INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPC-501** Course Title: **Pulping processes**

2. Contact Hours: **L: 3** **T: 0** **P: 2/2**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 2

4. Relative Weightage: **CWS** 15-30 **PRS** 20 **MTE** 15-25 **ETE** 30-40 **PRE** 0

5. Credits: 3 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To provide knowledge to the students regarding various types of pulping methodologies used for pulp manufacture.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Fibrous Raw Materials for Paper Making Introduction;** Importance of paper, definitions of pulp, paper and paperboard; Flow sheet of complete pulp and paper making process; Plant fibers, plant kingdom, plant body and organization of fibers and other cells in the plant; Structure of softwoods, hardwoods, and non-woods; Pulpwood species; Cell type; Ultrastructureture of the cell wall; Physical properties, variability, and defects of raw materials.	7
2.	**Mechanical Pulping:** Mechanical pulping nomenclature, stone groundwood process, refiner mechanical pulping, thermomechanical pulping, chemically modified mechanical pulping; Types of high-yield pulping processes; Neutral sulphite semi-chemical (NSSC) pulping; Cold soda, acid sulphite	7
3.	**Sulphite Pulping:** Nomenclature and definition of terms, process description, chemistry of sulphite pulping, chemistry of cooking liquor preparation, operation and control of cooking	6
4.	**Kraft and Soda Pulping Cycle:** Overview of alkaline pulping, kraft and soda pulping, standard terminologies; Description of kraft cooking process, kraft recovery cycle, composition and analysis of white liquor; Kraft process modifications, Digester additives; Extended delignification processes; Modified continuous cooking, super batch, rapid displacement heating process.	8
5.	**Pulp Mill Operations:** Batch and continuous digesters and their operations, heating systems, blowing, cold blowing, and blow heat recovery system;the Process variables, dependence of time and temperature, H-factor, control parameters.	7
6.	**Processing of Pulp:** Defibering, deknoting, brown stock washing, screening, centrifugal cleaning, thickening; Pulp characterization, Effect of raw material on pulp quality; Evaluation of pulps, kappa number, viscosity, and drainability.	7
	Total	**42**

List of Experiments:

1. Microscopic study of morphological characteristics of papermaking fibers.
2. Determination of solubility of fibrous raw material in hot water, 1% NaOH, and alcohol-benzene.

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3. Determination of lignin in raw material.
4. Determination of holocellulose in raw material.
5. Determination of pentosans in raw material.
6. Pulping of raw material
7. BaurMcnett fibre classification
8. Determination of kappa number.

Suggested Books:

S. No.	Name of Book / Authors	Year of Publication
1.	Browning B. L. "The Chemistry of Wood", John Wiley & Sons.	1981
2.	Kocurek M. J., "Pulp and Paper Manufacture, Volume 1: Properties of Fibrous Raw Materials and their Preparation for Pulping (Ed. Kocurek M. J. and Stevens C. F. B.)", TAPPI Press.	1983
3.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 3: Forest Products Chemistry (Ed. Stenius P.)", Finnish Paper Engineers' Association and TAPPI.	1998
4.	Sjostrom E., "Wood Chemistry Fundamentals and Applications", 2nd Ed., TAPPI Press.	1993
5	Smook G. A. "Handbook for Pulp and Paper Technologists", 7th Ed., TAPPI Press.	1989
6	Casey J. P. "Pulp and Paper Chemistry and Chemical Technology", Vol. 1, 3rd Ed., John Wiley and Sons.	1984
7	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 6: Chemical Pulping (Ed. Gullichsen J and Fogelholm C-J.)", Finnish Paper Engineers' Association and TAPPI.	1999
8	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 5: Mechanical Pulping (Ed. Sundholm J.)", Finnish Paper Engineers' Association and TAPPI.	1999
9	Kocurek M. J., "Pulp and Paper Manufacture, Volume 5: Alkaline Pulping (Ed. Grace T. M. and Melcolm E. W.)", TAPPI Press	1989
10	Kocurek M. J., "Pulp and Paper Manufacture, Volume 2: Mechanical Pulping (Ed. Leask R. A.)", TAPPI Press.	1987

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPC-503** Course Title: **Washing and Bleaching**

2. Contact Hours: **L: 2** **T: 0** **P: 2/2**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 2

4. Relative Weightage: **CWS** 15-30 **PRS** 20 **MTE** 15-25 **ETE** 30-40 **PRE** 0

5. Credits: 2 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To familiarize the students with washing, screening, cleaning, bleaching of pulp and secondary fibre processing.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Washing:** Importance of washing Mechanisms of washing, physico-chemical aspects of lignin removal in washing, operating targets for brown stock washing systems, displacement ratio, Norden efficiency, dilution factor, washing losses, factors affecting pulp washing; Washing equipments.	4
2.	**Screening:** Principles of screening, screening, Efficiency, variables affecting screening efficiency, Types of screens, and their applications, Screening Systems Design, combination of screens, common Screening Problems, causes and removal.	4
3.	**Cleaning:** Principals of cleaning, centrifugal cleaners, forward and reverse cleaners, , variables affecting centrifugal cleaner's performance, Process design calculations, process flow sheets for cleaning different types of pulps, combinations of centrifugal cleaners.	4
4.	**Bleaching Fundamentals:** Types of bleaching, conventional, ECF and TCF bleaching; Bleachability and its measurement; Bleached pulp characterization and measurement of different parameter like copper number, brightness, brightness reversion, P.C. number, viscosity; Factors affecting brightness reversion.	6
5.	**Bleaching Chemistry, Operations and Equipment:** Oxygen, chlorination, extraction, oxidative extraction, hypochlorite, chlorine dioxide, enzyme, ozone, peroxide and dithionite bleaching. Bleaching reactions, reaction kinetics, operating variables, pulp quality; Advantages and disadvantages of different bleaching agents, bleaching of mechanical and high yield pulps; bleach boosters. Bleaching equipments, towers, mixers, reactors	10 8
6.	**Secondary Fiber Processing**: Secondary fiber Contaminants. Effect of recycling of secondary fibers on machine operation and paper quality; Secondary fibers processing, Hydrapulper, screening and cleaning, systems, variables and process water reuse Deinking: Principles of deinking, washing and floatation deinking, deinking chemicals, deinking efficiency and quality of deinked pulp, variables affecting deinking efficiency; Flotation cell etc.	6
	Total	42

List of Experiments:

1-4 Bleaching with conventional/ ECF/TCF bleaching sequence and bleached pulps characterization by determination of brightness, pulp viscosity, P.C. number.

5- Pulping in hydra pulper and determination of freeness of pulp as a function of time

6- Deinking of pulp and determination of residual ink in pulp (ERIC value) and dirt count

11. Suggested Books:

S. No.	Name of Book / Authors	Year of Publication
1.	Dence C.W., and Reeve D.W., "Pulp Bleaching: Principles and Practices", TAPPI Press.	1996
2.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 7: Recycled Fiber and Deinking (Ed. Göttsching L. and Pakarinen H.)", Finnish Paper Engineers' Association and TAPPI.	1999
3.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 6: Chemical Pulping (Ed. Gullichsen J and Fogelholm C-J.)", Finnish Paper Engineers' Association and TAPPI.	1999
4.	Kocurek M. J., "Pulp and Paper Manufacture, Volume 3: Secondary Fibers and Non-wood Pulping (Ed. Hamilton F. and Leopold B.)", TAPPI Press.	1987
5.	Kocurek M. J., "Pulp and Paper Manufacture, Volume 5: Alkaline Pulping (Ed. Grace T. M. and Melcolm E. W.)", TAPPI Press.	1989
6.	Kulas K. A., "Elemental Chlorine Free Bleaching: A Tappi Press Anthology of Published Papers (Pulp/Wood Products)", TAPPI Press.	2005

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPC-505** Course Title: **Chemical Recovery Process**

2. Contact Hours: **L: 2** **T: 0** **P: 2/2**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 2

4. Relative Weightage: **CWS** 15-30 **PRS** 20 **MTE** 15-25 **ETE** 30-40 **PRE** 0

5. Credits: 2 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To provide knowledge to the students regarding various types of pulping methodologies used for pulp manufacture.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction**: Kraft and Soda recovery cycles, various terms associated with chemical Process; Impact of pulping and washing on chemical recovery process	3
2.	**Black Liquor Properties**: Chemical, physio-chemical, thermal and polymeric properties	3
3.	**Black Liquor Treatment**: Importance and methods of black liquor oxidation and desilication	3
4.	**Concentration of Black Liquor:** Multiple effect evaporators (MEE), process design calculations- feeding sequence, heat transfer area optimum cycle time; Scale formation and its remedies; Instrumentation and control of MEE; Condensers- indirect and direct types, process design calculations; Steam jet ejectors- operating principle, entrainment ratio, motive steam requirement, performance factors, load calculation	6
5.	**Incineration of Black Liquor:** Process chemistry, incineration process, recovery boilers and accessories, boiler safety, NOX generation, material and energy balance calculations, parameters affecting thermal performance; Recovery of fume particles, ESP, calculation of corona voltage, ionic density, corona current, particle charging, migration velocity, variables affecting emission of particulate from ESP; Cogeneration with recovery boiler	4
6.	**Causticizing of Green Liquor**: Green liquor treatment and clarification, slaking and causticizing reactions, causticization equilibrium, causticizing efficiency; White liquor clarification, mud washing and filtration equipment, soda loss in lime sludge, process design calculations for clarifiers, slakers, causticizers and mud filters; Soda, sulphur and water balance across the causticization plant	3
7	**Lime Mud Reburning**: Process description, lime kiln, variables affecting lime mud reburning, material and energy balance calculations, instrumentation and control.	3
8	**Non-Conventional Recovery Systems:** Process description of various unconventional recovery processes, application in medium and small-scale paper mills, production of lignin derivatives from black liquor	3
	Total	28

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List of Experiments:

1. Salt cake analysis
2. Available CaO in lime sample
3. Green liquor analysis
4. Sludge/Mud analysis
5. White liquor analysis
6. Black liquor analysis

Suggested Books:

S. No.	Name of Book / Authors	Year of Publication
1.	Hough, G., "Chemical Recovery in Alkaline Pulping Processes" TAPPI Press	1985
2.	Kocurek, M. J., "Pulp and Paper Manufacture, Volume 5: Alkaline Pulping (ed. Grace, T. M. and Melcolm, E. W.)", TAPPI Press	1989
3.	Adams, T. N., Frederick, W. J., Grace, T. M., Hupa, M., Iisa, K., Jones, A. K. and Tran, H. N., "Kraft Recovery Boiler" TAPPI Press	1997
4.	Gullichsen, J. and Paulapuro, H., "Papermaking Science and Technology, Book 6B: Chemical Pulping (ed. Gullichsen, J and Fogelholm, C-J.)", Finnish Paper Engineers' Association and TAPP	2009
5	Tappi Kraft Recovery Short Notes, TAPPI Press.	1996

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPC-507** Course Title: **Papermaking**

2. Contact Hours: **L: 2** **T: 0** **P: 2/2**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 2

4. Relative Weightage: **CWS** 20-35 **PRS** 0 **MTE** 20-30 **ETE** 40-50 **PRE** 0

5. Credits: 2 6. Semester: **Spring** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of the advances in the design and operation of papermaking processes.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Flow distribution and Headboxes:** Flow distributers; Headboxes, rectifier roll type, hydraulic headboxes, head control, control of jet velocity and jet angle	3
2	**Stock and Whitewater Systems:** Design principles of short circulation and long circulation, closing the whitewater system, saveall; Broke system design, handling of brokes of different grades such as coated, colored, wet strength papers; Design of piping system	4
3	**Sheet Formers:** Fordrinier and gap formers, hybrid formers, formers for multi-layered paper and boards; Formation, quantitative measurement of formation; Factors affecting sheet formation	5
4	**Pressing and Drying:** Development in press parts, emended nip presses, development in paper drying, steam and condensate handling, hoods and hood exhaust, IR drying; Surface sizing	5
5	**Finishing and Calendering:** Developments in calendering, soft calendering, moisture and temperature calendering; Rewinder and sheet cutters	2
6	**CD Variability and its Control:** Benefits of improved CD uniformity, online measurement, CD control of grammage, moisture, caliper, and smoothness	2
7	**Paper Machine Clothing**: Design of forming, press and dryer fabrics; Material of construction; Manufacturing techniques; Cleaning and conditioning of forming, press, and dryer fabrics	2
8	**Auxiliary Systems of Paper Machine:** Paper machine showers and doctors; Paper machine drives; Paper machine vacuum systems	3
9	**Paper Machine Safety:** Vibration measurement and control; Corrosion measurement and control; Safety from steam, moving parts and chemicals	2
	Total	**28**

11. Suggested books:

S. No.	Name of Authors/Book /Publisher	Year of Publication/ Reprint
1	Gullichsen, J. and Paulapuro, H., "Papermaking Science and Technology, Book 8: Papermaking Part 1, Stock Preparation and Wet End (ed. Paulapuro, H.)", Finnish Paper Engineers' Association and TAPPI	2000
2	Gullichsen, J. and Paulapuro, H., "Papermaking Science and Technology, Book 9: Papermaking Part 2, Drying (ed. Karlsson, M.)", Finnish Paper Engineers' Association and TAPPI	2000
3	Gullichsen, J. and Paulapuro, H., "Papermaking Science and Technology, Book 10: Papermaking Part 3, Finishing (ed. Jokio, M.)", Finnish Paper Engineers' Association and TAPPI	1999
4	Kocurek, M. J., "Pulp and Paper Manufacture, Volume 7: Paper Machine Operations (ed. Thorp, B.)", TAPPI Press	1991

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPC-509** Course Title: **Stock Preparation**

2. Contact Hours: **L: 2** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage: **CWS** 20-35 **PRS** 0 **MTE** 20-30 **ETE** 40-50 **PRE**

5. Credits: 2 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite:

9. Objective: To introduce the students with the concepts of stock preparation and sheet forming processes of papermaking.

10. Details of Course:

Sl. No.	Contents	Contact Hours
1	**Introduction:** Surface and colloid chemistry interactions, fiber water systems, thermodynamics of cellulose water system; Electrokinetic behavior of stock, charge determination, zeta potential, cationic demand.	2
2	**Fiber Bonding:** Importance of fiber bonding; Theories of fiber bonding; Effect of surface tension on fiber bonding; Types of bonds in dried paper; Measurement of fiber bonding and strength of bonds; Factor affecting fiber bonding; Effect of conformability, plasticity and swelling upon fiber bonding; Effect of fibrillation, fines, hemicelluloses, lignin, water, recycling, of alumina, sizing, fillers and other additives on fiber bonding; Effect of fibrillation and fiber cutting on paper properties; influence of coated broke on wet end chemistry, runability problems, deposits, white pitch, deposit control, dispersing and fixing agents.	3
2	**Refining:** Mechanism of refining, variables affecting refining, controlling parameters; Types of refiner; Effect of refining on pulp and paper properties.	3
3	**Sizing:** Basic surface science considerations in sizing, measurement of sizing; Types of sizing agents, rosin, AKD, ASA; Trouble-shooting of sizing problems.	4
4	**Strength Additives:** Dry and wet strength additives, mechanisms of strength development, factors affecting wet and dry strength properties.	3
5	**Fillers and Dyes:** Types of fillers, properties of fillers, effect of fillers	3

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	on optical and mechanical properties of paper; Dyes and pigments, dying of paper.	
6	**Control Chemicals at the Wet End**: Retention aids, drainage aids, defoamers, deflocculates and pitch controlling agents.	**2**
7	**Coagulation and Flocculation in Papermaking:** Coagulation with electrolytes, theory of flocculation and dispersion of colloidal materials, effects of additives on fiber flocculation.	**2**
8	**Foam and Slime Control:** Nature of foam, foam formation and stabilization, effect of additives on foam stability, theory of antifoam action; Micro-organisms and slime formation, chemical slime control.	**2**
9	**Water and Energy Balance in Pulp and Paper Industry**	**4**
	Total	**28**

11. Suggested Books:

S. No.	Name of Book / Authors	Year of Publication
1.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 4: Papermaking Chemistry (Ed. Neimo L.)", Finnish Paper Engineers' Association and TAPPI.	**1999**
2.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 8: Papermaking Part 1, Stock Preparation and Wet End (Ed. Paulapuro H.)", Finnish Paper Engineers' Association and TAPPI.	**2000**
3.	Kocurek M. J., "Pulp and Paper Manufacture, Volume 6: Stock Preparation (Ed. Hagemeyer R. W. and Manson D. W.)", TAPPI Press.	**1992**
4.	Kocurek M. J., "Pulp and Paper Manufacture, Volume 7: Paper Machine Operations (Ed. Thorp B.)", TAPPI Press.	**1991**
5.	Roberts J.C. "Paper Chemistry" 2nd Ed., Blackie Academic & Professional.	**1996**
6.	Scott W. C., "Principles of Wet End Chemistry", TAPPI Press.	**1996**

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NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPC-511** Course Title: **Paper Properties**

2. Contact Hours: **L: 2** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weightage: **CWS** 20-35 **PRS** 0 **MTE** 20-30 **ETE** 40-50 **PRE** 0

5. Credits: 2 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of properties of paper and their measurement.

10. Details of Course:

Sl. No.	Contents	Contact Hours
1	**Introduction**: Different grades of papers, boards and newsprint, and their specifications; BIS and ISO standards of paper; Paper properties and their dependence on paper-making processes; Calibration of instruments.	3
2	**Structure of Paper:** Two- and three-dimensional network geometry, formation, concept of orientation and flocculation, porous structure.	3
3	**Physical Properties**: Definitions and methods of determination of grammage, caliper, bulk, smoothness, and porosity, and standardization of size.	3
4	**Mechanical Properties:** Definitions and methods of determination of tensile strength, tear strength, burst strength, folding endurance, and bending stiffness.	4
5	**Optical Properties**: Interaction of light with paper, reflectance; Definitions and methods of determination of brightness, opacity, gloss and color.	3
6	**Resistance Properties:** Permeation of fluid through paper, water absorbency, Cobb test, oil absorbency, air/gas permeability.	2
7	**Interrelation between Properties**: Dependence of properties on water content and temperature; Standard test conditions.	2
8	**The influence of the Environment on Paper Properties:**	3

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	Interactions between paper and moisture, hygroscopic nature of wood fibers, measurement of moisture content, effects of moisture content on mechanical and structural properties (Basis weight and mechanical properties), sources of dimensional instability (Fundamental factors, fibrous furnish components, non-fibrous furnish components, beating and refining, sheet formation, drying conditions and converting operations), various effects of moisture on paper shade and dimensions (Expansion and contraction, thickness, cockle, curl, curl tests, wrinkling, wavy edges, tight edges and other effects of moisture).	
9	**The Permanence of Paper:** Environmental influence on permanence, factors affecting aging, and evaluation of aging characteristics.	**2**
10	**Statistical treatment of measured data:** Quality & statistical process control; Lot by lot sampling – types- the probability of acceptance in single, double, multiple sampling plans; Uncertainly analysis, assigned value, SDPA, fundamentals- factorial experiments – random design, Latin square design- Taguchi methods, loss function – experiments- S/N ratio and performance measure-orthogonal array; Definition- reliability vs quality, reliability function.	**3**
	Total	**28**

11. Suggested Books:

S. No.	Name of Book / Authors	Year of Publication
1.	Casey J.P., "Pulp and Paper Chemistry and Chemical Technology", 3rd Ed., Vol 3, John Wiley & Sons.	**1984**
2.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 17: Pulp and Paper Testing (Ed. Levlin J.-E. and Söderhjelm L.)", Finnish Paper Engineers' Association and TAPPI.	**1999**
3.	Hunter R.S. and Harold R.W. "Measurement of Appearance", John Wiley & Sons.	**1987**
4.	Mark R. E., "Handbook of Physical and Mechanical Testing of Paper and Paperboard", Vol. 1, Marcel Dekker.	**2002**
5	Mark R. E., "Handbook of Physical and Mechanical Testing of Paper and Paperboard", Vol. 2, Marcel Dekker.	**2002**
6.	Scott W.E., Abbott J.C. and Trosset S., "Properties of Paper: An Introduction", TAPPI Press.	**1995**
7.	ISO/IEC -17025: General requirements for the competence of testing and calibration laboratories, published by the International Organization for Standardization, Ch. de Blandonnet 8 Case Postale 401 CH – 1214 Vernier, Geneva Switzerland.	**2019**
8.	IS: 1060 Part-1, Part-2, and Part3: Methods of sampling and test for paper and allied paper products, Bureau of Indian Standards	**2019**

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPC-513** Course Title: **Stock Preparation and Paper Properties**

2. Contact Hours: **L: 0** **T: 0** **P: 6**

3. Examination Duration (Hrs.): **Theory** 0 **Practical** 6

4. Relative Weightage: **CWS** 50 **PRS** 50 **MTE** 0 **ETE** 0 **PRE** 0

5. Credits: 3 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To provide practical knowledge to the students regarding stock preparation, papermaking and paper properties

10. Details of Course:

List of Experiments:

List of Experiment

i. Laboratory coating with different coating color compositions and super calendaring
ii. Evaluation of grammage, density, bulk, gloss, opacity, brightness, smoothness, porosity, and bending stiffness o the coated sheets of experiment i.
iii. Determination of surface strength (Scott Bond test), oil absorbency of paper (COP) and water klemn
iv. Demonstration of printability testing with an IGT printability tester
v. Preparation of handsheets with different dosage of dye and determination of color (L,a,b values)
vi. Determination of formation factor
vii. Determination of compression strength of paper & board
viii. Beating of a given pulp and preparation of handsheets at different °SR. Beating of pulp in PFI mill at different revolutions and determination of energy consumption.
ix. To determine strength properties of handsheets prepared in Experiment viii: tensile index, stretch, burst index, folding endurance, and tear index.
x. Preparation of hand sheets from a given pulp at different dosing of sizing agents (AKD, ASA and rosin-alum).
xi. Evaluation of sizing efficiency as a function of sizing dose for the handsheets prepared in Experiment .
xii. Preparation of hand sheets at different dosing of fillers.
xiii. Evaluation of brightness and opacity as function of ash retained for the handsheets prepared in Experiment xii.
xiv. Evaluation of tensile strength, stretch, modulus of elasticity of paper, burst, tear double fold, porosity (both Gurley and Bendsten), smoothness, roughness, MD and CD of paper, top and bottom sides of paper, bulk and density of a given paper

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Suggested Books:

S. No.	Name of Book / Authors	Year of Publication
1.	Tappi Standard Test Methods-2007: T-401 om-88: Fiber analysis of paper and paperboard, T-403 om-91: Bursting strength of paper, T-404 om-87: Tensile breaking strength and elongation of paper and paperboard (using pendulum-type tester), T-407 wd-71: Amount of coating on mineral-coated paper, T-408 om-88: Rosin in paper and paperboard, T- 409 om-88: Machine direction of paper and paperboard, T-410 om-88: Grammage of paper and paperboard (weight per unit area), T-411 om-89: Thickness (Caliper) of paper, Paperboard, and combined board, T-412 om-90: Moisture in paper and paperboard, T-413 om-85: Ash in paper and paperboard, T-414 om-88: Internal tearing resistance of paper (Elmendorf-type method), T-416 wd-39: Rosin in paper (qualitative), T-419 om-91: Starch in paper, T-423 om-89: Folding endurance of paper (Schöpper type tester), T-425 om-91: Opacity of paper (15 degrees/diffuse illuminate A, T-426 wd-70: Bulking thickness of paper and paperboard, T-433 cm-84: Water resistance of sized paper and paperboard, T-442 om-88: Spectral reflectance factor transmittance, and Color, T-452 om-92: Brightness of pulp, paper and paperboard, T-456 om-87: Wet tensile breaking strength of paper and paperboard, T-457 wd-76: Stretch of paper and paperboard, T-458 om-89: Surface wettability of paper (angel of contact method), T-459 om-88: Surface strength of paper (wax pick test), T-460 om-88: Air resistance of paper, T-462 om-88: Castor-oil penetration test for paper, T-472 wd-76: Compression resistance of paperboard (ring crush test), Moisture in paper and paperboard by toluene distillation, T-494 om-88: Tensile breaking properties of paper and paperboard, T-543 pm-84: Stiffness of paper (Gurley type stiffness tester), Tappi publications, Atlanta (USA).	2007
2.	Bureau of Indian Standards: IS 1060 (Part 4/Sec1): 2014 ISO187: Methods of sampling and test for paper and allied products: Part 4 methods of test for Paper, board and Pulp: Sec I standard atmosphere for conditioning and testing and procedure for monitoring the atmosphere and condition of samples; IS10 1060 (Part 4/Sec 2) : 2018 ISO 1762:2015: Methods of sampling and test for paper and allied products: Part 4 methods of test for paper, board and pulps: Sec 2 determination of residue (ash) on ignition at 525°C; IS 1060 (Part 4/Sec 3) : 2018 ISO 2144: Methods of sampling and test for paper and allied products: Part 4 methods of test for paper, board and pulps: Sec 3 determination of residue (Ash) on ignition at 900°C; IS 1060 (Part5/Sec 2): 2021 ISO 287:2017: Methods of sampling and test for paper and allied products part 5 methods of test for paper and board section 2 determination of moisture content of a lot oven-drying methods; IS 1060 (Part5/Sec 3): 2014 ISO 534: Methods of sampling and test for paper and allied products: part 5 methods of test for paper and board: sec 3 determination of thickness, density and specific volume ; IS 1060 (Part 5/Sec 4) :2014 ISO 535: Methods of sampling and test for paper and allied products: part 5 methods of test for paper and board: sec 4 determination of water absorptiveness - Cobb method; IS 1060 (Part 5/ Sec 5) : 2021 ISO 536: 2019: Methods of sampling and test for paper and allied products: part 5 methods of test for paper and board: section 5 determination of grammage; IS 1060 (Part 5/Sec 6): 2014 ISO 1924-2 : Methods of sampling and test for paper and allied products: Part 5 Methods of test for paper and board: sec 6 determination of tensile properties –Constant rate of elongation method (20 MM/min) ; IS 1060 (Part 5/Sec 8): 2024 ISO 2493-2:2020: Methods of sampling and test for paper and allied products: Part 5 Methods of test for paper and board section 8 determination of bending resistance Taber-type tester ; IS 1060 (Part 5/Sec 8) :2014 ISO 3783: Methods of sampling and test for paper and allied products: Part 5 Methods of test for paper and board: Sec 8 determination of bending resistance- Taber-type tester; IS 1060(Part 5/Sec 11): 2021 ISO 5636-3:2013: Methods of sampling and test for paper and allied products: Part 5 Methods of test for paper and board section 11 Determination of air permeance medium range- Bendtsen method ; IS 1060 (Part 5/Sec 12):2021 ISO 8254-1:2009: Methods of sampling and test for paper and allied products: Part 5 Methods of test for paper and board section 12 measurement of specular gloss 75 degree gloss with a converging beam TAPPI method ; IS 1060(Part 5/Sec 14): 2014 ISO 5636-5: Methods of sampling and test for paper and allied products: Part 5 Methods of test for paper and board section 14 determination of air permeance and air resistance (medium Range)-Gurley method; IS 1060(Part 5/Sec 16): 2015 ISO 8787: Methods of sampling and test for paper and allied products: Part 5 Methods of test for paper and board : sec 16 determination of capillary rise- Klemn method ; IS 1060 (Part 5/Sec 17): 2014 ISO 8791-4:2021: Methods of sampling and test for paper and allied products: Part 5 Methods of test for paper and board: sec 17 determination of roughness/smoothness (air leak methods)-print surf method ; IS 1060 (Part 5/Sec 17): 2024 ISO 8791-4: 2021: Methods of sampling and test for paper and allied products part 5 methods of test for paper and board section 17 determination of roughness-smoothness air leak methods print-surf method; IS 1060 (Part 5/Sec 20): 2018 ISO 8791-2:2013: Methods of sampling and test for paper and allied products: Part 5 methods of test for	2019

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	paper and board: Sec 20 determination of roughness/smoothness (air leak methods)- Bendtsen method; IS 1060 (Part 6/Sec 1): 2014 ISO 1974: Methods of sampling and test for paper and allied products: Part 6 methods of test for paper: Sec 1 Determination of tearing resistance – Elmendorf method ; IS 1060 (Part 6/Sec 2): 2024 ISO 2758:2014: Methods of sampling and test for paper and allied products: Part 6 Methods of test for paper section 2 determination of bursting strength of paper ; IS 1060 (Part 6/Sec 2): 2014 ISO 2758:2014: Methods of sampling and test for paper and allied products: Part 6 methods of test for paper: sec 2 determination of bursting strength of paper ; IS 1060 (Part 6/Sec 3): 2015 ISO 5626: Methods of sampling and test for paper and allied products: Part 6 methods of test for paper: sec 3 determination of folding endurance of paper ; IS 1060 (Part 7/Sec 1): 2014 ISO 2759: Methods of sampling and test for paper and allied products: Part 7 methods of test for board: Sec 1 determination of bursting strength of board ; IS 11080: 1984: Method of determination of porosity of paper; IS 11091: 1984: Method of test for degree of curd of paper and degree of sizing. BIS, Manak Bhawan, Bahadur Shah Zafar Marg, New Delhi.	

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPL-501** Course Title: **Process Equipment Design**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: **CWS** 20-35 **PRS** 0 20-30 40-50 0

5. Credits: 3 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of mechanical design aspects of various pressure vessels and storage tanks used in process industries.

10. Details of Course:

Sl. No.	Contents	Contact Hours
1	**Mechanics of Materials:** Stress-strain relationship for elastic bodies, theories of failure, thermal stresses; Torsion of solid and hollow cylindrical shafts; Thin and thick cylinders under stress.	6
2	**Pressure Vessels:** Introduction of codes for pressure vessel design; Classification of pressure vessels; Design of cylindrical and spherical shells under internal and external pressure; Selection and design of closures; Optimum length to diameter ratio of pressure vessel using common types of closures; Design of jacketed portion of vessels.	10
3	**Accessories of Pressure Vessels:** Selection and design of nozzles; Elementary idea of compensation for openings; Selection of gaskets; Selection and design of flanges; Pipe thickness calculation under internal and external pressure.	4
4	**Tall Tower Design:** Design of shell, skirt, bearing plate, and anchor bolts for tall towers used at high wind and seismic conditions; Examples of design of tall towers, such as bleaching towers, and chimneys.	6
5	**Supports:** Design of lug support and saddle support including bearing plates and anchor bolts.	3
6	**Storage Tanks:** Filling and breathing losses; Classification of storage tanks; Design of liquid and gas tanks; Design of storage tanks for process industries.	7
7	**Application to Design of Plant Equipment:** Design of reactors,	6

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	evaporators, and drum dryers; Inspection and testing of pressure vessels, radiography; Introduction to flexibility analysis of piping systems.	
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Brownell L.E. and Young H.E., "Process Equipment Design" 2nd Ed., John Wiley.	**2004**
2.	Bhattacharya B.C., "Introduction of Chemical Equipment Design", CBS Publishers.	**2003**
3.	Joshi M.V. and Mahajani V. V., "Process Equipment Design", MacMillan India.	**1996**
4.	I.S: 2825-1969 (Reaffirmed), "Code for Unfired Pressure Vessels", BIS, New Delhi.	**2007**
5.	I.S: 803-1976 (Reaffirmed), "Code of Practice for Design, Fabrication and Erection of Vertical Mild Steel Cylindrical Welded Oil Storage Tanks", BIS, New Delhi.	**2006**

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPL-502** Course Title: **Pulp Mill Calculations**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** [3] **Practical** [0]

4. Relative Weightage: **CWS** [20-35] **PRS** [0] **MTE** [20-30] **ETE** [40-50] **PRE** [0]

5. Credits: [3] 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of process calculations for pulping, screening, cleaning, washing and bleaching systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Raw Material Preparation Section:** Material and energy balance calculations for raw material preparation section; Physical properties of raw materials, bulk density; Energy calculations for conveyers, chippers, and chip screens	4
2	**Pulping Section:** Analysis of white, green and black liquors, process calculations for batch and continuous digesters, bath ratio; Calculations for Superbatch, RDH, MCC, and EMCC processes; Steam and power calculations; Modeling of soda and kraft pulping, calculation of H- and modified H-factors, use of empirical models for prediction of various parameters; Calculation for blow-heat recovery, digester and liquor heater	10
3	**Screening and Cleaning Systems:** Performance of screening and cleaning systems and their process design aspects, mass balance and efficiency for single and multiple stage systems, screening and cleaning equipment sizing, power consumption calculations	4
4	**Washing Systems:** Material and energy balance calculations for different types of washing systems, washing losses and washing efficiency, calculation of washing efficiency for varying dilution factor, displacement ratio and number of stages; Norden efficiency	5
5	**Bleaching Systems:** Calculations involving bleach liquor analysis; Material and energy balance for single and multiple stage bleaching sequences; Process design of tower, mixer and reactors; Calculations for bleaching efficiency, target brightness, shrinkage and environmental impact	5
6	**Recovery Section:** Material and energy balance calculations for multiple effect evaporators, area requirement and efficiency; Process design calculations for condensers and steam-jet ejectors; Process design calculations for slakers, causticizers, clarifiers, mud washers, filters, lime mud reburning system; Energy efficiency and performance calculations	10
7	**Stock Pumps and Piping:** Sizing of piping and pumps for stock flow in different sections of a pulp mill, power requirement for pumping	4
	Total	**42**

11. Suggested books:

S. No.	Name of Authors/Book /Publisher	Year of Publicatio Reprint
1	Dence, C. W. and Reeve, D. W., "Pulp Bleaching: Principles & Practice", TAPPI Press	1996
2	Gullichsen, J. and Paulapuro, H., "Papermaking Science and Technology, Book 6: Chemical Pulping (ed. Gullichsen, J and Fogelholm, C-J.)", Finnish Paper Engineers' Association and TAPPI	1999
3	Kocurek, M. J., "Pulp and Paper Manufacture, Volume 5: Alkaline Pulping (ed. Grace, T. M. and Melcolm, E. W.)", TAPPI Press	1989
4	Abrams, T. L., "Process Engineering Design Criteria Hand Book: Pulp and Paper Normal Design Criteria," TAPPI Press	1996
5	Adams, T. N., Frederick, W. J., Grace, T. M., Hupa, M., Iisa, K., Jones, A. K. and Tran, H. N., "Kraft	1997

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	Recovery Boiler" TAPPI Press	
6	Gullichsen, J. and Paulapuro, H., "Papermaking Science and Technology, Book 6B: Chemical Pulping (ed. Gullichsen, J and Fogelholm, C-J.)", Finnish Paper Engineers' Association and TAPPI	1999

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NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPL-503** Course Title: **Paper Mill Calculations**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: **CWS** 20-35 **PRS** 0 **MTE** 20-30 **ETE** 40-50 **PRE** 0

5. Credits: 3 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of process design calculation of papermaking processes.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Approach Flow System:** Basic Mass balance calculations in approach flow system, sizing of chests and piping, design parameters of screens, cleaners, and fan pumps, deaerator, flow distributors; Estimation of electrical power consumption	6
2	**Headbox:** Calculations for the required head, pressure and thrust in the headbox, selection of perforated rolls, no-wake distance for the nozzle, calculations for the pressurized and hydraulic headbox, characterization of turbulence; Calculations for jet angle, slice opening, volumetric flow rate from the head box	4
3	**Formers:** Drainage rate calculations, wire tension, selection of forming fabrics, dimensions of wire, sizing of different rolls, drainage elements and suction boxes on wire table; Calculation of vacuum, drag load, and other parameters for wire part; Design of cylinder mold machines; Calculation of drive load.	7
4	**Overall Water and Fiber Balance:** Mass balance for white water and fiber systems, broke handling, first pass retention, savealls, water requirement for showers and other cleaning devices, Concepts of system closure	4
5	**Vacuum Systems:** Vacuum producing devices; Sizing of vacuum pumps, piping, foils and separators; Calculation of energy requirements	3
6	**Press Part:** Water removal rate calculations; Dimensioning of press rolls and water drainage elements; Selection of press fabrics; Calculation of press parameters; Calculation of drive load	4
7	**Dryer Part:** Material and energy balance for multi-cylinder and Yankee dryers; Calculations of drying rate, surface area of dryers, air and steam requirement; Steam and condensate handling systems, sizing of steam piping; Calculation of drying rate for surface sized and pigment coated papers, calculations for IR and air impingement dryers, calculation for dryer hoods; Calculation of drive load	10
8	**Stock Pumps and Piping:** Sizing of piping and pumps for stock flow in different sections of a paper mill, power requirement for pumping	4
	Total	**42**

11. Suggested books:

S. No.	Name of Authors/Book /Publisher	Year of Publicatio Reprint
1	Gullichsen, J. and Paulapuro, H., "Papermaking Science and Technology, Book 8: Papermaking Part 1, Stock Preparation and Wet End (ed. Paulapuro, H.)", Finnish Paper Engineers' Association and TAPPI	2000
2	Gullichsen, J. and Paulapuro, H., "Papermaking Science and Technology, Book 9: Papermaking Part 2, Drying (ed. Karlsson, M.)", Finnish Paper Engineers' Association and TAPPI	2000
3	Gullichsen, J. and Paulapuro, H., "Papermaking Science and Technology, Book 10: Papermaking Part	1999

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	3, Finishing (ed. Jokio, M.)", Finnish Paper Engineers' Association and TAPPI	
4	Kocurek, M. J., "Pulp and Paper Manufacture", Vol. 7, TAPPI Press	1994
5	TAPPI Technical Information Papers, TAPPI Press	2004

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPL-504** Course Title: **Chemical Recovery Process Calculations**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: **CWS** 20-35 **PRS** 0 **MTE** 20-30 **ETE** 40-50 **PRE** 0

5. Credits: 3 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite:

9. Objective: To impart knowledge of process design calculations in chemical recovery systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Multiple Effect Evaporators:** Material and energy balance calculations for different types of evaporators, calculation for area requirement and efficiency, process design calculations for condensers and steam-jet ejectors.	9
2.	**Recovery Boiler:** Material and energy balance calculations for recovery boilers, performance calculations, effect of various parameters on performance, calculations of effective cooling area for water walls.	10
3.	**Electrostatic Precipitator:** Process design calculations.	6
4.	**Causticizing Section:** Process design calculations for slakers, causticizers, clarifiers, mud washers and filters.	10
5.	**Lime Mud Reburning Systems:** Process design calculations, energy efficiency, performance calculations.	7
	Total	42

11. Suggested Books:

S. No.	Name of Authors/Books/Publisher	Year of Publication
1.	Abrams T.L., "Process Engineering Design Criteria Hand Book: Pulp and Paper Normal Design Criteria," TAPPI Press.	1996
2.	Adams T.N., Frederick W.J., Grace T.M., Hupa M., Iisa K., Jones A.K., Tran H.N., "Kraft Recovery Boiler" TAPPI Press.	1997
3.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 6B: Chemical Pulping (Ed. Gullichsen J and Fogelholm C-J.)", Finnish Paper Engineers' Association and TAPPI.	1999
4.	Tappi Kraft Recovery Short Notes, TAPPI Press.	1996

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NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPL-505** Course Title: **Secondary Fiber Processing**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: **CWS** 20-35 **PRS** 0 20-30 40-50 0

5. Credits: 3 6. Semester: **Autumn** 7. Subject Area: **PEC**

8. Pre-requisite: **NIL**

9. Objective: To impart knowledge about the availability, collection, utilization, and environmental aspects of secondary fibers.

10. Details of Course:

Sl. No.	Contents	Contact Hours
1	**General Aspects**: Utilization, collection, and recovery rate, future utilization of recovered paper; Legislation for recycled fibers; Quality control of the recovered paper; Recyclability of paper products; Economics of secondary fiber utilization.	2
2	**Recycled Versus Virgin- Fiber Characteristics:** Comparison, General effect of recycling, Effect of furnish and initial beating of virgin pulp, Interaction between fiber properties and process variables; Discussion related to fiber strength, Coarseness & freeness change of recycled fibers.	4
3	**Stickies in Recycled Fiber Pulp:** Type and size of stickies, origin and behavior of stickies, characterization of stickies; Print quality of recycled fiber papers; Impact of secondary fiber on the paper machine, and fiber reactivity versus chemical use.	4
4	**Unit Operations and Equipment:** Secondary fiber processing, batch and continuous pulpers, slushing, deflaking, fractionation, dispersion and kneading, dewatering, refining, screening, and cleaning; Effect of variables like temperature, pressure, agitation, consistency, and chemicals on pulp properties.	7
5	**Deinking:** Deinking operations, washing and floatation, advances in deinking techniques.	6

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6	**Environmental Aspects:** Characterization of wastes and emissions from mills using recovered fiber, Process water clarification, Reject handling and sludge pressing in recycling and deinking systems	**3**
7	**Flow Sheet Considerations:** Process parameters that influence the design of flow-sheets, simple system, crude cleaning, OCC system, systems for deinking newsprint and magazine papers, deinking of printing and writing grades.	**2**
	Total Contact Hours	**28**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 7: Recycled Fiber and Deinking (Ed. Göttsching L. and Pakarinen, H.)", Finnish Paper Engineers' Association and TAPPI.	**2000**
2.	Kocurek M. J., "Pulp and Paper Manufacture, Volume 3: Secondary Fibers and Non-wood Pulping (Ed. Hamilton F. and Leopold B.)", TAPPI Press.	**1987**
3.	McKinney R.W.J., "Technology of paper Recycling", Blackie and Academic Professional.	**1995**
4.	Spangenberg R.J., "Secondary Fiber Recycling", TAPPI Press.	**1993**

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NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code:**PPL-506** Course Title: **Bio-process and its Application**

2. Contact Hours: L:**3** T:**0** P: **0**

3. Examination Duration (Hrs.): Theory **3** Practical **0**

4. Relative weightage: CWS **20-35** PRS **0** MTE **20-30** ETE **40-50** PRE **0**

5. Credit: **3** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Prerequisite: **Nil**

9. Objective: To impart knowledge regarding application of biotechnology in pulp and paper industry.

10. Details of Course:

S. No.	Contents	Contac Hours
1.	**Introduction:** What is biotechnology? A typical plant and animal cell and cell organelles; Genetic engineering; Importance, interdisciplinary pursuit, product safety, public perception.	8
2.	**White-rot Fungi:** Taxonomy, production of fungal inoculum, enzymology and molecular genetics; Factors affecting enzyme production; Solid-state and submerged fermentation conditions wood degradation by white-rot fungi.	8
3.	**Raw Material Preparation**: Wood pretreatment to remove toxic extractives, bio-debarking, bio-retting of flax, bio-depithing.	3
4.	**Pulping and Bleaching:** Advantages and principles of bio-pulping and bio-bleaching; Fungal pretreatment of wood chips for chemical pulping, Principles of bio-mechanical pulping; Production of dissolving pulp; Removal of shives; Bleaching with xylanases and enzymes of white-rot fungi; Bio-deinking, principles and comparison with chemi-deinking process.	11
5.	**Fiber Modification:** Use of enzymes in beating, refining, drainage aids; Fuel generation, Sources of biomass, ethanol from biomass, biodiesel and biohydrogen and other applications.	8
6.	**Effluent Treatment:** Treatment of wastewaters with aerobic and/or anaerobic techniques; Decolorization and detoxification of bleached kraft effluents; Purification of process water in closed-cycle mills; Management of wastewater treatment sludges.	4
Total		42

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publicatio Reprint
1.	Bajpai P. and Bajpai P.K., "Biotechnology in the Pulp and Paper Industry", PIRA International.	1997
2.	Bajpai P., Bajpai P.K. and Kondo R. "Biotechnology for Environmental Protection in the Pulp and Paper Industry", Springer.	1999
3.	Raymond A.Y. and Akhtar M., "Environmentally Friendly Technologies for the Pulp and Paper Industry", John Wiley.	2003
4.	Smith J.E., "Biotechnology" 3rd Ed., Cambridge University Press.	1996

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPL-507** Course Title: **Electro kinetics in Papermaking**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: **CWS** 20-35 **PRS** 0 **MTE** 20-30 **ETE** 40-50 **PRE** 0

5. Credits: 3 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of electrokinetics in papermaking processes.

10. Details of Course:

S. No.	Contents	Contac Hours
1	**Colloidal State:** Classification of colloidal systems, the motion of particles in liquid media	2
2	**Surface and Total charge:** Charge on fibre, filler and other particles in papermaking furnish, charged groups and their ionization	4
3	**Factors Affecting Fibre Charge:** Effect of chemical environment - pH, electrolyte concentration, valency of counter ion; Anionic trash in papermaking	5
4	**Electrokinetic Phenomena:** Electric double layer, effects of stock additives and process operations such as pulping, bleaching, and refining on electrokinetic properties of papermaking furnish	6
5	**Charge Measurement:** Zeta potential, microelectrophoresis, streaming potential, AC streaming current, titration techniques such as potentiometric, conductometric and polyelectrolyte, colloid titration ratio, absolute charge and charge demand	6
6	**Sorption and Swelling:** Sorption and swelling of cellulosic materials in water and other media, physical- and chemi-adsorption, surface area of cellulose and cellulosic materials	5
7	**Coagulation and Flocculation in papermaking:** Coagulation with electrolytes, flocculation and dispersion of colloidal materials, effects of additives on fiber flocculation	5
8	**Retention Mechanisms:** Charge neutralization, patch model, bridging, complex flocculation, dissolved and colloidal substances; Influence of shear	4
9	**Foam and Slime Control:** Nature of foam, foam formation and stabilization, effect of additives on foam stability, antifoam action; Micro-organisms and slime formation, chemical slime control	5
	Total	**42**

11. Suggested books:

S. No.	Name of Authors/Book /Publisher	Year of Publicatio Reprint
1	Eklund, D. and Lindstrom, T. D., "Paper Chemistry: An Introduction", TAPPI Press	1991
2	Gess, J. M., "Retention of Fines and Fillers During Papermaking", TAPPI Press	1998
3	Gullichsen, J. and Paulapuro, H., "Papermaking Science and Technology, Book 4: Papermaking Chemistry (ed. Neimo, L.)", Finnish Paper Engineers' Association and TAPPI	1999
4	Kocurek, M. J., "Pulp and Paper Manufacture, Volume 6: Stock Preparation (ed. Hagemeyer, R. W. and Manson, D. W.)", TAPPI Press	1992
5	Swanson, J., "Colloid Chemistry of Papermaking Materials", TAPPI Press	2002

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code:**PPL-508** Course Title: **Coated and Specialty Papers**

2. Contact Hours: L:**3** T:**0** P:**0**

3. Examination Duration (Hrs.): Theory **3** Practical **0**

4. Relative weightage: CWS **20-35** PRS **0** MTE **20-30** ETE **40-50** PRE **0**

5. Credit: **3** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Prerequisite **Nil**

9. Objective: To provide knowledge on the characteristics of various constituents used in aqueous pigment coating processes, and characteristics and applications of various specialty paper grades.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Base Paper and Coating Ingredients:** Requirements of coating base paper; mechanical and wood free papers; Coating pigments such as kaolin, GCC, PCC, talc, titanium dioxide, gypsum, aluminum trihydrate, synthetic plastic pigments; Coating binders such as latex, synthetic co- binders and thickeners, starch, soya-protein, CMC, polyvinyl alcohol; Coating additives, characteristics and application of dispersants, viscosity modifiers, insolubilizers, lubricants; Principles of specialty chemicals such as sodium hexametaphosphate, fire retardants, softening agents and corrosion inhibitors etc.	8
2.	**Coating Processes:** Coating color preparation, coating techniques, multiple coating of paper, coating of board, drying of coated paper, process control and automation, rheology of pigment slurries.	5
3.	**Writing and Papers:** Characteristics of various grades such as newsprint, super calendared papers, coated mechanical papers, uncoated fine papers, coated fine papers, special fine papers, Different value-added grades such as MICR paper, photographic paper, azure laid paper, ARSR paper, TDL poster etc., Trouble shooting related to various grades; Requirements of writing and printing papers according to BIS:1848	8
4.	**Absorbent Grade Paper:** Requirement of absorbent grade paper; Different valued-added grades such as barrier paper, ivory base paper, overlay tissue, pictorial circuit board, seed germination paper, DBTU paper,	5
5.	**Wrapping and Packaging Paper:** Requirement of wrapping and packaging paper; Different value added quality papers such as abrasive base paper, anti-rust paper, food grade papers, paper cups, playing card paper etc., problems related to wrapping and packaging grades	4
6.	**Paperboard Grades:** Carton boards classification and quality requirements for various applications, containerboards and linerboard, corrugating medium, special boards, wallpaper base, core board and plaster board.	4
7.	**Tissue and Air-laid Papers:** Tissue converting, embossing, printing and perforation; Process of manufacture of air-laid papers, their characteristics and applications.	3
8.	**Industrial Specialty Papers:** Electrical insulation papers, automobile filter paper, special strong papers, release papers, copy and imaging papers, thermal papers, building papers, cigarette papers, and other functional papers.	5
	Total	42

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publicatio
1.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 11: Pigment	2000

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	Coating and Surface Sizing of Paper (Ed. Lehtinen E.)", Finnish Paper Engineers' Association and TAPPI.	
2.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 18: Paper and Board Grades (Ed. Paulapuro H.)", Finnish Paper Engineers' Association and TAPPI.	**2000**
3.	Kocurek M. J., "Pulp and Paper Manufacture, Volume 8: Coating, Converting, and Speciality Papers (Ed. Kouris M.)", TAPPI Press.	**1990**

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Paper Technology**

1. Subject Code: **PPL-509** Course Title: **Risk Analysis and Management in Industry**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: **CWS** 20-35 **PRS** 0 **MTE** 20-30 **ETE** 40-50 **PRE** 0

5. Credits: 3 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To familiarize the students with the risks associated with manufacturing paper, paperboard and packaging materials and the remediation strategies.

10. Details of Course:

Sl. No.	Contents	Contact Hours
1.	**Introduction**: Sources of environmental hazards; Types of environmental risks, safety, and ecological risks; Risk assessment framework - regulatory perspectives and requirements; Risk analysis and management; Social benefit Vs. technological risks, the path to risk analysis; Perception of risk- risk assessment in different disciplines.	6
2.	**Chemical Handling and Safety:** Introduction: accidents, an overview of chemicals used in the paper industry; Chemical hazards; Unsafe acts, pulping chemicals, bleach chemicals, chlorine gas, and other hazardous chemicals; Non-hazardous chemicals; Handling of chemicals and precautions; Accident prevention.	5
3.	**Material Handling in Industry:** Equipment concept of material handling; Material handling equipments; Continuous movement conveyors, batch movement equipments, suitability of these equipments in paper industry; Design features; Power requirements; Bucket elevators; Roller conveyors, pneumatic conveyor; Pressure systems; Vacuum systems; Fluidizing systems; Batch movement equipments; Bridge cranes, jib cranes, monorails, crane trucks, hand trucks; Various sections of material handling in paper industry; Safety in material handling	6
4.	**Elements of Environmental Risk Assessment:** Hazard identification and accounting, properties, processes, and parameters that control the fate and transport of contaminants; Dose-response evaluation, slope factors, Dose-response calculations, and dose conversion factor	4

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5.	**Risk Characterization and Consequence Determination:** Estimating carcinogenic and non-carcinogenic risks to human health, exposure assessment, exposure factors, multimedia, and multipath way exposure modeling of contaminant concentrations in air, water, soils, and vegetation.	**4**
6.	**Toxicology:** Effect of toxicants on biological organisms; Toxicological studies; Dose versus response, models for dose and response curves, relative toxicity, threshold limit values, national fire protection association (NFPA) diamond.	**4**
7.	**Industrial Hygiene:** Government laws and regulations; OSHA, process safety management; EPA, risk management plan; DHS, chemical facility anti-terrorism standards (CFATS); Industrial hygiene, anticipation and identification, evaluation, control; Source models, introduction to source models, the flow of liquid through holes, and pipes, the flow of gases or vapors through holes and pipes, flashing liquids, liquid pool evaporation or boiling, conservative analysis	**6**
8.	**Concepts to Prevent Fires and Explosions:** Inerting, static electricity and its control, explosion-proof equipment and instruments, ventilation, sprinkler systems; Miscellaneous concepts for preventing fires and explosions; Hazards identification, process hazards checklists, surveys, hazards and operability studies, safety reviews, and other methods; Risk Assessment, review of probability theory, event trees, fault trees, QRA, and LOPA.	7
	Total Contact Hours	**42**

11. Suggested Books:

S. No.	Name of Book / Authors	Year of Publication
1.	Kofi Asante Duah, "Risk Assessment in Environmental management", John Wiley and sons, Singapore, 1998.	1998
2.	Cutter, S.L., Environmental Risk and Hazards, Prentice-Hall of India Pvt. Ltd., New Delhi, 1999	1999
3.	Kolluru Rao, Bartell Steven, Pitblado R and Stricoff, "Risk Assessment and Management Handbook", McGraw Hill Inc., New York, 1996.	1996
4.	Carlton W. Dence, Douglas W. Reeve, "Pulp Bleaching: Principles and Practice", TAPPI, 1996	1996
5.	J. Grant, "Modern Paper Making", Nature, 1947	1947
6.	Stephenson J. Newell, "Preparation of Stock for Paper Making", McGraw Hill, 1951	1951

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPL- 510** Course Title: System Closure

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** **3** **Practical** **0**

4. Relative Weightage: **CWS** **20-35** **PRS** **0** **MTE** **20-30** **ETE** **40-50** **PRE** **0**

5. Credits: **3** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of methodology for conserving water, energy and fiber resources.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction:** Concepts, issues and challenges of sustainability, section wise inputs and outputs in paper manufacturing, open, partially closed, and closed systems	4
2	**Legislative and Sustainable Approaches:** Discharge standards for liquid, solid and gaseous emissions, the Earth summit and other protocols, environmental impact assessment (EIA), eco-labeling, green rating, greenhouse gas emissions, life cycle analysis (LCA), paper use and disposal; Energy usages, clean development mechanism	6
3	**Process Integration and Pinch Technology:** Concept of process integration and its applications to various process operations; Role of thermodynamics in process design; Targeting of energy, area, number of units and cost, super targeting: Concept of pinch technology, heat exchanger network analysis, Water and energy balance in pulp and paper industry, Kidney technology, Closed loop systems, Nearly zero liquid effluent discharge.	9
4	**Energy Management in Pulp and Paper Mills:** Renewable and non-renewable energy sources, increasing use of bio-mass, cogeneration, development of energy efficient processes, process integration	7
5	**Water Needs of Pulp and Paper Industry:** Water sourcing; Closed system operations in fiber preparation, pulping, bleaching, papermaking and chemical recovery; Condensate recovery, management of non process elements; Process integration in closed water cycle; Rain water Harvesting	8
6	**Waste Management:** Liquid effluent discharges, tertiary treatment methods; Issues of TDS, Color, and AOX; Solid waste management, incineration and land fill; Air emission control for SO_x, NO_x, HCI, NCGs, TRS, and VOC	8
	Total	**42**

11. Suggested books:

S. No.	Name of Authors/Book /Publisher	Year of Publication/ Reprint
1	Brune, D., Chapman, D. V., Gwynne, M. D. and Pacyna, J. M., "The Global Environment: Science, Technology and Management", Marcel Dekker	1996
2	Environmental Issues and Technology in Pulp and Paper Industry – TAPPI Press Anthology of Published Papers, 1991-94	1995
3	Gullichsen, J. and Paulapuro, H., "Papermaking Science and Technology, Book 19: Environmental Control (ed. Hynninen, P.)", Finnish Paper Engineers' Association and TAPPI	1998
4	Nebel, B. J., Adams, C. E. and Wright, N., "Environmental Science – The Way World Works", 4th Ed., Prentice Hall	1999
5	Boyce, M. P., "Handbook of Cogeneration and Combined Cycle Power", ASME Press	2002
6	El Halwagi M. M., "Process Integration", 7th Ed., Academic Press.	**2006**

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7	Kemp I.C., "Pinch Analysis and Process Integration: A User Guide on Process Integration for the Efficient Use of Energy", 2nd Ed., Butterworth Heinemann.	**2007**

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NAME OF DEPTT. /CENTRE: **Department of Paper Technology**

1. 1. Subject Code: **PPL-511** Course Title: **Advanced Paper and Packaging Materials Characterization**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: **CWS** 20-35 **PRS** 0 20-30 40-50 0

5. Credits: 3 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: **To impart knowledge of characterization techniques by various analytical Methods**

10. Details of Course:

Sl. No.	Contents	Contact Hours
1	**Elemental Analysis:** CHNSO, inductively coupled plasma optical emission, spectroscopy	4
2	**Spectroscopic Characterization:** Vibrational spectroscopy (FTIR, ATR- IR, and Raman spectroscopy), UV-visible and photoluminescence, XPS, NMR, mass spectroscopy.	8
3	**Thermal Analysis:** Principles and applications of differential scanning calorimetry (DSC), differential thermal analysis (DTA), thermogravimetric analysis (TGA).	8
4	**X-ray Diffraction:** Introduction to X-rays, crystal structures, structural factor, the principle of X-ray diffractions, wide-angle X-ray diffraction, and small-angle X-ray scattering of paper and packaging material samples.	5
5	**Molecular Weight Determination:** Principle and instrumentation of gel permeation chromatography and static light scattering method.	6
6	**Optical Microscopic Characterization:** Introduction to optical, fluorescence, confocal microscopy.	5
7	**Advanced Microscopic Characterization:** Electron microscopy, construction details of electron microscopes, e.g., SEM, TEM, and STM, and their detailed principle to study different nano/micro/meso structures; Principle and usage of atomic force microscopy (AFM)	6
	Total Contact Hours	42

11. List of Experiments

1. Identification of compounds using DSC
2. Identification of compounds in an unknown sample by XRD
3. Sample preparation for optical microscopy and examination of microstructure.
4. Use of SEM to examine structure and particle size.

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5. Demonstration of AFM for analyzing nanomaterials
6. Determination of molecular weight by SLS method.

12. Suggested Books

S. No.	Name of Authors /Books/Publishers	Year of Publication
1	Goodhew P.J., Humphreys J. and Beanland, R., "Electron Microscopy and Analysis", 3rd Ed., Taylor and Francis.	2001
2	Cullity B.D. and Stock S.R., "Elements of X-Ray Diffraction", 3rd Ed., Prentice Hall.	2001
3	Williams D. B. and Carter, C. B., "Transmission Electron Microscopy: A Textbook for Materials Science", 2nd Ed., Springer.	2009
4	Goldstein J., Newbury D.E., Joy, D.C., Lyman C.E., Echlin P., Lifshin E., Sawyer L. and Michael J.R., "Scanning Electron Microscopy and X-ray Microanalysis", 3rd Ed., Springer.	2003
5	Speyer R., "Thermal Analysis of Materials", CRC Press.	1993
6	Dehoff R.T. and Rhines, F.N., "Quantitative Microscopy", McGraw Hill.	1968
7	Silverstein Webster and Kiemle, "Spectrometric identification of organic compounds" 7th Ed., John Wiley and Sons.	2005
8	Nakamoto K., "IR and Raman spectra of inorganic and coordination compounds" 4th Ed., John Wiley and Sons.	1986
9	Winefordner J. D. (Editor:), "Raman spectroscopy in chemical analysis" Vol. 157, John Wiley and Sons.	2000
10	Yang R., Analytical Methods for Polymer Characterization, CRC Press.	2018

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code:**PPL-512** Course Title: **Paper Making Chemistry**

2. Contact Hours: L:**3** T:**0** P:**0**

3. Examination Duration (Hrs.): Theory **3** Practical **0**

4. Relative eightage: CWS **20-35** PRS **0** MTE **20-30** ETE **40-50** PRE **0**

5. Credit: **3** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Prerequisite **Nil**

9. Objective: To impart knowledge regarding advances in chemistry aspects in stock preparation and papermaking.

10. Details of Course:

S. o.	Contents	Contact
1.	**Introduction:** Importance of papermaking chemistry; Fiber-fiber water bonding; Rheology, surface energy, and surface tension of colloidal systems.	5
2.	**Fiber Bonding:** Importance of fiber bonding; Theories of fiber bonding; Effect of surface tension on fiber bonding; Types of bonds in dried paper; Measurement of fiber bonding and strength of bonds; Factor affecting fiber bonding; Effect of conformability, plasticity and swelling upon fiber bonding; Effect of fibrillation, fines, hemicelluloses, lignin, water, recycling, of alumina, sizing, fillers and other additives on fiber bonding; Effect of conditioning on paper properties; Permanence and barrier properties and paper defects.	11
3.	**Sorption and Swelling:** Sorption and swelling of cellulosic materials in water and other media, types of adsorption, physical- and chemi-adsorption, surface area of cellulose and cellulosic materials.	5
4.	**Electrokinetic Properties of Cellulose:** Ion exchange, electrokinetic phenomena, effects of chemical environment and processing operations such as pulping, bleaching, and refining on electrokinetic properties.	8
5.	**Coagulation and Flocculation in Papermaking:** Coagulation with electrolytes, theory of flocculation and dispersion of colloidal materials, effects of additives on fiber flocculation	5
6.	**Retention Mechanism:** Charge neutralization, patch model, bridging, complex flocculation, dissolved and colloidal substances; Influence of shear.	4
7.	**Foam and Slime Control:** Nature of foam, foam formation and stabilization, effect of additives on foam stability, theory of antifoam action; Micro-organisms and slime formation, chemical slime control.	4
Total		42

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication/ Reprint
1.	Eklund D. and Lindstrom T.D., "Paper Chemistry: An Introduction", TAPPI Press.	1991
2.	Gess J.M "Retention of Fines and Fillers During Papermaking",	1998

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	TAPPI Press.	
3.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 4: Papermaking Chemistry (Ed. Neimo L.)", Finnish Paper Engineers' Association and TAPPI.	1999
4.	Kocurek M. J., "Pulp and Paper Manufacture, Volume 6: Stock Preparation (Ed. Hagemeyer R. W. and Manson D. W.)", TAPPI Press.	1992
5.	Roberts J.C. "Paper Chemistry", Blackie Academic & Professional.	1996
6.	Swanson J., "Colloid Chemistry of Papermaking Materials", TAPPI Press.	2002

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPL-513** Course Title: **Process Integration in Paper Industry**
2. Contact Hours: **L: 3** **T: 0** **P: 0**
3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: **CWS** 20-35 **PRS** 0 20-30 40-50 0

5. Credits: 3 6. Semester: **Autumn** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge about the applications of process integration aspects in pulp and paper industry.

10. Details of Course:

Sl. No.	Contents	Contact Hours
1	**Introduction:** Concept of process integration and its applications to various process operations; Role of thermodynamics in process design; Targeting of energy, area, number of units and cost, super targeting; Concept of water networking; Optimization using pinch.	8
2	**Pinch Technology:** Concepts, heat exchanger network analysis, maximum energy recovery (MER) network for multiple utilities and multiple pinches, optimum design of heat exchanger network, tank and mass integration.	12
3	**Applications:** Heat-integrated distillation columns, evaporators, dryers, reactors; Waste and wastewater minimization; Flue gas emission targeting; Heat and power integration.	10
4	**Process Intensification:** Introduction; Applications, correlations with process integration.	3
5	**Case Studies:** Black liquor evaporator, MF and MG cylinder drying, distillation column; Water networking using pinch analysis.	9
	Total Contact Hours	42

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11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	El Halwagi M. M., "Process Integration", 7th Ed., Academic Press.	2006
2.	Kemp I.C., "Pinch Analysis and Process Integration: A User Guide on Process Integration for the Efficient Use of Energy", 2nd Ed., Butterworth Heinemann.	2007
3.	Shenoy U.V., "Heat Exchanger Network Synthesis", Gulf Publishing Company.	1995
4.	Sinnot R. K., "Coulson & Richardson's Chemical Engineering, Volume 6: Chemical Engineering Design", 4th Ed., Butterworth Heinemann.	1999
5.	Smith R., "Chemical Process Design", 2nd Ed., McGraw Hill.	2005
6.	David Reay, Colin Ramshaw and Adam Harvey, "Process intensification: Engineering for Efficiency, Sustainability and Flexibility, 2nd Ed., Butterworth Heinemann	2008

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPL-514** Course Title: **Environmental Management**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: **CWS** 20-35 **MTE** 20-30 **ETE** 40-50 **PRS** 0 **PRE** 0

5. Credits: 3 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite:

9. Objective: To make the students conversant about various environmental issues and management aspects related to Paper Industry.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Environmental issues for paper industry; Emissions and effluents; Environmental policy of India, environmental laws and standards, corporate responsibility for environmental protection.	4
2.	**Pollution Prevention:** Process modification; Recovery of by- products from industrial emissions and effluents; Energy and fresh water minimization, energy recovery; Housekeeping for limiting fugitive emission and leakages; Pollution dispersion and diffusion.	7
3.	**Pre and Primary Treatment:** Dilution, neutralization, sedimentation, coagulation and flocculation; Process design calculation	5
4.	**Biological Treatment:** Anaerobic and aerobic treatment of carbonaceous matter; Various treatment systems such as trickling filters, lagoons, UASB reactors and activated sludge processes; Sludge disposal and management; Process design calculation	9
5.	**Tertiary Treatment:** Color and toxicity removal systems, adsorption, membrane treatment systems, advance oxidation process; Process design calculation; Construct wetlands	7
6.	**Air Pollution Control:** Sources and quantities of pollutants; Particulate emission control by mechanical separation and electrostatic precipitation, wet gas scrubbing, gaseous emission control by adsorption and adsorption.	4
7.	**Solids Wastes:** Sources and quantities of solid waste in paper industry; Characterization and disposal methods; Compositing, landfill and briquetting; Pyrolysis, gasification and incineration; Reuse.	6
	Total	42

11. Suggested Books:

S. No.	Name of Book / Authors	Year of Publication/ Reprint
1.	Eckenfelder W.W. and Ford D., "Water Pollution Control" 3rd Ed., Jonkins Publishing Company.	2000
2.	Pollution Control Acts, Rules and Notifications, Central Pollution Control Board, New Delhi.	2003
3.	Pichtel J, "Waste Management Practices: Municipal, Hazardous and Industrial", CRC Press.	2005
4.	Tchobanoglous G., Burton B.L., Metcalf L., and Stensel H.D., "Waste Water Engineering" 4th Ed., McGraw Hill.	2008
5.	Vallero D, "Fundamentals of Air Pollution", 4th Ed., Academic Press.	2007

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPL-515** Course Title: **Printing and Converting Operation**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits: 3 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To familiarize the students with printing principles and processes and knowledge of web converting operations.

10. Details of Course:

Sl. No.	Contents	Contact Hours
1.	**Introduction to Printing:** Different printing processes include letterpress, lithography/offset, gravure, flexography, and screen printing.	5
2.	**Printing Machinery:** Sheet and web-fed machines; Plate-making methods for letterpress, lithography, flexography, and gravure printing; Pre-make-ready concepts; Ink and water balance in lithography; Screen mesh, frames, and different method of stencil preparation.	9
3.	**Printing inks:** General characteristics, physical properties, drying mechanism, formulation of inks for different printing processes and specific end-use applications; Constituents of inks: pigments and dyestuffs, oils, solvents, resin, plasticizers, driers, waxes, surfactants, antioxidants, and other additives.	7
4.	**Graphic Reproduction:** Line and halftone production; Colour reproduction; Process photography; Process films; Colour filters; Colour separation; Halftone screen angles; Black printer; Colour correction.	7
5.	**Colour Science and Engineering:** Attributes of colour; Principles of colour reproduction; Colour measurement; Tristimulus values; Chromaticity diagrams; CIE colour spaces; Colour-difference; Colour conversion and separation; Tone reproduction and colour balance; Spectral sensitivities for colour separation; Halftone dots Murray Davis and yule-Neilson equations; Additivity and proportionality of densities; Mathematical analysis of colour correction; Colour matching and mixing; Colour proof.	10
6.	**Introduction to digital printing:** Thermal printing; Electrostatic	4

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	printing; Laser printing; Ink jet printing; Desktop publishing.	
Total Contact Hours		**42**

11. Suggested books:

S. No.	Name of Authors/Book /Publisher	Year of Publication/ Reprint
1	Kocurek, M. J., "Pulp and Paper Manufacture, Volume 8: Coating, Converting, and Specialty Papers (ed. Kouris, M.)", TAPPI Press	1990
2	Adams J.M., Faux. D.D. and Rieber L.J., "Printing Technology" 4th ed., Delmar Publishers	1996
3	Gullichsen, J. and Paulapuro, H., "Papermaking Science and Technology, Book 11: Pigment Coating and Surface Sizing of Paper (ed. Lehtinen, E.)", Finnish Paper Engineers' Association and TAPPI	2000
4	Gullichsen J. and Paulapuro, H., "Papermaking Science and Technology, Book 12: Paper And Paperboard Converting (ed. Savolainen, A.)", Finnish Paper Engineers' Association and TAPPI	1999
5	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 13: Printing (Ed. Oittinen P. and Saarelma H.)", Finnish Paper Engineers' Association and TAPPI.	2012
6	Noemer E.F., "The Handbook of modern halftone photography" Perfect Graphic Arts.	1982
7	Harald Johnson, "Mastering Digital Printing, 2nd ed." Cengage Learning PTR	2004

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPL-516** Course Title: **Packaging Papers and Boards**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: **CWS** 20-35 **PRS** 0 **MTE** 20-30 **ETE** 40-50 **PRE** 0

5. Credits: 3 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To familiarize the students with various types of packaging paper and boards

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Paper and board for packaging:** Use of paper and paperboard in flexible and rigid packaging, comparison with other packaging materials, kraft paper, flexible packaging paper, extensible kraft; Grades of paperboard, multilayer boards, solid bleached board, unbleached kraft paperboard, uncoated recycled paperboard, coated recycled paperboard, application of various board in packaging	8
2.	**Paper Board Manufacture:** Forming section, wet pressing, drying, and calandering.	4
3.	**Paper and board:** Paper and paperboard properties, their control during the manufacture of paper	4
4.	**Pigment Coating**: Pigments, binders, additives, coating formulations and preparation of coating mixture, coating techniques, properties of coated paper and board	5
5.	**Converted Products**: Converted paper products; Pigment and functional coating; Corrugating, laminating; Manufacturing of Packages: Pouches, sacks, boxes, cartons, composite cans and fiber drums, aseptic drink boxes	4
6.	**Corrugating:** Corrugated board types and properties; Production of corrugated board; Gluing; Quality control.	3
7.	**Manufacturing of Packages**: Pouches, sacks, boxes, cartons, composite cans and fiber drums, aseptic drink boxes, package printing, sealing and gluing, liquid packaging	3
8.	**Polymer dispersions as Barrier coatings:** Properties of the polymers used, application techniques, rheology of polymer dispersions, properties of polymer dispersion films	4
9.	**Extrusion coating:** Extrusion coating plastics, substrates, extrusion coating process, properties and applications of extrusion coated products.	4
10.	**Lamination**: laminating methods, laminating substrates, adhesives, properties of laminated paper and board products	3
	Total	42

11. Suggested Books:

S. No.	Name of Book / Authors	Year of Publication
1.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 12: Paper And Paperboard Converting (Ed. Savolainen A.)", Finnish Paper Engineers' Association and TAPPI.	2012
2.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 13: Printing (Ed. Oittinen P. and Saarelma H.)", Finnish Paper Engineers' Association and TAPPI.	2012
3.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 17: Pulp and Paper Testing (Ed. Levlin J.-E. and Söderhjelm L.)", Finnish Paper Engineers' Association and TAPPI.	2012
4.	Mark R. E., "Handbook of Physical and Mechanical Testing of Paper and Paperboard", Vol. 1,	2002

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	Marcel Dekker.	
5.	Brudson J.A., " Plastic materials" , Newnes Butterworth	**1989**
6.	Campbell I.M., "Introduction to synthetic polymers", Oxford University Press	**2000**
7.	Erhstein G., "Polymeric materials", Hanser-Gardner	**2001**
8.	Korschwitz J., "Polymer Characterization and Analysis", John Wiley	**1990**

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPT-502** Course Title: **Environmental Control**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: **CWS** 20-35 **PRS** 0 **MTE** 20-30 **ETE** 40-50 **PRE** 0

5. Credits: 3 6. Semester: 7. Subject Area:

8. Pre-requisite: **Nil**

9. Objective:

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Environmental issues for paper industry; Emissions and effluents.	3
2.	**Environmental Controls:** Regulatory Controls; Handling of environmental issues by the EU; Environmental protection policy, Basic Principles, Environmental action programs, The IPPC Directive, Eco-Management and Audit Scheme(EMAS), Environmental labels, Packaging and Waste Packaging Directive, Environmental-related information and the European Environment Agency(EAA), Environmental Protection legislation, Economic instruments, Market instruments, Other measures.	6
2.	**Environmental permits for industry :** Discharge of effluents to receiving waters, Location-related environmental permits, Environmental Impact Assessment (EIA).	4
4.	**Effluent loadings from the forest industry:** Measurement of effluent discharges,Discharge levels from manufacturing processes, Process modifications to reduce emissions; Sulfate pulp production, Mechanical pulps, Recycled fiber, Paper and board, Sawmills.	4
5.	**Raw Water Treatment:** Quality requirements, Impurities, Treatment methods and equipment: Mechanical Treatment, Chemical Treatment, Flocculation, Clarification, Filtration, Water supply system.	4
6.	**Effluent Treatment:** Solids Removal: Clarification, flotation and filtration, Chemical coagulation and Flocculation, Biological methods; Activated sludge process, Other aerobic treatment, Anaerobic processes, Other Treatment Methods: Activated carbon adsorption, Evaporation, Lignin removal process, Stripping, Ion exchange, Chemical oxidation, Freezing, Removal of organic matter in effluent treatment.	4
7.	**Reducing emissions to Air:** Flue gases and the need for treatment, Ways of reducing particulate emissions,Ways of reducing sulfur dioxide emissions, Reducing nitrogen oxide emissions, Simultaneous removal of NO2 and SO2, Biological gas treatment, collection and disposal of concentrated and Dilute maladorous gases; Concentrated malodorous gases, Dilute Malodorous gases.	6
8.	**Solids and liquid Wastes:** Waste volumes from different production processes; Sludges, Ash, Other wastes, Amounts of waste per product, Waste handling; Sludge handling, Sludge handling methods, Waste Incineration; Combustion of sludge, Landfilling of wastes, Landfilling of Sludges, Disposal of	5

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	other wastes; Soil improvement, Returning sludge to the production process, production of animal feeds from sludge, Other Products from sludge.	
9.	**Other Environmental Impacts and their Reduction:** Wood Procurement, Noise abatement, Transport.	**3**
10.	**Tools for Environmental Management:** Economic calculations, Life-cycle Analysis, Environmental systems, Environmental Impact Assessment.	**3**
	Total	**42**

Suggested Books:

S. No.	Name of Book / Authors	Year of Publication
1	Brune, D., Chapman, D. V., Gwynne, M. D. and Pacyna, J. M., "The Global Environment: Science, Technology and Management", Marcel Dekker	**1996**
2	Environmental Issues and Technology in Pulp and Paper Industry – TAPPI Press Anthology of Published Papers, 1991-94	**1995**
3	Gullichsen, J. and Paulapuro, H., "Papermaking Science and Technology, Book 19: Environmental Control (ed. Hynninen, P.)", Finnish Paper Engineers' Association and TAPPI	**1998**
4	Nebel, B. J., Adams, C. E. and Wright, N., "Environmental Science – The Way World Works", 4th Ed., Prentice Hall	**1999**

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Paper Technology

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NAME OF DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPT-501** Course Title: **STAR-Pulp, Paper, and Packaging**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: **CWS** 20-35 **PRS** 0 **MTE** 20-30 **ETE** 40-50 **PRE** 0

5. Credits: 3 6. Semester: **Autumn** 7. Subject Area:

8. Pre-requisite: **Nil**

9. Objective: To familiarize the students with various types of pulping methodologies, bleaching, and paper-making for packaging

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Raw Materials Pulping and Chemical Recovery:** Overview of Pulping Methodology: Mechanical Pulping, Sulfite Pulping, Kraft Pulping,Black liquor Oxidation, Evaporation, Recovery Boiler, Recausticizing, Recovery of Sulphite Liquors Alternative Kraft Recovery.	4
2.	**Bleaching:** Bleaching Sequences, Preparation of Bleach Chemicals, Chlorination & Extraction, Oxygen Bleaching, Hypochorite Bleaching, Chlorine Dioxide bleaching, chlorine Dioxide Bleaching, Peroxide Bleaching, Ozone Bleaching, Bleaching Equipment, Recycle of filtrates, Pulp Brightening.	5
3.	**Stock Preparation:** Repulping(Dispersion), Refining: Mechanism of Refining, Variables affecting Refining Types of Refiners, Effect of Refining on Paper Properties, Metering and Blending of furnishes, Structural, Optical and Mechanical Properties of Paper	5
4.	**Paper Making and Testing:** Wet End Operations: Introduction to the paper Machine, Approach System, Flowspreader and Headbox, Sheet-forming process, Wire-part (Fourdrinier), Twin-Wire Forming, White Water System, Broke System, Pressing, Vacuum System, Dry End Operations: Paper Drying, Calendering, Profile control, Reeling, Paper machine Drivers, Winding, Roll Finishing, Surface sizing.	6
5.	**Secondary Fibre Processing:** Waste water Procurement, Degree of Recycling, Re-pulping, Contaminant Removal, Deinking: Principles of deinking, washing and flotation deinking, Secondary Fiber Utilization	5
6	**Packaging Papers, Paperboard and Cardboard** Types of Packaging Papers (Kraft, Sack Kraft, Linerboard, Medium), Properties and Suitability for Packaging Applications, Specialized Packaging Papers (Greaseproof, Waxed, Water-resistant) , Paperboard and Cardboard Production, Folding Carton vs. Solid Board Packaging Properties and Applications of Different Grades, Sustainability Considerations in Paperboard Packaging	10
7	**Packaging Applications** Corrugated Boxes and Packaging, Folding Cartons and Retail Packaging, Bag Packaging and Sack Kraft Applications, Specialty Packaging Papers (Food Packaging, Medical Packaging)	5
	Environmental Considerations and Sustainability Sustainable Sourcing of Raw Materials	2

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8	Energy and Water Usage in Pulp and Paper Industry, Waste Management and Recycling Initiatives, Life Cycle Analysis and Carbon Footprint of Packaging Materials	

11. Suggested Books:

S. No.	Name of Book / Authors	Year of Publication
1.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 4: Papermaking Chemistry (Ed. Neimo L.)", Finnish Paper Engineers' Association and TAPPI.	1999
2.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 8: Papermaking Part 1, Stock Preparation and Wet End (Ed. Paulapuro H.)", Finnish Paper Engineers' Association and TAPPI.	2000
3.	Kocurek M. J., "Pulp and Paper Manufacture, Volume 6: Stock Preparation (Ed. Hagemeyer R. W. and Manson D. W.)", TAPPI Press.	1992
4	Smook G. A. "Handbook for Pulp and Paper Technologists", 7th Ed., TAPPI Press.	1989
5	Casey J. P. "Pulp and Paper Chemistry and Chemical Technology", Vol. 1, 3rd Ed., John Wiley and Sons.	1984
6	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 6: Chemical Pulping (Ed. Gullichsen J and Fogelholm C-J.)", Finnish Paper Engineers' Association and TAPPI.	1999
7	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 5: Mechanical Pulping (Ed. Sundholm J.)", Finnish Paper Engineers' Association and TAPPI.	1999

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8	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 7: Recycled Fiber and Deinking (Ed. Göttsching L. and Pakarinen, H.)", Finnish Paper Engineers' Association and TAPPI.	**2000**
9	Kocurek M. J., "Pulp and Paper Manufacture, Volume 3: Secondary Fibers and Non-wood Pulping (Ed. Hamilton F. and Leopold B.)", TAPPI Press.	**1987**
10	McKinney R.W.J., "Technology of paper Recycling", Blackie and Academic Professional.	**1995**
11	Twede, Diana, Susan EM Selke, Donatien-Pascal Kamdem, and David Shires. Cartons, Crates And Corrugated Board: Handbook of Paper and Wood Packaging Technology. DEStech Publications, Inc, 2014.	**2014**
12	Kirwan, M. J. (Ed.). (2012). Handbook of Paper and Paperboard Packaging Technology. John Wiley & Sons.	**2012**

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