysis of shade for L a b values, Reproduction of shade. Colour difference and Pass-fail system

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

Books Recommended:

1. Bird C L and Boston W S, "The theory of coloration of textiles", Dyers Company Publication Trust, Bradford, England, 1975.
2. Manivaskaram N, "Treatment of Textile Processing Effluent", Sakthi Publications, Coimbatore, 1995.
3. Peters R H, "Textile Chemistry", Vol- III, Elsevier Scientific Publishing Co., New York, 1975,
4. Smethurst G, "Basic water Treatment", IBT Publications, Delhi, 1989.
5. Sule A D, "Computer colour analysis", New Age International (P) Ltd., New Delhi, 1997.

TTPE-327 Chemical Processing of Manmade Fibres and Blended Textiles [3 0 0 3]

Course Outcomes

CO1	Objective of blending and classification of blends
CO2	Technology of Pretreatment of blends
CO3	Technology of colouration of blends
CO4	Technology of printing of blends
CO5	Technology of finishing of blends

Introduction: Structural study of manmade fibres and their blends, Stability of manmade fibres against chemical treatment.

Classification of blends: Objectives of blending, Classification, compatibility of components in a blend.

Pretreatment of man- made and blends : Pretreatment of polyester, nylon, acrylic, acetate fibres and their blends, viz. singeing, desizing, scouring, bleaching, mercerizing and heat setting, Pretreatment machineries.

Dyeing of man makes: Dye-fibre attachment. Role of fibre structure in dyeing, Dyeing of polyester in HTHP, carrier, thermosol dyeing processes, Mechanism of carrier action. Dyeing of nylon with acid, metal complex, disperse, reactive and direct dyes. Dyeing of acrylic with disperse, acid and cationic dyes, Dyeing of differentially dyeable manmade fibres. Barre: definition and rating. Reasons for formation of barre and precautionary measures to be taken.

Dyeing of blends: Characterisation of blends, dyeing of primary, binary and ternary blends. Single bath, 1-bath 2-step and 2-bath 2-step methods to produce different shades. Reserve, cross, shadow and solid shades, Feasibility of producing various shades on different blends.

Printing of manmades and blends: Direct, resist and discharge styles of printing of polyester and its blends. Pigment printing, Carbonised prints. Transfer printing of polyester, nylon, acrylic and their blends.

Finishing of man-made and blends: Mechanical finishing of man makes. Optical whitening, anti-pilling and durable press finishes. Soil release, water repellent and flame retardant finishes on man makes and blends, Anti-stat finish.

Finishing of terry-woolen textiles: Crabbing, blowing, cropping, anti-felting, pressing and decatizing.

Books Recommended:

1. Nunn D. M, "The Dyeing of Synthetic Polymer and Acetate Fibres", Dyers Company Publication Trust, London, 1979.
2. Shore J, "Colorants and Auxiliaries", Vol- I and II, Society of Dyers and Colorists, Bradford, England, 1990
3. Gulrajani M.L, "Polyester Textiles", Book of papers: 37th National Textile Conference, The Textile Association (India), Mumbai, 1980.
4. Gulrajani M.L, "Blended Textiles", Book of papers: 38th National Textile Conference, The Textile Association (India), Mumbai, 1981.
5. Datye K.V and Vaidye A.A, "Chemical Processing of Synthetic Fibres and Blends", John Wiley and Sons, New York, 1984

TTPE- 328 Financial Management in Textiles [3 0 0 3]

Course Outcomes

CO1	To understand the concept of financial management
CO2	To understand the preparation and significance of financial statements
CO3	To be able to assess the financial position of a company through its financial statements
CO4	To analyse the various long term sources of finance
CO5	To understand working capital management

Introduction: Scope of finance, finance functions, financial manager's role, financial goals and firm's objectives.

Financial Statements: Accounting system, financial statements, Profit and Loss A/c and Balance Sheet, Use and importance of financial statements, Limitations of Financial statements.

Ratio Analysis: Meaning and nature of Ratio Analysis, Use and significance of Ratio Analysis Limitations of Ratio Analysis, Classification of ratio, Test for short-term financial position: Current liquid and Absolute liquid ratios, Efficiency and Activity ratios: Stock turnover, Debtor turnover Ratio, Average collection period, creditors turnover ratio, Average Payment Period, Test of solvency: Debt-Equity ratio, Equity ratio, Solvency ratio, and Net Worth ratio, Profitability ratios: Gross profit, Operating Expense, Net profit And operating profit ratios, Return on Investment and Earnings Per Share.

Statements of changes in Financial Position: Fund flow statement, Cash flow statement.

Sources of Finance: Classification of sources of finance, Security financing, Ownership securities, Equity Shares, Preference Shares, Deferred Shares, Debentures and Retained Earnings, Depreciation as source of funds, factoring, commercial banks, public deposits, lease financing and mutual funds.

Working Capital Management: Meaning, concept and classification of working capital, Needs and objectives of working capital, Disadvantages of Inadequate and redundant working capital, Principles of working capital management, Estimation of working capital requirements, Financing of working capital.

Control of Capital Issues: Securities and Exchange Board of India (SEBI), SEBI Act 1992,

Capital Budgeting: Introduction to investment, types of investment decisions, Factors affecting investment decisions Traditional techniques of capital budgeting: Payback Period and Average Rate of return methods, Modern techniques of capital budgeting: Net Present Value and Internal Rate of Return methods Capital Rationing.

Books Recommended:

1. Pandey, I M, "Financial Management", 8th Ed., Vikas Publishing House, New Delhi.
2. Sharma R K, Gupta, Shashi K, "Management Accounting", 9th revised edition, Kalayani Publishers, New Delhi.
3. James C Van Horne, "Financial Management and Policy", 11th edition, Prentice Hall of India
4. Fred R Kren, "Corporate Finance: Concepts and Policies", Blackwell Business, Oxford (U K)

TTPE-329 Advances in Yarn Manufacturing [3 0 0 3]

Course Outcomes

CO1	Sequential development in yarn manufacturing
CO2	Impact of a particular development
CO3	The properties of the product and its application area
CO4	The latest trend of development in product and machine
CO5	The status of different spinning technologies

A brief review of conventional spinning system. Fibre characteristics requirements for different leading spinning technologies, Role of fibre friction characteristics at different stages of spinning. Contaminants and its removal techniques. Possibilities and limitations of different spinning technologies. Principle and raw material preparation for rotor spinning. Specifications of different organs and effect of each on the process and product quality. New developments

Process and machine parameters affecting product quality. Principle of vortex yarn manufacture. Difference between air jet spun and vortex spun yarn structure. Principle and raw material preparation for friction spinning, Process and machine parameters affecting product quality. Assessment of DREF-II and DREF-III yarn structures and properties. Principle and raw material preparation for compact spinning and Eli-Twist spinning. Comparative assessment of the structure and performance of the yarns with respect to ring yarn. Principles of different converters. Self twist, twist less and warp spinning, Electrostatic spinning, Core spinning, Siro spinning, Bobtex yarn manufacture, solo spun yarn manufacture. Basic principles of textured yarn manufacture.

Books Recommended:

1. Salhotra K R and Ishtiaque S M, Rotor Spinning : Its advantages, limitations and prospects in India, 1st Ed; National Information Centre for Textile and Allied Subjects,1995.
2. Klein W, Manual of Textile Technology: New Spinning Systems, 1st Ed; The Textile Institute, Manchester, UK 1993.
3. Lawrence C A, Fundamentals of Spun Yarn Technology, 1st Ed; CRC Press LLC, Florida,USA (2003)
4. Chattopadhyay R and Ishtiaque S M, Advances in Yarn Manufacturing Process, Department of Textile Technology, IIT Delhi 1991.
5. Hearle J W S, Hollick L and Wilson D K, “ Yarn Texturing Technology”, Woodhead Publishing Ltd., UK, 2002

TTPE- 330 Advances in Fabric Manufacturing [3 0 0 3]

CO1	Problems associated with shuttle loom
CO2	Basic concept behind increasing the weft insertion rate
CO3	Study of projectile and rapier weaving machine
CO4	Weft insertion through air and water jet systems
CO5	Concept of Multiphase weaving and circular weaving

Preparation of Yarn for shuttle-less weaving: Winding, warping, sizing and weft preparation and drawing of warp yarn.

Problems of shuttle loom: Maximum speed of shuttle loom, design problem of shuttle loom, basic concept of increasing the weft insertion rate in weaving machine.

Techno-economics of shuttle-less weaving. Weft feeding in shuttle-less weaving.

Projectile Weaving Machine: Basic principle of projectile loom, sequence of weft insertion, cam drive shedding mechanism, beat-up, torsion bar picking, loom timing, checking of gripper, let-off and take-up motion, selvedge formation, Energy equation of torsion bar, velocity and acceleration of the projectile.

Air jet weaving machine: Problem in air jet weft insertion, Sequence of weft insertion in air jet loom. Design of confuser guide, design of profile reed and relay jet. Loom timing. Fabric fractional cover.

Water-jet Weaving machine: Weft insertion mechanism, quality of warp required for water jet, selvedge formation, environmental problem, quality of water, problem of water-jet loom.

Rapier Weaving Machine: Different types of rapier weaving machines, weft insertion sequence in rapier weaving process. Different methods to drive the rapier head. Single phase double acting rapier. Velocity of the rapier. Loom timing.

Multi phase Weaving Machine: Basic concept of multiphase weaving. shedding operation in warp way and weft way multiphase loom. Advantages and disadvantages of multiphase weaving process, circular loom, yarn path and weft insertion in circular loom.

Narrow Fabric Loom: Different type of narrow fabrics. Mechanism of weft insertion and fabric formation in narrow fabric weaving machine.

Carpet Weaving: Woven carpet, design and process of manufacturing Wilton and Brussel carpets technical specifications and its and uses.

Multi Axial Warp knitted Fabric: Fabric Structure, Properties and end uses

Books Recommended:

1. Marks R and Robinsons A T C, "Principles of weaving", Textile Institute, UK, 1986.
2. Lord P R and Mohamad M H, "Weaving: Conversion of Yarn to Fabric", Merrow Technical Library, UK, 1988.
3. Ormerod A, "Modern preparations and weaving machinery", Buttersworth and co., UK, 1983.
4. Talavasek O and Svaty V, "Shuttleless weaving machine", Elsevier Scientific Publishing Co., Amsterdam, 1981.
5. AdanurSabit, "Handbook of Weaving", CRC Press
6. Mk TalukdarPkSriramulu, DbAjgaonkar, "Weaving Machines Mechanisms Management", Published by Mahajan Publishers Pvt Ltd

Departmental Electives (TTPE-XXX)

7th and 8th Semester (TTPE-4XX)

TTPE-421 Characterization of Fibres and Polymers [3-0-0-3]

Course Outcomes

CO1	Concept of fibre forming polymers
CO2	Understanding various structural features of fibres
CO3	Knowledge of significance and measurement of molecular weight
CO4	Techniques for characterisation of fibre structure
CO5	Thermal analysis of fibres and polymers

Molecular weight and dimensions: Number average, weight average and other expressions of molecular weight. Different approaches of determination of molecular weight. Methods of determination of molecular weight, viz., end group analysis, osmometry, light scattering, viscometry, GPC. Characterisation of structure (different structural elements), techniques for characterisation of structure, e.g., Electron microscopy, IR spectroscopy, NMR spectroscopy, X-ray scattering. Thermal characterization: DSC, TGA, TMA, DMA.

Books Recommended:

1. "Polymers; Polymer characterization and analysis", ED., J I Kroschwitz, John Wiley and Sons, 1990.
2. "Thermal characterization of polymeric materials", Ed., E A Turi, Vol I and II, Academic Press, 1997.
3. "Text book of polymer science", Billmeyer F W, John Wiley and Sons, 1984.

TTPE- 422 Production Management [3 0 0 3]

Course Outcomes

CO1	Basic concepts of managing operations
CO2	Concept of inventory and enterprise resource planning
CO3	Study of Location and layout
CO4	Basics of work study and time study
CO5	Different types of machine and labour productivity.

Managing Operations: Historical evolution of production and operations Management, strategic role of operations, trends in operations Management, process and control of operations strategies.

EnterpriseResource Planning: What ERP does, ERP Applications, ways to use ERP.

Planning and Conversion System: New product Design, Developing New products and processes.

Location and Layout: Need for location planning, general procedures for facility location, Free trade and location alternatives, layout concepts, developing the different types of layouts.

Inventory Management: Inventory concepts, inventory reduction tactics, ABC analysis, EOQ, P and Q systems.

Resource Planning: Overview of material requirement planning, Benefits of MRP, outputs of MRP.

Work Management: Basics of work study and time study.

Productivity: Different types of machine and labour productivity.

Books Recommended:

1. Raymond R Mayer, “Production and Operations Management”, Tata McGraw Hill, 3rd Edition, 1989.
2. Asawathappa K and Shridhara Bhat, “Production and Operations Management”, Himalaya Publishing House, 1999.
3. Buffa S E and Sarin R “Modern Production/ Operations Management”, John Wiley and Sons, Delhi, 1995.
4. Selvan R P, “Production and Operation Management”, Prentice Hall India, New Delhi, 2002.
5. Ahuja K K, “Production Management”, CBS Publishers and Distributors, Delhi, 1998.

TTPE-423 Textile Structural Composites [3-0-0-3]

Course Outcomes

CO1	Introduction to fibres for high performance composites
CO2	Influence of fibre architectures on the properties of composites
CO3	Concept of reinforcing materials
CO4	Mechanism of stress transfer in a composite and its mechanical properties
CO5	Concept of composites for structural engineering and application

Introduction to fibres for high performance composites: Influence of fibre architectures on the properties of composites, Unidirectional, planar, 3D and net-shaped performing, Introduction to matrix types and their properties, Polymeric matrices for rigid and flexible composites,

Reinforcing materials and the effect of their geometry on the properties of composites, the Fibre-matrix interface; role of coupling agents, Mechanism of stress transfer, Toughness and Thermal behavior of composites, various techniques of composites design and fabrication, Composites for structural engineering, electrical, civil, aerospace, defense, automobile, Sporting goods and other applications, Basic design and analysis of textile structural composites.

Books Recommended:

1. Reinhart T J, “Introduction to Composites”, in Engineering Materials Handbook, Vol. 1, Composites, ASM International, 1993.
2. Chau T, and Ko F K, eds., “Textile Structural Composites”, Elsevier, 1989.
3. Russell Diefendorf, “Carbon/Graphite Fibers”, in Engineering Materials Handbook, Vol. 1, Composites, ASM International, 1993.
4. Adanaur S, “Textile Structural Composites”, in Handbook of Industrial Textiles. ed. S Adanaur, Technomic Publishing Co., USA, 231-274.

TTPE-424 Waste Management and Pollution Control in Textile Industry [3 0 0 3]

Course Outcomes

CO1	Generation, classification, re-use and management of spinning/weaving waste
CO2	Textile waste water characteristics
CO3	Effect of waste-water on sewage and land
CO4	Chemical used in textile industry
CO5	Treatment of textile effluents & Effluent Testing

Spinning waste: Its generation, classification, its re-use and management, Soft waste, hard waste, different types of pollution in spinning industry.

Weaving waste: Its generation, different types, its re-use and management. Different types of pollution in weaving industry. Its impact on human being.

Waste water load: Chemical nature of discharged bath after each process, contribution of chemicals to the waste water load. Concept of biological and chemical oxygen demand. Effect of waste-water on sewage and land. Toxicity of various chemicals, viz alkalis, oxidizing and reducing agents, acids, carriers, resins and bleaching agents etc, Role of each chemical on waste water load.

Treatment of textile effluents: Primary, secondary and tertiary treatments in ETP. Colour removal, various chemicals used in ETP.

Effluent Testing: Testing of BOD, COD, TOC and interpretation of results.

Books Recommended:

1. Asolekar S, "Environmental problems in chemical processing of textiles" 1st Ed. NCUTE, Department of Textile Technology, IIT-Delhi, 2000.
2. Padma Vankar, "Textile Effluents" 1st Ed. NCUTE, Department of Textile Technology, IIT-Delhi, 2002.
3. Edmund B, "The Treatment of Industrial Wastes" 2nd Ed. McGraw-Hill Kogakusha, New Delhi, 1976
4. Peavy, Rowe and Tchobanoglous, "Environmental Engineering" 2nd Ed. McGraw-Hill, Singapore, 1985.
5. Vaidya A A, "Production of Synthetic fibres", Prentice-Hall India Ltd, New Delhi, 1988.

TTPE-425 Apparel Marketing and Merchandising [3 0 0 3]

Course Outcomes

CO1	Knowledge of domestic and International marketing
CO2	Skill of Merchandising, Merchandise forecasting, Planning and Budgeting.
CO3	Study of Export houses, start trading export houses and Outsourcing.
CO4	Setting up the dealers and merchandisers.
CO5	Other knowledges of product promotion, advertising and sale promotion of apparels.

Marketing: Domestic and International marketing, challenges for international marketing, Development of a product line, design, costing, developing a sample, specifications, market research, identification of markets, promotion mix, advertising, sale promotion, promotion budget, coordination between sales and production,

Merchandising: Export houses, star trading export houses, Outsourcing, Merchandise buying and handling process, Merchandise plans, determining merchandise sources, demand analysis, evaluating merchandise, merchandise forecasting and budgeting, planning inventory levels, development of relationship between the textile and retailing industry, setting up the dealers and merchandisers

Books Recommended:

1. Kotler Philip, “Marketing Management”, Prentice Hall of India, Delhi, 9th Edition, 1998.
2. Bheda R, “Managing Productivity in the apparel Industry”, Communications, New Delhi, 2000.
3. Cooklin G, “Introduction to Clothing Manufacture”, Om book service, New Delhi, 2002.
4. Mehta P V and Bhardwaj S K, “Managing Quality”, New Age International, New Delhi, 2001.
5. Rosenau J A and Wilson D L, “Apparel Merchandising”, Amazon, USA, 2001.

TTPE-426 Project Formulation and Appraisal [3 0 0 3]

Course Outcomes

CO1	Physical understanding of textile process
CO2	Modeling of carding process
CO3	Modeling of draw frame and ring frame
CO4	Modeling of weaving and knitting process
CO5	Project Review and Administration

Industrial ownerships – Proprietor/Single ownership, Partnership (General and Limited), Joint Stock Companies (Private Limited and Public Limited), Public Sector Undertakings, Cooperative Societies

Project Planning – Capital expenditure, phases of capital budgeting, generation and screening of project ideas, project rating index, resource allocation framework.

Project Analysis - Feasibility study, product life cycle, market analysis, market planning, market survey and characterisation of markets, demand analysis, demand forecasting, technical analysis, project charts and layouts.

Financial analysis – Time value of money and cost of capital, Cost of project, sources of finance, projected financial statements, working capital requirement, estimate of sale and production, cost of production, cash flow.

Appraisal criteria – net present value, benefit cost ratio, internal rate of return, payback period, analysis of risk and social cost benefit analysis.

Project implementation - Network techniques, PERT, CPM. Project Review and Administration.

Books Recommended:

1. Jain S P, Narang K L and Dhingra T R, “Cost Accounting”, 6thEd., Kalyani publishers, N Delhi, 2000.
2. Kerzner H, “Project Management” 1st Ed., CBS Publishers and distributors, Delhi, 1987.
3. PrasanaC, “Projects- Planning, Analysis, Selection, Implementation and Review”, 6th Ed., Tata Mc Grawhill Publishing Co. Ltd., N. Delhi, 1996.
4. Ormerod A, “Textile Project Management”, The Textile Institute, ManchesterUK, 1992.

TTPE-427 Textile Process Simulations and Modeling [3 0 0 3]

Course Outcomes

CO1	Physical understanding of textile process
CO2	Modeling of carding process
CO3	Modeling of draw frame and ring frame
CO4	Modeling of weaving and knitting process

Introduction: Understanding process simulation and modeling and its usefulness in textile processes.

Simulation techniques: Different simulation techniques, mathematical modeling, concept of fuzzy model, artificial neural network, expert system, Combination of different systems, comparison of different techniques.

Yarn manufacturing: Simulation of fibre properties, carding process, drafting, yarn formation, package building, balloon theory.

Fabric manufacturing: Modeling of weaving and knitting and stitching process, monitoring of online process performance.

Fabric properties: Modelling of fabric low stress properties.

Books Recommended:

1. "Computers in the World of Textiles", Paper presented at the Annual World Conference, Hong Kong, September 26 – 29, 1984.
2. Textile Research Journal, Princeton, USA and Journal of Textile Institute, Manchester, UK.
3. Hearle J W S, Thwaites J J and Amirbayat, "Mechanics of Flexible Fibre Assemblies", Sijthff and Noordhoff International Publishers BV, Alphen aan den Rijn, Netherlands 1980.
4. Haykin S, "Neural Networks: A comprehensive Foundation", MacMillan, New York, 1994.
5. Fausett L, "Fundamentals of Neural Networks: Architectures, Algorithms and Applications", Prentice Hall International, New York, 1994.

TTPE- 428 Woollen Technology [3 0 0 3]

Course Outcomes

CO1	Long staple spinning
CO2	Process parameters that influence quality
CO3	Differentiate with other spinning technologies
CO4	Product range and application area
CO5	Quality control

Wool fibre and its properties: Morphological structure, components of fibre, fibre diameter, fibre contour, crimp, length, luster, specific gravity and refractive index, moisture relations, wet ability, fibre mechanical properties, gross composition of raw wool, molecular structures.

Manufacturing wastes: Noils, soft wastes, hard wastes, finishing wastes, recovered wools, method of recovery, rag picking and garneting.

Wool blends with manmade fibres: Purpose of blending, effect of blend composition on performance of fabrics.

Woollen or carded Yarns: Preliminary processes, blending or mixing, oiling of the stock, woollen carding, woollen spinning, yarn number and wool grade.

Worsted top making and spinning of worsted yarn: Worsted carding, backwashing, oiling, gilling or preparing, worsted combing, tow-to-top conversion systems, worsted drawing, worsted yarn spinning, norms and modern developments.

Manufacture of woollen fabrics: Woven Fabrics produced by projectile and rapier weaving machines, knitted and nonwoven woollen fabrics, use of FAST in worsted garment manufacturing.

Chemical Processing of wool: Objectives. Carbonization of wool in batch and continuous methods of scouring fibre, yarn and fabric; peroxide and per-acetic acid bleach of wool; production of anti-shrink wool, basic principle of treatment and parameters; dyeing, printing and finishing, testing and quality control of woollen processing.

Wool Dyeing: Chemistry of dyeing wool and blend with acid, mordant, metal-complex and reactive dyes, Top and tip dyeing of wool.

Wool Finishing: Scooping, damping, decatizing and paper pressing of wool, Testing and Quality Control.

Books Recommended:

1. Blended Textiles, Textile Association (India), 1981.
2. Lepenkov Y, "Wool Spinning", Vol. 1 and 2, 1st Ed. Mir Publisher, Moscow, 1983.
3. Bergen W V, "Wool Handbook," vol.1 and 2, 3rd Ed., Interscience publisher, London.
4. Teasdale D C, "The Wool Handbook", 4th Ed., 1996.
5. Trotman E R, "Dyeing and Chemical Technology of Textile Fibres", Charles Griffin and Co. Ltd., London, 1975

TTPE-429 Intelligent and Functional Textile [3 0 0 3]

Course Outcomes

CO1	Basic concept of smart and intelligent textiles
CO2	Phase change materials and their applications
CO3	Concept of extreme winter clothing and other environment sensitive textiles
CO4	
CO5	Exposure of Breathable textiles
	Recent advances in multifunctional textiles

Definition of smart and intelligent textiles, Passive and active functionality, Textile with high protection and comfort properties, Extreme winter clothing with low heat transmission, heat absorbing, heat storing systems. Phase change materials, incorporation of PCMs in fibres and fabrics. Breathable textile. Multifunctional textiles with incorporated electronics for integrated communication, music, health monitoring, defence support functions, wearable computers. Environmentally sensitive textiles- photochromic and thermochromic (chameleonic) fabrics, camouflage (radar shielding) fabrics, variable heat absorption surfaces, stimuli sensitive polymers such as temperature, pH, ionic, magnetic sensitive materials, design and their applications to textile. Fibres as solar cells, Recent advances in multifunctional textiles.

Books Recommended:

1. X. Tao, Xiaoming Tao ,” Smart Fibres, Fabrics, And Clothing”, Woodhead publishing (2001).
2. Jinlian Hu , “Adaptive and Functi polymers, Textiles and Their Applications”, imperial college press (2011).
3. Tao Xiaoming, “Wearable Electronics And Photonics”, Woodhead publishing limited (2005).
4. H. Mattila, H. Mattila, “ Intelligent Textiles and Clothing”, CRC press (2006).
5. Vincenzini, “Smart Textiles”, Trans tech pub ltd (2009).

TTPE-430 Quality Control in Textile Chemical Processing [3 0 0 3]

Course Outcomes

CO1	Exposure on quality control and its importance in TCP
CO2	Recipe and quality control parameters of pretreatment processing
CO3	Testing of chemicals, auxiliary and fabric quality and properties
CO4	Printing paste recipe, different methods and style of printing and their control parameter
CO5	Various finishes and their control parameters

Reviewing various areas of chemical processing of textiles, viz. pretreatment, dyeing, printing and finishing.

Pretreatment: Optimized process parameters imparted to textiles in pretreatment and quality of products obtained, viz. singeing, desizing, scouring, bleaching, mercerization, Assessment of quality of pretreated product after each stage.

Colouration: Optimized dyeing parameters for dyeing of natural, manmade and blended textiles with different dyes and quality of product, Quality printing in various styles and methods.

Finishing: Optimized finishing parameters to impart various finishes on different fibres. Process parameters / process modification / any other changes. Change in quality due to selection of impure chemicals / faulty fabric / machine handling. Methods to assess quality of processed product after every stage of processing and that of final product. Standardization of instruments / machineries, analysis of colour to check impurity percentage, evaluation of chemicals to check their efficiencies.

Books Recommended

1. Gokhale S V and Modi J R, “*Process and Quality Control in Chemical Processing of Textiles*”, ATIRA, Ahmedabad, 1992.
2. Doshi S M and Shah H A, “*Quality and Process Control*”, Chemical Processing Tablet IX, The Textile Association Education System, Ed. P C Mehta, The Textile Association (India), 1984.
3. Karmakar S R, “*Chemical Technology in the pretreatment processes of Textiles*”, Textile Science and Technology Series, Vol-12, 1st Edition, Elsevier (1999).
4. Peters R H, “*Textile Chemistry*”, Vol- III, Elsevier Scientific Publishing Co., New York, 1975.
5. Datye K.V and Vaidye A.A, “*Chemical Processing of Synthetic Fibres and Blends*”, John Wiley and Sons, New York, 1984.

TTPE- 431 Advancement in Manmade Fibres [3 0 0 3]

Course Outcomes

CO1	Structural principles of fibre forming polymers
CO2	Influence of process variables in melt spinning
CO3	Concept of high speed melt spinning
CO4	Melt spinning of speciality fibres and after finishes
CO5	Concepts of other techniques of fibre production

Structural principles of fibre forming polymers. Development of fibre structure during man-made fibre spinning. Variables in melt spinning.

High speed melt spinning: One step and two step spinning. Recent developments in melt, dry and wet technology. Various types of spinneret profiles. Mechanism of crystallization during MMF spinning.

Melt spinning of Hollow, multicomponent, Ultra fine and Nano fibres.

Spin finish application: Composition of spin finish, various methods of spin finish application, spin finish for staple fibre and textured yarns.

Technology of drawing of synthetic fibres, detailed study of mechanism of heat setting of synthetic fibres. Study of property changes in synthetic fibres during heat setting.

Simulation in melt spinning for fibre production. Process control in man-made fibre spinning.

Books Recommended:

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", Chapman and Hall, London, 1999.
3. "Hand Book of Fibre Chemistry", Ed. M Lewin and E M Pearce, Mercel Dekker Inc., 1998.
4. Hearle J.W.S., High Performance Fibres, Textile Institute, Woodhead Publishing, 2001
5. Mukhopadyay. S.K, "High Performance Fibres", Textile progress Vol. 25, Textile Institute Manchester, 1993.

TTPE-432 Application of Operations Research in Textiles [3 0 0 3]

Course Outcomes

CO1	Concept of research and managerial decision making
CO2	Optimization technique, primarily LPP
CO3	Scope of operations research in textile in textile operations
CO4	Transportation and assignment problems and the optimization techniques
CO5	Concept of inventory management

Operation research - Introduction, historical development, phases of operation research study; Linear programming; simplex method; Application of LPP in yarn production; Transportation problem and its application in textile production; Methods of finding an initial solution, degeneracy, optimum solution; Assignment problems, variation in assignment problems, queuing theory. Inventory management techniques- selective inventory control: ABC analysis, economics order quantity, ordering cost, acquisition cost, inventory carrying cost or holding cost, just in time, information systems for inventory management, store management and merchandising, make or buy decision, analysis of investment in inventory, value analysis and material management; Enterprise resource planning.

Books Recommended:

1. Heera D S and Gupta P K, "Operation research", 1st Ed., S Chand and Co., Delhi, 1997.
2. Taha H, "Operation research", 6th Ed., Prentice Hall of India, Delhi, 1997.
3. Verma A P, "Operation research", 1st Edition, S K Kataria and Sons, Delhi, 1998.
4. Menon K S, "Purchasing and inventory control", 3rd Ed., Wheeler Publishing House, N. Delhi, 1997.
5. Ahuja K K, "Production management", 1st Ed., CBS Publishers and Distributors, Delhi, 1998.
6. Christopher M, "Logistics and supply chain management", Pitman Publishing, UK, 1992.

TTPE - 433 Clothing Science and Engineering [3 0 0 3]

Course Outcomes

CO1	Study of development of textile products emphasizing garment comfort
CO2	Through clothing science with Current trends and new developments
CO3	Study of clothing including new materials and finishes
CO4	Study of new techniques and new concepts
CO5	Study of clothing behaviour with respect to kinesthetic and somesthetic

Factors involved in the study of clothing: the balance needed for comfort; boarder aspects of comfort; nonthermal components of comfort; environmental ranges and corresponding clothing.

Heat and moisture relations in clothing: approaches for studying heat and moisture exchange in clothing systems; heat and moisture factors in clothing as worn; heat and moisture transmission properties of clothing materials.

Physical properties of clothing and clothing materials in relation to comfort : thermal transmission or resistance; water vapor diffusion resistance ;water transport in clothing materials; water holding properties ;thickness of clothing materials; surface properties of fabrics; porosity and permeability properties; flammability of clothing materials; stiffness and bending properties etc.

Current trends and new developments in the study of clothing: new materials and finishes; new techniques and new concepts.

Books Recommended:

1. Lyman Fourt and Norman R.S. Hollies, "Clothing Comfort and Function", Marcel Dekker, INC., New York, 1971

2. Kothari, V K, "Testing and Quality Management ", CBS Book Publishers, New Delhi, 2000.
3. Zhang Wei Yuan, "Clothing Comfort and Function", China Textile Press, 2011
4. Saville B P, "Physical Testing of Textiles," The Textile Institute, Woodhead Publication Limited, Cambridge, 1999.

TTPE-434 High performance fibres [3 0 0 3]

Course Outcomes

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|-----|--|
| CO1 | Basic concept of high performance fibres |
| CO2 | Understanding the structural features of high performance fibres |
| CO3 | Manufacturing processes of high performance fibres |
| CO4 | Knowledge of common high performance fibres |
| CO5 | Applications of other high performance fibres |

Basic concept of high performance fibres; Hi -Performance Gelspun Polyethylene fibres- Manufacture fibres characteristics, properties and applications; Aramids- Introduction, polymer preparation, Spinning, Structure and properties, applications.

Carbon Fibres- Introduction, production, Physical properties of Rayon based, PAN based and Pitch based Carbon fibres.

Applications: Glass Fibres- Fibre manufacture, fibre finish, fibre properties and application. Vectran (Melt spun wholly aromatic polyester fibre) Fibre production; properties and application, PBO (Polyphenylene benzobisoxazole) fibres- Fibre production, properties and application. PEEK Fibres -Fibre production, properties and application.

Books Recommended:

1. T. Hongu, New fibres, Ellis Horwood, New York 1990.
2. Lewis. E .M. Pearce, J .Preston, Hand book of fibre science and technology Vol-4, , Marcel Dekkar, New York 1989.
3. Donnet J. B. Bansol R .C Carbon fibres , Marcel Dekkar, New York 1990.
4. Hearle J.W.S., High Performance Fibres, Textile Institute, Woodhead Publishing, 2001.
5. Mukhopadyay. S.K, "High Performance Fibres", Textile progress Vol. 25, Textile Institute Manchester, 1993

TTPE 436 Advancement in Textile Testing [3 0 0 3]

Course Outcomes

- | | |
|-----|--|
| CO1 | New approaches to textile measurements |
| CO2 | Innovations in yarn testing instruments and fabric testing |
| CO3 | Tests related to garment appearance and performance |
| CO4 | Testing of technical textiles |
| CO5 | International quality parameters and standards |

Fiber, Yarn and Fabric Testing: New approaches to textile measurements, Innovations in yarn testing instruments (dynamic, continuous and on-line testing of yarn quality) and fabric testing, Assessment of comfort, Standard tests, analysis of data and test reports such as HVI, AFIS, Classimat, Colour matching, Analysis of KES and FAST data.

Testing of Garments: Tests related to garment appearance and performance such as measurement of seam pucker, seams slippage, seam strength and buffer strength etc.

Testing of Technical Textiles: Testing of Filtration Characteristics, Test for geotextiles, Test for protective clothing, Test of various form of medical textiles, Test for textiles for sports application, Test for Composites, Testing for sewing threads, industrial cords etc, Special tests for carpets and nonwoven fabrics.

Product Leveling and Standards: Textile product leveling. International quality parameters and standards like Uster standards, AITCC, JIS and ASTM.

Books Recommended:

1. Saville B P, "Physical Testing of Textiles", Woodhead Publishing Ltd, Cambridge, 2002.
2. Booth J E, "Principles of Textile Testing", CBS Publishers and Distributors, New Delhi, 1999.
3. Fabric Testing, Ed. J Hu, Woodhead Textiles Series No. 76, 2008, UK.
4. "Testing and Quality Management", Ed. V. K. Kothari, IAFL Publications, New Delhi, 1999.
5. Mukhopadhyay A, "Process Characterization and Evaluation of Filter Media" in "Pulse-Jet Filtration: An Effective Way to Control Industrial Pollution -Part II", Textile Progress, 42 (1), Taylor and Francis, UK., 2010.

TTPE- 437 Bioprocessing of Textiles [3 0 0 3]

Course Outcomes

CO1	Ecological issues associated with chemical processing of textiles
CO2	Chemical properties and characterization of enzymes
CO3	Classification and selection of enzymes for specific textile use
CO4	Performance of an enzyme or enzyme combination in textile processing
CO5	Immobilization of enzyme and its performance over conventional application

Introduction: Environmental problems caused by conventional processing of textiles, viz. singeing, desizing, scouring, bleaching, dyeing and finishing.

Chemistry of Enzymes: Concept and classification of enzymes. Chemistry of different enzymes, viz. lipase, catalase, protease, Cellulase, pectinase, trans-glutaminase etc and their mechanism of working in textile processes and fibres.

Biopolishing of textiles: Significance, process and influencing parameters. Bio-processing of cotton fabric using different varieties of cellulases and their comparative performance. Bio-washing of denim, related problems of backsaining and precautionary measures to reduce it. Biopolishing of wool using proteolytic enzymes/

Bio-desizing: Enzymatic desizing with amylase. Mechanism of removal of starch with amylase, enzyme inactivation

Bio-scouring: Application of different enzymes in scouring, viz. lipase, pectinase, protease and their working on various impurities during scouring. Assessment of bio-scouring efficiency, viz. absorption, copper number, methylene blue absorption, fluidity etc.

Bio-bleaching: A review of peroxide and peracetic acid bleaching. Application of glucose-oxidase for bleaching of cotton and protein fibres. Influence of catalase on peroxide stability. Bleaching with laccase. Evaluation of bleaching efficiency.

Colouration with enzymes: Properties of enzymes towards influencing dyebath activity. Enzymatic reduction of vat and sulphur dyes. Concept of reduction potential of bath and its influence on reduction of dye and dye uptake. Dyeing of denim with indigouising enzyme as reduction catalyst. Acid dyeing of wool with protease, problem of degradation and recovery using trans-glutaminase. Simultaneous dyeing and bio-polishing of textiles. Dyeing with natural colours.

Bio-Finish: Finishing of textiles with natural herbs, materials and products. Aloe vera, neem etc extract finishing.

Anti-shrink finish on wool: Action of proteolytic enzymes on anti-felting property of wool, degradation of wool and recovery using transglutaminase.

Application techniques of enzymes: Performance gap in free and immobilised enzyme application and the reason thereof. Technology of immobilisation of enzymes and suitability of different support systems for efficient applications

Books Recommended:

1. Cavaco-Paulo A and Gubitz G M, *Textile processing with enzymes*, Woodhead Publishing, Cambridge, UK. (2003),
2. Nierstrasz V A and Cavaco-Paulo, *Advances in textile Bio-technology*, Woodhead Publishing, Cambridge, UK (2010)

Open Electives

TTOE- 451 Polymers and Fibre Science [3-0-0-3]

Course Outcomes

CO1	Introduction about polymer and fibre forming polymers
CO2	Concept of structure of polymers
CO3	Concept of various polymerization processes
CO4	Concept of common polymer fibres
CO5	Applications of fibres

Introduction: Introduction about polymer. Differences between low molecular weight material and high molecular weight material. Specific features of high molecular weight materials.

Structure of polymers: Specific features of polymer structure, i.e., regularity and irregularity; molecular weight and size; Configuration and conformation of molecules; Determination of molecular weight and effect of molecular weight on the structure and properties of polymer; Concept of rubbery state and rubber elasticity; Transition from glassy to rubbery state; Melting of polymers; Factors influencing T_g and T_m of polymers; Basic concept of methods of investigation of polymer structure.

Polymerisation: Different methods of polymerization; Basic concept of bulk, solution, suspension and emulsion polymerisation.

Fibre: Introduction about fibre, special features of fibre / fibre forming polymers. Different processes for conversion of polymer to fibre. Basic understanding about common synthetic

fibres ,e.g, Polyester, Nylon, Acrylic; Concept of high performance fibre; Introduction and use of Aramids, Carbon, Glass etc.

Introduction about application of fibres in Mechanical (Composite); Civil (Geotextile), Electronics (E-textile) etc.

Books Recommended:

1. Billmeyer W, “Textbook of Polymer Science”, John Wiley and Sons, New York, 1994.
2. Gowariker V. R, Viswanathan N.V and and Sridhar J, “Polymer Science”, New AgeInternational Ltd. Publishers, New Delhi, 1996.
3. Hearle JWS, “Polymers and their properties”, Vol.I, John Wiley and Sons, NY, 1982.
4. Gupta V B and Kothari V K, “Manufactured Fibre Technology”, Chapman and Hall, London, 1999.
5. High Performance fibre Hand book of fibre science andTech.

TTOE-452 Properties of Polymer and Fibers [3 0 0 3]

Course Outcomes

CO1	Exposure of polymer structure of various fibres
CO2	Structure investigation by different analytical methods
CO3	Idea of moisture, tensile and dielectrical properties of polymers and fibres
CO4	Knowledge of thermal, static and friction behaviour of polymers and fibres

Fiber structure: Traditional view of fibre structure; Chemical structure and physical structure; Degree of order and degree of orientation.

Structure investigation: Methods of investigation of fibre structure; Identification of chemical structure by IR spectroscopy; Identification of physical structure by X-ray, SEM, NMR.

Moisture absorption: Definitions of humidity, moisture regain and moisture content; Relation between regain and relative humidity; Effect of stress and temperature on regain; Heat of sorption; Swelling of fibres; Quantitative theory of moisture absorption.

Tensile properties: Factors influencing results of tensile experiment; Expressing results; Different experimental methods; Effect of variability; Elastic recovery; Effect of test conditions on recovery; Cyclic testing. Fibre fracture and fatigue; Time effect. Creep and stress relaxation; Introduction to dynamic testing and fatigue; Concept of models; Kelvin and Maxwell model; Bending and torsional rigidity of fibre; Structural effect on extension behaviour.

Dielectric properties: Definition and effect of different parameters on dielectric properties; Electric resistance and effect of different factors on the electrical resistance of fibres;

Static electricity: Introduction and significance; Measurement of static electricity; Explanation of static phenomena.

Optical properties: Refractive index and birefringence; Birefringence and orientation of fiber; Reflection and lustre.

Thermal properties: Structural changes on heating; Thermal transitions; Concept Heat setting of fibres.

Fibre friction: Technological importance; Measurement of friction; Effect of load and area of contact; Static and kinetic friction; General theory of friction and application to fiber.

Books Recommended:

1. Meredith R, "The Mechanical Properties of Textile Fibres", North Holland Publishing Co; Amsterdam 1959.
2. Morton W E and Hearle J W S, "Physical Properties of Textile Fibres", 1st reprint, The Textile Institute, Manchester, 1986.
3. Gupta V B and Kothari V K, "Manufactured Fibre Technology", 1st Ed., Chapman and Hall, London, 1997.
4. Hearle JWS, "Polymers and their properties", Vol. I, John Wiley and Sons, NY, 1982.
5. Gedde U W, "Polymer Physics", Chapman Hall, London, 1995.

TTOE-453 Textile Machines and processes [3 0 0 3]

Course Outcomes

CO1	In this course the fundamental knowledge of textiles different textile product
CO2	Study of product specifications and their quality parameters
CO3	Classification of different textile industries, 4. Basic concept of textile fiber, filament, yarn and fabric
CO4	Basic concept of textile fiber, filament, yarn and fabric
CO5	Focusing the conversion of fibre into garment is being emphasized with relevant involvement of mechanical and chemical processes, products and machineries.

Introduction: Different textile products, product specifications and their quality parameters, classification of textile industries, basic concept of textile fibre, filament, yarn and fabric, flow of material from raw material to the finished product.

Textile machine for fibre spinning: Concept of fibre spinning, machines involved in fibre production.

Yarn manufacturing: Machines for opening and cleaning, drafting stages, twisting and winding, package formation.

Fabric manufacturing: Mechanics of weaving process, weaving machineries, development of machines, basic concept of knitting process and machines, classification of nonwoven fabrics, method of manufacturing of nonwoven fabrics.

Dyeing, printing and finishing: Basic concept of dyeing, printing and finishing, machineries involved in the process.

Books Recommended:

1. Rose Sinclair, Textiles and Fashion: Materials, Design and Technology, Woodhead Publishing Ltd., Cambridge, 2015
2. Gohl E P G and Valensky, "Textile Science", CBS Publishers, Delhi, 1983.

3. Klein W, "Manual of Textile Technology" Vol. I - V, 1st Ed., The Textile Institute, Manchester, 1995.
4. Talukdar M K, Srirammulu P K and Ajgaokar D B, "Weaving – Machine, Mechanism and Management", Mahajan Publisher Private Ltd., Ahmedabad, India, 1998.
5. Spencer D J, "Knitting Technology" 2nd edition, Pergamon Press, 1989
6. Lunenschloss J and Albrecht W, "Nonwoven Bonded Fabric", Ellis and Horwood Ltd., UK, 1985.

TTOE-454 Textile design [3-0-0-3]

Course Outcomes

CO1	Understanding the basics of textile design from fibre to product purchase
CO2	Knowledge about different types of fibre, yarns and fabric along with production methods
CO3	Analysis of structure of woven, knitted and technical textiles
CO4	Understand computer aided textile design and its applications
CO5	Knowledge about latest and newer developments in textile design

Introduction to textiles and textile designs from fiber to product purchase, textile numbering system, types of fibers, yarns and fabrics, and their production methods, diversity of textile design, principles and elements of textile design, weave and structure of woven textile design (point paper, graphical), knitwear design, Principles: Surface approaches to textile design (Surface design of textiles, printed textile design, Embroidered textile design, Designing through dyeing and finishing), design of technical textile, key issues affecting textile and fashion design, commercial aspects of design, computer aided textile designing, Designing future textiles: new developments in textile structures and surface treatments

Books Recommended:

1. Gohl E P G and Vilensky LD, "Textile Science", CBS Publishers, Delhi, 1983.
2. Bernard P. Corbman, "Textiles Fiber to Fabric", McGraw-Hill International Editions, Singapore, 1983.
3. "Handbook of Technical Textiles", Ed. A R Horrocks and S C Anand, Woodhead Publication Ltd., Cambridge, 2000.
4. Textile design: Principles, advances and applications, Edited by A Briggs-Goode and K Townsend, Woodhead Publishing Series in Textiles No. 112, 2011.
5. Handbook of nonwovens, Edited by S Russell, Woodhead Publishing Series in Textiles No. 58, 2006.
6. Handbook of Textile design: Principles, Processes and Practice, by Jacquie Wilson, Woodhead Publishing Ltd, Cambridge 2001.
7. Angappan P and Gopalakrishnan R, "Textile Testing", SSM Institute of Textile Technology, Komarapalayam, 2002.

TTOE-455 Fashion and Textiles [3 0 0 3]

Course Outcomes

CO1	Development of textile products
CO2	Emphasizing the optimization of both textile (I- handle) and fashion (I- Fashion)
CO3	Product development (I- system).
CO4	I- style is a being emphasized for apparel designfocusing the origin of fashion
CO5	Fashion concepts, Fashion analysis, Fashion trends, Fashion creations, Fashion theories withFashion promotion

Fashion: Introduction to fashion and apparel design, Origin of fashion, Definition, Terminology, Fashion concepts, Fashion analysis, Fashion trends, Fashion creations.

Fashion theories:- Fashion of different eras, French revolution.

Fashion promotion:- From design to production. Style, Fad, Trends, Fashion industry. Design, Definition, Structural, decorative, Dress designing and creating varieties, Through designs. Principals of design, Definition, Harmony, Proportion balance, Rhythm, Emphasis, Meaning, Types and application on apparel. Colour:- definition dimension of colour, Hue, Value, Intensity. Colour scheme: - importance, And application of colour in apparel. Psychology of clothing: – First impression, role of socio psychological and economical aspects of clothing. Comfort of the apparel; Textiles:- Historical development of textile fibres. Classification of fibres, definition and general properties. Natural fibres- cellulose, cotton, Wool and silk, Minor fibres, Mineral fibres; Physical and chemical properties. Man-made and synthetic fibres, Rayon, Nylon, Polyester, Acrylic fibres, Physical and chemical properties; Identification of fibres. Yarn:- Yarn properties, yarn count, , Yarn twist, yarn types single , plied and cord yarn, Sewing thread, Complex Yarns:- Novelty Yarns, Textured Yarns and metallic Yarns. Fabric: - characteristics, Types, weaves- plain, Twill, Satin and variations. Fancy weaves:- dobby, jacquard, Leno, Lappet, swiss, double cloth. Knitting:- circular, Tubular, Jersey. Non wovens:- films, foams, felting, braiding, bonding and laminating.

Books Recommended:

1. Erwin Mabel (1994):- Clothing for Moderns, Macmillan Co. London.
2. Tate (1977) Sharon lee:- “Inside Fashion Design” Farnisco Canfield Press.
3. Bhattacharya Anand:- “Garment Technology” NCUTE, IIT, Delhi(2003).
4. Cooklin Gerry:- “Garment technology for fashion designers” OM Book service, New Delhi.
5. Bernard P. Corbman :- “Textile- Fiber to Fabric” McGraw –Hill international editions.
6. E P G Gohl and Vilensky :- “Textile Science” CBS Publishersand Distributors, New Delhi

TTOE- 456 Fashion Designing [3 0 0 3]

Course Outcomes

CO1	Garment is designed by emphasizing the Fashion and consumer psychology viz. Fashion Theories
CO2	Study of Fashion of different eras,
CO3	Study of French and Greek revolutions,
CO4	Study of Fashion promotion, style-fad-trends.
CO5	Study of Fashion Design fundamentals

Fashion: Introduction to fashion and apparel design. Origin of fashion, concept, analysis, trends and creations.

Fashion Theories: Fashion of different eras, French and Greek revolutions, fashion promotion, style-fad-trends.

Fashion Design fundamentals: Basic concept of design, elements of art, Definition of line shape, form, size, space, texture and colour. Structural and decorative dress designing, creating varieties through designs.

Principles of Design: Definition Harmony, Proportion, Balance, Rhythm, Emphasis, meaning types and application on apparel psychology of clothing.

Anatomy for designers: Human Proportion and figure construction. Methods of determining individual proportions.

Psychology of Clothes: First impression, role of socio- psychological and economical aspects.

Display of fashion materials: definition and importance, source technique and window display, classic fashion shows. Important fashion centers of the world and India.

Computer aided designing: Fashion sketching, colour matching and computer graphics.

Folios: Creative, Dress, designer.

Books Recommended:

1. Erwin Model, "Clothing for Moderns", Mac Millan Publications, New York, 1994.
2. Tate and Sharon Lee, "Inside fashion design", Harper Publication Inc., UK, 1976.
3. Mary Kefgen, "Individuality in Clothing – Selection and Personal Appearance", Mac Millan Publications, New York, 1981.
4. Mikell P, Grover and E Mory, "Computer Aided Design and Manufacturing", Prentice Hall of India Ltd. Delhi, 1993.
5. Bhattacharya Anand, "Garment Technology", NCUTE, IIT, Delhi, 2003.

TTOE-457 Geotextiles [3 0 0 3]

Course Outcomes

CO1	Exposure on textile materials for the geotextiles
CO2	Types of geosynthetics
CO3	Area and Application of geo textiles
CO4	Geotextile in filtration and reinforcement
CO5	Evaluation of Geotextile and geo synthetic materials

Usefulness of geotextiles, Understanding soil characteristics, properties affecting engineering behaviour of soil, identification, classifications, permeability, effective stress and pore water pressure, seepage of soils and design of filter criteria.

Geosynthetics types, functions and application areas of geotextiles, fibres and fabric selection criteria for geotextile applications. Mechanics of reinforcement, filtration and drainage by geotextiles and functions, material construction and manufacturing processes in case of geotextiles, evaluation of geotextiles with and without soil, evaluation of filtration and drainage functions, reinforcement, creep, moisture barrier characteristics, durability and ageing.

Geotextiles and reinforced soil structures: Retaining walls, embankment, foundation. Geotextiles in roads and railways: separation, draining and filtering. Geotextiles in environmental control: covers and liners, landslides, and erosion control.

Books Recommended:

- 1 “Geosynthetics in civil engineering”, Ed. R W Sarsby, Woodhead Textiles Series No. 57, 2006, UK.
- 2 Shukla S K, Yin Jian-hua, Fundamentals of Geosynthetic Engineering, Taylor and Francis, 2006, UK.
- 3 John N W M, “Geotextiles”, Blakie, Chapman and Hall, 1987, New York, USA,
- 4 Raj P Purushothama, “Soil Mechanics and Foundation Engineering”, Pearson, 2007, India.
- 5 “Engineering with Geosynthetics”, Ed. G V Rao and G V S Raju, Tata McGraw Hill Publishing Co. Ltd., New Delhi, 1990.

TTOE-458 Designs of Experiment [3 0 0 3]

Course Outcomes

- CO1 Introduction about various statistical tools and their usefulness
- CO2 Objectives and principles of experimental design.
- CO3 Analysis of variance (ANOVA)
- CO4 Experiment with single factor, Introduction to factorial designs
- CO5 Multiple regression and correlation analysis

General introduction about various statistical tools and their usefulness. Objectives and principles of experimental design. Experimental design terminology. Increasing accuracy of experiments. Completely randomized designs. Blocking designs. Latin square designs.

Analysis of variance (ANOVA). Correlation and regression. Principles of experimental design. Typical application of experimental design. Simple comparative experiments. Experiment with single factor, Introduction to factorial designs. Concept of fractional factorial design. Two level design. Three level design, Response surface designs. Central composite and Box-Behnken designs. Concept of Split-plot design.

Fitting regression models. Multiple regression and correlation analysis, Partial correlation. Test of significance and model lack of fit. Use of replicates. Orthogonal design and Taguchi Approach. Use of computers and software package.

Books Recommended:

1. Cochran W G and Cox G M, "Experimental Designs", Second Edition, John Wiley and Sons, Inc., New York, 1957.
2. Montgomery D C, "Design and Analysis of Experiments", Fifth Edition, John Wiley and Sons, Inc., New York, 2001.
3. Leaf G A V, "Practical Statistics for the Textile Industry", (Part-I and II), The Textile Institute, UK, 1984.
4. Khuri, A. I., and Cornell, J. A., *Response Surfaces: Design and Analyses*, Marcel Dekker, New York, NY, 1987.
5. Diamond William J., *Practical Experiment Designs*, first Indian Edition, CBS Publishers and Distributors, New Delhi, 1987.
6. Motogomery D C, Peck E A, Vinning G G, "Introduction to Linear Regression Analysis", Third Edition, John Willey and Sons., Inc., 2004.

TTOE 459 Application of nanotechnology on polymers and fibres [3 0 0 3]

Course Outcomes

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|-----|---|
| CO1 | Introduction of Nanotechnology |
| CO2 | Introduction and Definition of Nanotechnology and Today's World |
| CO3 | Importance of Nanoscale Science and Technology. |
| CO4 | Use of Nanotechnology in different fields and as well as in Fibres and polymers |
| CO5 | Latest Development in Nanotechnology |

Introduction and Definition of Nanotechnology. Knowing the Size. Understanding Nanotechnology. Nanotechnology and Today's World. Importance of Nanoscale Science and Technology. Contribution of Different Scientist in Nanotechnology. Nanotechnology in Different Fields. Use of Nanotechnology in the field of Fibres and polymers. **Latest Development in Nanotechnology**

Books Recommended:

1. Nanotechnology: Science, Innovation, and Opportunity by Lynn E. Foster. Publisher: Prentice Hall Professional Technical Reference December 2005.
2. Nanotechnology: A Gentle Introduction to the Next Big Idea by Mark Ratner, Daniel Ratner. Prentice Hall Professional Technical Reference. 2002
3. Nanocomposite Science And Technology by Braun Paul V. Wiley-VCH.

TTOE-460 Environmental Science and Management [3 0 0 3]

Course Outcomes

CO1	Exposure of environment
CO2	Various types of pollution
CO3	Knowledge of Solid waste Management
CO4	Idea of Sustainable and ecological balance of environment
CO5	Assessment and control of pollution

The Environment: Its definition, the impact of human interference upon the environment, biosphere, hydrologic cycle, nutrient cycle. Improvement of environment quality, Environment laws.

Greenhouse effect: Greenhouse phenomenon and its relationship with greenhouse gases. Mechanism of global warming and various influencing factors working on it.

Environment pollution: Different types of pollution: Water, air, soil, noise, thermal, radiation, etc.

Air pollution: Definition and limits, classification and properties of air pollutants, emission sources, effect of air pollution, air pollution laws and standards, pollution analysis and measurement, its control methods and management.

Water pollution: Definition, types of water pollution and their effects, waste water sampling and analysis, water quality standards, waste water treatment and management.

Solid waste management: Definition, sources and classification, different methods of collection, disposal methods and its management.

Noise pollution: Definition, sources and classification, its impact, its analysis and management.

Soil pollution: Definition, sources and classification, its impact its analysis and management.

Thermal pollution: Definition, sources and classification, its impact, and management.

Radiation pollution: Definition, sources and classification, its impact, and management.

Books Recommended:

1. Peavy, Rowe and Tchobanoglous, "Environmental Engineering", 2nd Ed. McGraw-Hill, Singapore, 1985.
2. Khoppar S M, "Environmental Pollution Analysis", 2nd Ed. New Age International, New Delhi, 1993.
3. Gilbert, "Introduction to Environmental Engineering and Science", 1st Ed., Prentice Hall of India, New Delhi, 1995.
4. Rao MN, "Environmental Engineering", 2nd Ed., Tata McGraw-Hill, New Delhi, 1993.
5. Puneet Mohan, "Environmental Studies", 1st Ed., Sun India Publications, New Delhi, 2004.

TTOE-461 Industrial Textiles [3 0 0 3]

Course Outcomes

CO1	Classification and growth of industrial textiles
CO2	Brief idea about technical fibres, role of yarn and fabric construction
CO3	Functions and application areas of geotextiles
CO4	Concept of solid liquid separation & filtration requirements
CO5	Application of textiles in automobiles

Introduction: Classification and growth of industrial textiles, brief idea about technical fibres, role of yarn and fabric construction, composite material.

Geotextiles: Usefulness of geotextiles, Understanding soil characteristics, properties affecting engineering behaviour of soil, identification, classifications, permeability, effective stress and pore water pressure, seepage of soils and design of filter criteria.

Geosynthetics types, functions and application areas of geotextiles, fibres and fabric selection criteria for geotextile applications. Mechanics of reinforcement, filtration and drainage by geotextiles and functions, material construction and manufacturing processes in case of geotextiles, evaluation of geotextiles with and without soil, evaluation of filtration and drainage functions, reinforcement, creep, moisture barrier characteristics, durability and ageing.

Geotextiles and reinforced soil structures: Retaining walls, embankment, foundation. Geotextiles in roads and railways: separation, draining and filtering. Geotextiles in environmental control: covers and liners, landslides, and erosion control.

Filtration textiles: Definition of filtration parameters, Dust collection and solid liquid separation, filtration requirements, concept of pore size and particle size, role of fiber, fabric construction and finishing treatments.

Protective Clothing: Brief idea about different type of protective clothing, cut resistant fabric, functional requirement of textiles in defence including ballistic protection materials and parachute cloth, temperature and flame retardant clothing, chemical protective clothing, water proof breathable fabrics.

Automotive Textiles: Application of textiles in automobiles, requirement and design for different tyres, airbags and belts, methods of production and properties of textiles used in these applications.

Other uses of industrial textile: Cords and ropes, functional requirements and types of textiles used for paper making, agricultural, electronics, power transmission belting, hoses, canvas covers and tarpaulins.

Books Recommended:

1. "Handbook of Technical Textiles", Ed. A R Horrocks and S C Anand, Woodhead Publication Ltd., Cambridge, 2000.
2. "Wellington Sears Handbook of Industrial Textiles", Ed. Sabit Adanaur, Technomic Publishing Company, Inc., Pennsylvania, USA, 1995.
3. Shukla S K, Yin Jian-hua, Fundamentals of Geosynthetic Engineering, Taylor and Francis, 2006, UK.
4. "Modern Textile Characterization Methods", Ed. M Raheel, Marcel Dekker, Inc., 1996.
5. Nonwoven Fabrics; Ed. W. Albrecht, H. Fuchs, and W. Kittelmann, WILEY VCH Publication, 2003, UK.

TTOE-462 Marketing and Merchandising of Products [3 0 0 3]

Course Outcomes

CO1	Exposure of marketing management and research
CO2	Idea of product like cycle
CO3	Idea of Merchandising and related terminology
CO4	Exposure on product pricing
CO5	Understanding of retailing

Marketing Management: Product development, Product life cycle, pricing, marketing channels and promotion Mix.

Marketing Research: Basic concepts, research process, identifying market segment, product research, Advertising Research.

Merchandising: Philosophy, Types of Merchandising, Buying and holding process, merchandise pricing, Framework of retailing, Factors affecting retail pricing, selection of manpower and job of executives, career in retailing..

Books Recommended:

1. Kotler P: "Marketing Management", 9th ed, Prentice Hall India New Delhi, 1998.
2. Barry Band Joel R.E. "Retail Management" Metmiiam Publishing Co., New York 1989.
3. Ernest H R " Retail Merchandising" Macmillian Publishing Co., New York, 1991.

TTOE-463 Clothing Science [3 0 0 3]

Course Outcomes

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|-----|---|
| CO1 | Development of textile products |
| CO2 | Emphasizing the optimization of both textile (I- handle) and fashion (I- Fashion) |
| CO3 | Study of Product development (I- system). |
| CO4 | I- style is a being emphasized for apparel design focusing the origin of fashion |
| CO5 | Study of Fashion concepts, Fashion analysis, Fashion trends, Fashion creations, Fashion theories with fashion promotion |

Introduction: Factors involved in the study of clothing; clothing considered as a system interacting with the body

Dimensional Stability: Hygral expansion. Relaxationshrinkage. Swelling shrinkage. Felting shrinkage Shrinkage in knitted fabrics. Stretch and recovery properties.

Serviceability: Abrasion resistance. Tear strength. Colour fastness. Seam slippage. Seam strength. Snagging. Pilling.

Transmission properties: Air permeability. Water vapour permeability. Wetting. Longitudinal and transverse wicking. Waterabsorption. Thermal conductivity. Electrical conductivity.

Thermal Comfort: Thermal transfer processes – Dry heat transfer and Rapid heat transfer. Flammability – burning behaviour. Thermal degradation. Function of Textiles in enhancing thermal comfort.

Fabric Handle: Tensile properties. Shear properties. Bending properties. Compressional properties. Roughness and Frictional properties. Buckling behaviour and Formability. Low stress mechanical properties and tailor ability. Sewability of fabrics.

Books Recommended:

1. Lyman Fourt and Norman R.S. Hollies, "Clothing Comfort and Function" Marcel Dekker, INC., NEW YORK 1971

2. Kothari, V K, "Testing and Quality Management ", CBS Book Publishers, New Delhi, 2000.
3. Zhang Wei Yuan, "Clothing Comfort and Function", China Textile Press ,2011
4. Saville B P, "Physical Testing of Textiles," The Textile Institute, Woodhead publication limited, Cambridge, 1999,
5. J.E. Booth , " Principles of Textile Testing, Butterworth Heinemann Ltd.,U.K. , Indian Edition: 1996

TTOE -464 High performance fibres [3-0-0-3]

Course Outcomes

CO1	Basic concepts of high performance fibres
CO2	Factors influencing properties / performance of fibre
CO3	Different approaches for development of high performance fibres.
CO4	Manufacturing methods of high performance fibres
CO5	Features and applications of various high performance fibres such as Aramid, Carbon, glass etc.

Basic concepts of fibres. Factors influencing properties / performance of fibre. Necessity of high performance fibres. Different approaches for development of high performance fibres.

Hi -Performance Gelspun Polyethylene fibres- Manufacture, fibres characteristics, properties and applications.

Aramids- Introduction, polymer preparation, Spinning, Structure and properties, applications.

Carbon Fibres- Introduction, production, Physical properties of Rayon based, PAN based and Pitch based Carbon fibres. Applications.

Glass Fibres- Fibre manufacture, fibre finish, fibre properties and application.

Vectran (Melt spun wholly aromatic polyester fibre), Fibre production, properties and

application, PBO (Polyphenylene benzobisoxazole) fibres- Fibre production, properties and application.

Books Recommended:

1. T. Hongu, New fibres, Ellis Horwood, New York 1990.
2. Lewis. E .M. Pearce, J .Preston, Hand book of fibre science and technology Vol-4, Marcel Dekkar, New York 1989.
3. Donnet J. B. Bansol R .C, Carbon fibres, Marcel Dekkar, New York 1990.
4. Hearle J.W.S., High Performance Fibres, Textile Institute, Woodhead Publishing, 2001.
5. Mukhopadyay. S.K, "High Performance Fibres", Textile progress, Vol. 25, Textile InstituteManchester, 1993.

Department of Textile Technology

Teaching and Evaluation Scheme
&
Course Content

(B Tech MINOR DEGREE)



**Dr. B R AMBEDKAR
NATIONAL INSTITUTE OF TECHNOLOGY
JALANDHAR – 144011
2018**

Syllabus of Individual Minor Degree Courses

**DR B R AMBEDKAR NATIONAL INSTITUTE OF TECHNOLOGY
JALANDHAR**

Department of Textile Technology
B Tech MINOR DEGREE
 Teaching and Evaluation Scheme - 2018

List & Syllabus Of The Minor Degree Courses To Be Offered By The Department:

Courses to be offered from 3rd to 8th semesters :

S. No	Semester	Course No.	Subject	Periods			Credit
				L	T	P	
1	3 rd	TTMI-201	Fundamentals of Textile Machines & Processes	3	0	0	3
2	4 th	TTMI -202	Fibre Science	3	0	0	3
3	5 th	TTMI -301	Yarn Formation	3	0	0	3
4	6 th	TTMI -302	Fabric Manufacture	3	0	0	3
5	7 th	TTMI -401	Chemical Processing of Textiles	3	0	0	3
6	8 th	TTMI -402	Textile Structure and Applications	3	0	0	3
			Total	18	0	0	18

TTMI-201 Fundamentals of Textile Machines and Processes [3 0 0 3]

Course Outcomes

- CO1 Fundamental knowledge of different textile product
- CO2 Study of product specifications and their quality parameters
- CO3 Classification of textile industries
- CO4 Basic concept of textile fiber, filament, yarn and fabric
- CO5 Basic concept of conversion from fibre to garment

Basic characteristics of textile materials; Concept of dimensional characteristics of textiles; Applications of textiles in diversified fields; Variations in textile structure and properties based on applications; Role of different structure and material constituents for fulfilment of target requirements; Different machine sequences for processing textile materials differing in structure; Product properties and their measurement; Understanding the significance of parameters characterizing product properties; Need for process control and use of statistics; Improvement in product quality; Current trends in research and development of textile machines and processes.

Recommended Books:

1. Rose Sinclair, Textiles and Fashion: Materials, Design and Technology, Woodhead Publishing Ltd., Cambridge, 2015
2. Gohl E P G and Vilensky L D, Textile Science, CBS Publishers and Distributors, New Delhi.
3. Corbman Bernard P., "Textiles Fiber to Fabric", McGraw-Hill International Editions, Singapore, 1983.
4. "Handbook of Technical Textiles", Ed. A R Horrocks and S C Anand, Woodhead PublicationLtd., Cambridge, 2000.
5. Textile Design: Principles, Advances and Applications, Edited by A Briggs-Goode and K Townsend, Woodhead Publishing Series in Textiles No. 112, 2011.
6. Handbook of Nonwovens, Edited by S Russell, Woodhead Publishing Series in Textiles No. 58, 2006, UK.
7. Morton W E and Hearle J W S, "Physical Properties of Textile Fibres", Woodhead Publishing Series in Textiles No. 68, 2008, UK.

TTMI -202 Fibre Science (3 0 0 3)

Course Outcomes

CO1	Develop the concept of natural and synthetic fibre
CO2	Understanding various natural source of fibres and production of manmade fibres
CO3	Understanding the structure and Properties of Fibres
CO4	Application or use of natural and made fibres

Overview of fibre: Introduction to fibres, Global fibre market and production.

Fibres and polymers: Essential and desirable properties of textile fibers; Classification of textile fibers.

Fibre Structure and structure property relation: Importance of polymer as a basic building block; Effect of molecular arrangement and molecular weight on properties of polymers/fibers; Concept of thermoplastic and thermoset material.

Commodity Fibres: Basic requirements of commodity fibres. Natural and Manmade Commodity fibres. Concept of production of Manmade Fibres. Basic features, properties and applications of important commodity fibres, e.g., Cotton, Silk, Wool, Flax, Jute, Regenerated Cellulosics, Nylon, Polyester, PAN and PP.

High Performance Fibres: Basic concept of High Performance Fibres; Introduction, properties and applications of Aramids, Vectran, Zylon, Carbon and Glass fibres. Concept of Nanofibres and applications.

Books Recommended:

1. Cook Gordon J, "Hand Book of textile fibre", Vol. I and II, Woodhead Fibre Science Series, UK, 1984.
2. "Manufactured Fibre Technology", 1st Ed. V B Gupta and V K Kothari, 1st Ed., Chapman and Hall, London, 1997.
3. "Hand Book of Fibre Chemistry", Ed. M Lewin and E M Pearce, Mercel Dekker Inc., 1998.
4. Hearle J.W.S., High Performance Fibres, Textile Institute, Woodhead Publishing, 2001.

TTMI- 301 Yarn Formation [3-0-0-3]

Course Outcomes

CO1	Introduction to the important fibre characteristics for yarn production
CO2	To study Opening, cleaning, carding, draw frame process of yarn production
CO3	To study Objective and working of ring frame, doubling and winding operations
CO4	To study basic principals of non conventional yarn production
CO5	Numerical problems , norms , performance assessment; Latest development

Introduction to short staple spinning: Brief idea about short staple spinning technology.

Opening and cleaning in blow room–Introduction, Methods.

Mixing and blending–Definition; Compatibility requirements; Perfect blend; Blending deficiencies; Index of blend irregularity; Blending methods and techniques; Mixing and blending machines.

Carding–Objectives; Operating regions of the card; Forces acting on the fibres; Action between feed roller and licker-in, Cylinder and Flats, Transfer zone at doffer, Numerical problems, performance assessment, Developments in carding machine.

Doubling and Drafting- Basic principles; drafting operation in the drafting arrangement; behaviour of fibres in the drafting zone; fibre friction field; numerical problems; performance assessment;

Combing process: Objectives, preparation of stock for combing, combing cycle, noil extraction at backward feed and forward feed comber, mathematical problems, performance assessment. **Process related to roving formation:** Objectives, functions of different machine components and high drafting system, roving twist in speed frame, winding principles and equations related to bobbin leading and flyer leading, building motion, cone profile, numerical problems, performance assessment

Ring spinning Process: Function and mode of operation of ring frame, role of drafting system, yarn guiding devices, forces acting between ring and traveler, yarn tension variation, balloon tension at maximum diameter, tasks of traveller, traveler mass and material, different ring-traveller combinations, fiber lubrication, running on new-ring, winding process, cop structure, spinning geometry, , numerical problems, performance assessment,

Non-conventional spinning processes: Principle of open end spinning, rotor spinning, chief organs and their functions, yarn properties in comparison with ring-spun yarn, principle of friction spinning, function of chief organs, yarn properties and comparison of Dref-II and Dref-III friction spinning machines, basic principle to air jet spun yarn, functions of chief organs, yarn properties, numerical problems, performance assessment.

Books Recommended:

5. Klein W, “Manual of Textile Technology”, Vol. I – VI, The Textile Institute, UK, 1987.
6. Oxtoby E, “Spun Yarn Technology”, Butterworth and Co. Ltd., 1987.
7. Lawrence C A, “Fundamental of Spun Yarn Technology” CRC Press, USA, 2003.
8. Lord P R, “Handbook of Yarn Production”, The Textile Institute, Woodhead Publication Limited, Cambridge, 2003.

TTMI - 302 Fabric Manufacture (3 0 0 3)

Course Outcomes

CO1	Quality of yarn requirements for weaving
CO2	Importance of winding, warping and sizing
CO3	Basic concept of weaving ie shedding, let-off and take-up operations
CO4	Basic mechanism of modern looms ie projectile, air-jet and rapier weft insertion
CO5	Knowledge of knitting and nonwovens

Preparatory Process

Principles of winding processes and machines, package faults and their remedies; Yarn clearers and tensioners; Features of modern cone winding machines; Different types of warping creels; features of modern beam and sectional warping machines; Different sizing systems, sizing of spun and filament yarns, sizing machines; Principles of pirn winding processes and machines.

Fabric formation

Primary and secondary motions of loom, Dobby and jacquard shedding; weft replenishment; Multiple box motion; Principles of weft insertion systems of shuttle-less weaving machines; Principles of multiphase and circular looms.

Principles of knitting, basic weft and warp knitted structures;

Classification, production, properties and application of nonwoven fabrics.

Books Recommended:

1. 'Winding', BTRA Monograph Series, Bombay Textile Research Association, Bombay, 1981.
2. 'Warping and Sizing', BTRA Monograph Series, Bombay Textile Research Association, Bombay, 1981.
3. Mark R, Robinson A T C, "Principles of Weaving", The Textile Institute, Manchester, 1986.
4. Talukdar M K, Sriramulu P K and Ajgaokar D B, "Weaving – Machine, Mechanism and Management", Mahajan Publisher Private Ltd., Ahmedabad, India, 1998.
5. Booth J E, "Textile Mathematics", Part III, Textile Institute, Manchester, 1977.
6. Talavasek and Svaty V, Shuttleless Weaving machine, Elsevier Scientific Publishing Co, Amsterdam, 1981.
7. Lord P and Mohamod.M.H., " Weaving Conversion of Yarn to fabric", Merrow Technical Library, UK,1988
8. Krcma R, "Manual of Non wovens", Textile Trade Press, UK,1971

TTMI- 401 Chemical Processing of Textiles [3 0 0 3]

Course Outcomes

CO1	Flowsheet of chemical processing for different fibres and blends
CO2	Pretreatment of various textiles
CO3	Knowledge of colour and colouration of various textiles and blends
CO4	Printing of textiles
CO5	Finishing of textiles

Pretreatment: Process line for pretreatment, colouration and finishing of textiles. Gas singeing, desizing, scouring, bleaching of textiles and blends. Mercerization of cotton:

machine and methodology; efficiency of mercerization. Heat setting of manmades: mechanism and processes.

Colour: Visible spectrum, wavelength and blindness of colour. Additive and subtractive theories. Primary, secondary and tertiary colours. Tristimulus values of colour. Computer colour matching, Kubelka-Munk equation, reflectance factor. Colouring materials: dye, pigment and lake. Classification of colouring materials based on chemistry and application. Dye-fibre interaction.

Colouration of textiles: Dyeing technology of natural and manmade textiles with direct, reactive, vat, insoluble azoic, sulphur, solubilised vat, acid, metal-complex, basic and disperse dyes. Colouration with Pigments.

Dyeing of blends: Classification of blends and fancy shades, Methods for dyeing of blends. Suitability of each method for dyeing of specific blend.

Pretreatment and dyeing machineries: Singeing m/c, J-box, kier, mercerizing machine, loose fibre, yarn and package dyeing machines. Jigger, winch, jet and HTHP beam dyeing m/cs. padding mangles.

Carbonisation: Objectives, selection of chemical, process parameters, trouble shoots, precautionary measures and efficiency of carbonisation.

Printing of textiles: Constituent and characteristics of print paste, classification and mechanism of working of thickeners. Hand block, roller and screen printing processes. Direct, discharge and resist styles of printing on natural, man-made and blended textiles.

Transfer Printing: classification, mechanism of transfer in each type and machineries. Transfer printing of natural, manmade and blended textiles.

Finishing of Textiles: Calendering, softening and sanforising; Influence of working parameters, construction and function of m/cs for these finishes. Anti-crease, flame retardant, soil release and water repellent finishes.

Fastness assessment and identification of dye on dyed textiles.

Books Recommended

1. A K Roy Choudhary, "*Textile Preparation and Dyeing*", Science Publishers, USA (2006).
2. Peters R. H, "*Textile Chemistry*", Vol - II, Elsevier Publishing Company, London (1967).
3. Shore J, "*Cellulosics dyeing*", Society of Dyers and Colourists, Bradford, UK (1979).
4. Karmakar S R, "*Chemical Technology in the pretreatment processes of Textiles*", Textile Science and Technology Series, Vol-12, 1st Edition, Elsevier (1999).
5. Nunn D M, "*The Dyeing of Synthetic Polymer and Acetate Fibres*", Dyers Company Publication Trust, London, 1979.
6. Miles L W C, "*Textile Printing*", Dyers Company Publication Trust, Bradford, 1981.
7. Shenai V A, "*Technology of Printing*", Sevak Publications, Mumbai, 1990.
8. Hall A J, "*Textile Finishing*", Haywood Books, London, 1996.

TTMI- 402 Textile Structure and Applications [3 0 0 3]

Course Outcomes

CO1	Basic concepts of structure of yarn and fabric
CO2	Relation of yarn structure with properties
CO3	Relation of Fabric structure and properties
CO4	Study of fabric geometry
CO5	Modeling of fabric structure

An engineering approach to textile Structures

Yarn Geometry: Basic geometry of twisted yarns, the idealized helical yarn structure.

Real yarn: Twist contraction and retraction, packing of fibers in yarn, forms of twisting

Structural Mechanics: Extension of yarn under small load. Analysis of tensile forces of yarn under stress. Prediction of breakage. Design of Technical Yarn for Industrial Textiles.

Fabric Geometry: Engineering approach to the analysis of the fabric, Ashenhurst theory, Cover

factor and its relationship with GSM. Pierce geometrical model of plain woven fabric. Design of Jammed Structure. Geometry of knitted fabric. Elementary idea on tensile, bending, shear and drape of fabric.

Application of the theory for the design of woven and knitted fabric. Use of Textile fabric for Industrial Application.

Books Recommended:

1. Hearle J W S, Grosberg P and Backer S, “Structural Mechanics of Fibers yarn and Fabrics”,

Wiley Interscience, New York, 1969.

2. Goswami B C, Martindale J G and Scardino F, “Textured yarn technology, structural and applications”, Wiley Interscience, New York, 1969.

3. Peirce F T and Womersley J R, “ Cloth Geometry”, reprint, The Textile Institute, Manchester, 1978