

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Polymer & Process Engineering**

1. Subject Code: **PE-901** Course Title: **Engineering Polymeric Composites**

2. Contact Hours: **L: 3 T: 1 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 : **4** 6. Semester: **Autumn / Spring** 7. Subject Area: **Pre-PhD**

8. Pre-requisite: **Nil**

9. Objective: The course will impart knowledge of advanced composites for high-tech applications.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction: Need to reinforce polymers, particulate, short and continuous fiber and nano fibers reinforced composites based on thermoplastic and thermoset matrices.	1
2.	Particulate Polymeric Composites: Principles of reinforcing filler and particle selection, incorporation and packing of reinforcement particles, melt flow and rheology of particulate polymeric composites and their processing. Extrusion, Compounding, and Injection molding, Properties, statistical mechanics and semi-empirical equations for mechanical properties; Applications.	8
3.	Short Fiber Reinforced Polymeric Composites: Short Synthetic and Natural Fibers as Reinforcement Materials and their selection, orientation and its effects on reinforcement efficiency, melt flow and rheology of particulate polymeric composites and their processing. Extrusion, Compounding, and Injection molding, Properties, interface, compatibilizer, matrix modification, fiber treatment, statistical mechanics and semi-empirical equations for mechanical properties; Applications.	9
4.	Continuous Fiber Reinforced Thermoset Polymeric Composites: Thermosetting matrix resins, Reinforcing Fibers : Carbon, glass, kevlar, silica, boron fibers, fiber forms, orientation, aspect ratio, mats, fiber-matrix interphase, adhesion, interface improvement, interfacial agents, fiber surface treatment, matrix modification compatibilizer, Fabrication techniques processes and equipment, compression moulding, pultrusion and advanced processing properties and statistical mechanics, semi empirical equations for mechanical properties; Applications.	9
5.	Continuous Fiber Reinforced Thermoplastic Polymeric Composites: Thermoplastic resins, interphase, adhesion, interface improvement, interfacial agents, fiber surface treatment and matrix modification compatibilizer, Fabrication techniques processes and equipment, Applications.	8

6.	Nano Composites: Fillers: Plate, equi-axed, inorganic fillers, carbon and other nano tubes. Matrices: Engineering, high tech and liquid crystal polymer matrices. Processing; Direct and solution mixing, in-situ polymerization.	5
7.	Applications: Fire resistant, high temperature, automobile, and aerospace applications.	2
	Total	42

11. Suggested Books:

S. No.	Name of Books / Authors / Publisher	Year of Publication
1.	Ajayan P. M., Schadler L. S., Braun P. V., "Nanocomposite Science & Technology", Wiley-VCH.	2003
2.	De S and White J, "Short Fiber Composites", Technomic.	2006
3.	Palsule S., "Polymer Composites", New Age International	2008
4.	Summerscales J and Short D, "Fiber Reinforced Polymers", Technomic.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PPN-502** Course Title: **Washing and Bleaching**

2. Contact Hours: **L: 3 T: 1 P: 2/2**

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

4. Relative Weightage: **CWS : 20 PRS : 20 MTE : 20 ETE : 40 PRE : 0**

5. Credits : **4** 6. Semester: **Spring** 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/ Reprints
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. Götsching 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

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PPN-504** Course Title: **Papermaking**

2. Contact Hours: **L: 3 T: 1 P: 2/2**

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

4. Relative Weightage: **CWS : 20 PRS : 20 MTE : 20 ETE : 40 PRE : 0**

5. Credits: **4** 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 distributors; Headboxes, rectifier roll type, hydraulic headboxes, head control, control of jet velocity and jet angle	4
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	6
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	7
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	11
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	6
9	Paper Machine Safety: Vibration measurement and control; Corrosion measurement and control; Safety from steam, moving parts and chemicals	2
Total		42

List of Experiment

- i. Laboratory coating with different coating color compositions and super calendering
- ii. Evaluation of gloss, smoothness, porosity, and bending stiffness o the coated sheets
- iii. Determination of surface strength and oil absorbency of paper
- iv. Demonstration of printability testing with an IGT printability tester

- v. Preparation of handsheets with different dosage of dye and determination of color
- vi. Determination of formation factor
- vii. Determination of compression strength of paper & board

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

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PPN-512** 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 : 25 MTE : 25 ETE : 50 PRS : 0 PRE : 0**

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

8. Pre-requisite: **Nil**

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" 3 rd 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" 4 th Ed., McGraw Hill.	2008
5.	Vallero D, "Fundamentals of Air Pollution", 4 th Ed., Academic Press.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PPN- 514** 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 : 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 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, green house 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	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 , HCl, 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", 4 th 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", 7 th Ed., Academic Press.	2006
7	Kemp I.C., "Pinch Analysis and Process Integration: A User Guide on Process Integration for the Efficient Use of Energy", 2 nd Ed., Butterworth Heinemann.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PPN-516** 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 : 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 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/ Reprints
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

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PPN-522** Course Title: **Paper Making Chemistry**

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 impart knowledge regarding advances in chemistry aspects in stock preparation and papermaking.

10. Details of Course:

S.No.	Contents	Contact Hours
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 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.	14
3.	Properties variation: Effect of conditioning on paper properties; Permanence and barrier properties and paper defects, manufacturing variables that influence paper permanence, atmospheric properties affecting the permanence and durability of paper, reasons for change in various properties like brightness, strength properties and structural properties.	4
4.	Retention Mechanism: Charge neutralization, patch model, bridging, complex flocculation, dissolved and colloidal substances; Influence of shear.	4
5.	Chemistry of sizing agents: Chemistry of aluminium in papermaking, Aqueous coordinate chemistry, aqueous hydrolysis, olation and polymerization, distribution of aluminium species as a function of pH, aluminium adsorption; Basics of wetting and penetration, Licas's Washburn equation, factors affecting penetration,	3
6.	Chemistry of dry strength additives and wet strength additives.	2
7.	Paper Machine Water Chemistry: Com[osition of white water, origin of dissolved materials, mechanical, chemical deinked pulps, fillers chemicals; Influence of salts and dissolved substances in white water; Key parameters in controlling the chemistry in papermaking, solid contents and retention, ph, conductivity, charge, calcium ion concentration, aluminium ion, COD and TOC concentrations, silicate contents, temperature and gas contents, close loop systems.	5
8.	Paper machine Microbiology: Microbes, microbes in the taxonomic systems,	5

bacteria, fungi, algae and protozoa, cell composition, metabolic properties and growth conditions of microbes such as nutrients, temperature and pH, retention time and toxic compounds; Problems caused by microbes such as slime, runability, corrosion, additive and product problems; Problems that cause the occurrence of microbes in papermaking system, factors affecting the growth of microbes; identification of microbes.	
Total	42

11. Suggested Books:

S.No.	Name of Books / Authors	Year of Publication/ Reprints
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.	Roberts J.C. "Paper Chemistry", Blackie Academic & Professional.	1996
6.	Swanson J., "Colloid Chemistry of Papermaking Materials", TAPPI Press.	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PPN-524** Course Title: **Electrokinetics in Papermaking**

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 impart knowledge of electrokinetics in papermaking processes.

10. Details of Course:

S. No.	Contents	Contact 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 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", 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

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PPN-526** 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 : 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 impart knowledge regarding application of biotechnology in pulp and paper industry.

10. Details of Course:

S. No.	Contents	Contact 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 Publication/ 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" 3 rd Ed., Cambridge University Press.	1996

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PPN-528** 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 : 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 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 Publication/ 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 Recovery Boiler" TAPPI Press	1997
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

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PPN-532** 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 impart knowledge of principal features of web converting operations and converted products.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Printing Processes: Letterpress, flexography, gravure, lithography, and screen printing; Printing plates; Printing presses; Digital printing; Halftone printing; Plate making and printing operation	5
2.	Color and Color Images: Light and color, human visual system, measurement of color, reproduction of color	3
3.	Paper in Printing: Printing paper, runnability, printability, ink transfer	4
4.	Printing Inks: Composition of inks, pigments, binders, and additive; Optical properties; Rheological properties; Drying characteristics of printing inks.	3
5.	Introduction to pigment coating: Raw materials for paper coating, base stock, pigments, binders, and additives; Coating mixture preparation, pigment coating formulations	5
6.	Pigment Coating Processes: Application systems; Metering systems; surface sizing and film coating; Drying, calendering and finishing of pigment coated papers; Properties of pigment coated papers	5
7.	Adhesives in Converting: Theories of adhesion, measurement of wetting and adhesion,; Types and properties of adhesives.	3
8.	Corrugating: Corrugated board types and properties; Production of corrugated board; Gluing; Quality control.	4
9.	Dispersion Coatings: Solution and emulsion properties of polymers, preparation of polymer solutions, formation and properties of coating films, functional properties of coated papers; Coating methods, polymers used in functional coatings.	4
10.	Extrusion Coatings: Coating processes and equipment; Coated product properties; Application of extrusion coated products. and emulsion properties of polymers, preparation of polymer solutions, formation and properties of coating films, functional properties of coated papers; Coating methods, polymers used in functional coatings.	3
11.	Lamination and Other Converting Processes: Substrates for lamination; Laminating methods, drying, radiation curing; Laminated product application; Metalizing; Wax coating; Hot melt coating; Lacquer coating.	3
Total		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	Casey, J. P., "Pulp and Paper: Chemistry and Chemical Technology", Vol. 4, 3 rd Ed., John Wiley	1981
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

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PPN-534** 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 : 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 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	3

	perforation; Process of manufacture of air-laid papers, their characteristics and applications.	
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 Publication/ Reprints
1.	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
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

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PPN-536** 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 : 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 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	9
2.	Paper Board Manufacture: Forming section, wet pressing, drying, and calendering, paperboard properties and their control during manufacture	6
3.	Pigment Coating: Pigments, binders, additives, coating formulations and preparation of coating mixture, coating techniques, properties of coated paper and board	4
4.	Corrugating: Corrugated board types and properties; Production of corrugated board; Gluing; Quality control.	4
5.	Manufacturing of Packages: Pouches, sacks, boxes, cartons, composite cans and fiber drums, aseptic drink boxes, package printing, sealing and gluing, liquid packaging	5
6.	Polymer dispersions as Barrier coatings: Properties of the polymers used, application techniques, rheology of polymer dispersions, properties of polymer dispersion films.,	6
7.	Extrusion coating: Extrusion coating plastics, substrates, extrusion coating process, properties and applications of extrusion coated products.	4
8.	Lamination: laminating methods, laminating substrates, adhesives, properties of laminated paper and board products	4
	Total	42

11. Suggested Books:

S.No.	Name of Book / Authors	Year of Publication/ Reprints
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&2, Marcel Dekker.	2002
5.	Campbell I.M., "Introduction to synthetic polymers", Oxford University Press	2000

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PPN-538** 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 : 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 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 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", Vol. 7, TAPPI Press	1994
5	TAPPI Technical Information Papers, TAPPI Press	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PPN-541** Course Title: **Packaging Principles, Processes and Sustainability**

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

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

4. Relative Weight : **CWS 25 PRS 0 MTE 25 ETE 50 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 the basic concepts of packaging principles, process and machinery.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Objectives of packaging: Maintaining the products quality; Facilitating handling, transportation, and dispensation; Helping to create a brand image, product identity and customers satisfaction; Packaging criteria, appearance, protection against chemical and physical hazards, functions regarding end use performance and machine performance; Cost and cost effectiveness; Disposability.	5
2.	Packaging materials and forms: Materials and their properties, wood, paper and paper boards, corrugated boards, glass, metals and foils, polymers; Packaging forms- Bag, pouch, blisters, strip, collapsible tubes, cans, boxes and cartons.	4
3.	Package Production: Manufacturing and fabrication processes; Injection, blow, rotational, compression molding, thermoforming, extrusion; Lamination; Vacuum metalizing; Electroless and electrolytic plating; Carton making	4
4.	Food packaging: Food decay, Methods of food preservations; Aseptic packaging; Modified atmosphere packaging.	3
5.	Packaging Operations and Machinery: Fundamentals of packaging line operations, packaging machinery, process analysis and standards;	12

	Process flow from filling to cartoning; Products & materials flow; Container filling, capping/insert, induction cap sealing, liquid packaging, palletizing, flexible packaging, form fill seal; Labeling; Boxing; Cartoning; Packaging Machinery-Materials and Machine components, simple machines, functions of typical packaging machines, usual patterns of line layout and operation.	
6.	In-process controls: Packaging Line; Robotics, area Clearance, machinery reliability; On-line inspection, benchmarking, reconciliation; Recording - accurate and on-time; Automatic Identification, bar codes, radio frequency, magnetic stripe, biometrics, voice and optical character recognition.	6
7.	Packaging sustainability: Environmental issues in packaging; Ethics and social responsibility; Factors that enhance secondary use, recycling, recovery of resources and proper disposal; Regulatory and market drivers; An introduction to Life Cycle Assessment (LCA) and other tools; Evaluating environmental impacts; Design for Environment checklists; Alternative strategies to reduce waste across the product lifecycle; Eco-efficiency analysis of packaging; Managing for sustainability	8
	Total	42

11. Suggested Books:

S. No.	Name of Book / Authors	Year of Publication
1.	Joseph F. Hanlon, Robert J. Kelsey and Hallie Forcinio, "Handbook of Package Engineering, 3 rd ed." CRC Press	1998
2.	John R Henry, " Packaging Machinery Handbook: The complete guide to automated packaging machinery including packaging line design Paperback", CPP	2012
3.	Gordon L. Robertson, "Food Packaging: Principles and Practice", 3 rd ed., CRC Press,	2012
4.	Walter Soroka, "Fundamentals of Packaging Technology" Institute of Packaging Professionals	1999

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PPN-543** Course Title: **Packaging Materials**

2. Contact Hours: **L: 4** **T: 0** **P: 2**

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

4. Relative Weight : **CWS 15 PRS 25 MTE 20 ETE 40 PRE 0**

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

8. Pre-requisite: **Nil**

9. Objective: To familiarize the students with various types of packaging materials paper and boards, glass, metals, ceramics and polymer

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Paper and board: Paper and paperboard properties, their control during manufacture of paper	4
2.	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	10
3.	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	6
4.	Glass and Metals: Glass containers- manufacture, properties, application and testing; Fiberboard cartons; Composite containers; Drums; Tins: Cans; Formed containers; Steel drums; Aluminium foil, collapsible tube and containers; Cushioning mechanism, containerization, pelletisation, and cargo marking fragility assessment, design, testing; Wooden containers; Textile bags,	8
5.	Introduction to Polymer: Classification and nomenclature, average molar mass and distributions, size and shape, elastomers, fibres and plastics,	2

	synthetic and natural Polymers	
6.	Polymerization and Copolymerization: Polymerization reactions initiated by metal catalysts and transfer reactions, condensation, addition polymerization and emulsion polymerization, Ring opening polymerization, Polymer Stereochemistry, reaction of polymers; Theories of visco-elasticity, visco-elastic behaviour and its models, time-temperature superposition, characterization of viscoelastic nature of polymer; Polyolefins and Vinyl Polymers	5
7.	Polymers for Films and Sheets: Structure, properties and morphology of film and sheet forming polymers; Types of packaging, film, sheet, and boxes, laminated packaging, packaging for electronic goods, commodity materials, medicines and food products.	7
8.	Mechanical Properties of Polymer: Stress-strain behaviour, models, tensile, compressive and flexural mechanical response, cold drawing, strain hardening, effect of temperature, plasticizer and additives on mechanical properties, characterization of tensile, compressive & flexural mechanical nature of polymers; Creep and Stress Relaxation, models, effects of cross-linking, temperature and other parameters; Dynamic Mechanical Thermal Properties, characterization of dynamic mechanical properties of polymer.	5
9.	Polymer Surface and Interface: Characterization by OM, SEM, TEM, ESCA, and XPS.	3
10.	High Performance Polymers: Epoxy, Polyesters, Polyurethanes, Polyimide, Polyamide, Polyether-ether Ketone and Liquid Crystal Polymers; Polymers for Engineering Application.	6
	Total	56

List of Experiments:

1. To determine Tensile index and stretch of paper and paper boards- Burst index, Folding endurance, and Tear index.
2. To determine Burst index, and Tear index of paper and paper boards
3. To determine Crush properties of boards
4. To determine the Folding endurance and bending stiffness of paper and paper boards
5. To determine the bonding strength of paper board
6. To determine the barrier properties of Paper and boards
- 7.

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, Marcel Dekker.	2002
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

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PPN-544** Course Title: **Package Performance**

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

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

4. Relative Weightage: **CWS : 20 PRS : 20 MTE : 20 ETE : 40 PRE : 0**

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

8. Prerequisite : **Nil**

9. Objective: To impart knowledge of package performance

10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction: Role of packing in protection and preservation, containment, communication; Structural requirements of packaging.	5
2	Hazard in Packaging: Thermal, mechanical, climate condition, pressure, temperature, humidity, permeability, diffusion, leaching.	5
3	Standard Organization for Packaging Test Performance: International Organization for Standardization, ASTM International, European Committee for Standardization, TAPPI, Military Standards, International Safe Transport Association	2
4	General Performance Evolution: Mechanical hazard, shock, vibration, compression, notch during handling, storage, shelving, transportation, permeability, compatibility, migration, diffusion; Measurement of comparative legibility by means of polarizing filter instrumentation; Determining effect of packaging on food and beverage products during storage; Foreign odors in paper packaging, method for odor and taste transfer from polymeric packaging film, method for odor and flavor transfer from rigid polymeric packaging; Methodology – sequential analysis, methods for assessing modifications to the flavour of foodstuffs due to packaging; Standard practice for conditioning containers, packages, or packaging components for testing, standard atmospheres for conditioning and testing flexible barrier materials,	10
5	Testing of Performance of Packing during Shipping and Transport: Performance testing of shipping containers and systems, performance testing of packages for single parcel delivery systems, complete filled transport packages – general rules for the compilation of performance test schedules, packaged-products for Less-Than-Truckload (LTL) Shipment, packaged products for distribution centre to retail outlet shipment, thermal controlled transport packaging for parcel delivery system shipment, thermal transport packaging used in parcel delivery system	10

6	Specific Performance Criteria for Major Packaging Industry: Electronic industry test and performance criteria of mechanical damage, cooling, radio frequency noise, electromagnetic interference, electrostatic charge, environmental stress test, thermal shock; Food and pharmaceutical industry, safety of drug and pharmaceutical, barrier property, self life, compatibility, sterilizability, temperature and child resistance; Medical packaging, grading of medical packaging, barrier property, compatibility with product, sterilizability of product, visibility, low temperature properties, degradation conditioning resistance, child and temperature resistance,	10
Total		42

List of practical

1. Experiment on mechanical properties of packaging materials
2. Experiment on freshness of food and vegetables maintains by packaging materials and tested by calorimetric and other spectroscopy methods
3. Experiment on packaging in maintaining anti microbial activity
4. Experiment on coating properties of packaging materials
5. Experiment on seal properties of packaging materials
6. Experiment on barrier properties of gases through packaging materials

11. Suggested Books:

S. No.	Name of Book / Authors	Year of Publication
1.	Salvatore Parisi, "Food Industry and Packaging Materials - Performance-oriented Guidelines for Users", Smithers Rapra	2013
2.	Richard Coles, Mark J. Kirwan, "Food and Beverage Packaging Technology" 2 nd Edition, Wiley-Blackwell	2011
3.	Brandenburg, Richard K., Lee, Julian June-Ling, "Fundamentals of Packaging Dynamics", 4th ed., L.A.B. Equipment.	2001
4.	Joseph F. Hanlon, Robert J. Kelsey, Hallie Forcinio, "Handbook of Packaging Engineering", 3rd edition, CRC Press.	1998
5.	Sek M. and Kirkpatrick J., "Corrugated Cushion Design Handbook", VUT, 2001	2001
6.	ASTM STP 1294 Durability Testing of Nonmetallic Materials, 1996	1996
7.	Lockhart, H., and Paine, F.A., "Packaging of Pharmaceuticals and Healthcare Products", Lockhart, H., and Paine, F.A., Blackie,	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PPN-545** Course Title: **Printing Technology**

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

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

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

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

8. Pre-requisite:

9. Objective: To familiarize the students with printing principles and processes

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Introduction to different printing processes such as letterpress, lithography/offset, gravure, flexography, and screen printing.	4
2.	Graphic Reproduction: Line and halftone production, colour reproduction; Process photography, reproduction cameras, contact printer, enlarger, layout of a darkroom, process films, exposure, developer & their ingredients, development, colour filters, colour separation, halftone screen angles, black printer, colour correction; Digital photography and transmission scanner.	4
3.	Colour Science and Engineering: Attributes of color, principles of color reproduction, color measurement, tristimulus values, chromaticity diagrams, CIE color spaces, color-difference, digitizing color, color conversion and separation, tone reproduction and color balance, spectral sensitivities for color separation; Halftone dots-murray-davis and yule-nielson equations, additivity and proportionality of densities, mathematical analysis of color correction, neugebauer equations, four-color printing and the black printer, color management system, color matching and mixing, color proof.	9
4.	Printing inks: General characteristics, Physical properties, drying mechanism, formulation of inks for different printing processes and	6

	specific end-use applications; Constituents of inks: pigments and dyestuffs, oils, solvents, resin, plasticisers, driers, waxes, surfactants, antioxidants and other additives; Health and safety aspects; Ink Testing.	
5.	Printing machinery: Sheet and web fed machines; Methods of plate making for letterpress, lithography, flexography and gravure printing; Pre-make-ready concepts, ink and water balance in lithography. Screen mesh, frames, degreasing, and different method of stencil preparation.	8
6.	Introduction to digital printing: Thermal printing, electrostatic printing, laser printing, ink jet printing etc.; Desktop publishing	3
7.	Digital image processing: Digital image representation, CCD color capture, image enhancement, image manipulation, frame grabbing. Imagesetters and platesetters, Raster image processor technology (RIP), Imaging of a page, Data compression/decompression, image compression like jpeg, mpeg, fractals group; Image transform (Fourier transforms, FFT), image enhancement, spatial filtering, enhancement in frequency domain. Colour image processing.	8
	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 13: Printing (Ed. Oittinen P. and Saarelma H.)", Finnish Paper Engineers' Association and TAPPI.	2012
2.	Adams J.M., Faux. D.D. and Rieber L.J., "Printing Technology" 4 th ed., Delmar Publishers	1996
3.	Noemer E.F., "The Handbook of modern halftone photography" Perfect Graphic Arts.	1982
4.	Harald Johnson, "Mastering Digital Printing, 2 nd ed." Cengage Learning PTR	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

- NAME OF DEPTT./CENTRE: **Department of Paper Technology**
1. Subject Code: **PPN-546** Course Title: **Packaging Design**
2. Contact Hours: **L:3 T: 0 P: 2**
3. Examination Duration (Hrs.): **Theory : 3 Practical : 0**
4. Relative Weightage: **CWS : 15 PRS : 25 MTE : 20 ETE : 40 PRE : 0**
5. Credit : **3** 6. Semester: **Spring** 7. Subject Area: **PCC**
8. Prerequisite : **Nil**
9. Objective: To impart knowledge of packaging design
10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction: Definition of packaging, business requirement of packaging, marketing & packaging, customers & packaging, product protection & product communication through packaging.	2
2	Aspects of Package Design: Functional of product and package design, graphic design, structural design, soft ware for design, economics of design, transport storage aspect of design, hazard aspects of design.	2
3	Functional of Product and Package Design: Brand representation, product differentiation, product positioning, shifting behavioural pattern, cutting edge innovation.	2
4	Graphic Design: Role of graphic design, demographics and psychographics; Environment (Retail, OEM), package aesthetic, decoration, feature layout.	3
5	Functional Requirement of Package: Protection and preservation, containment, communication.	3
6	Structural Design Aspects: Predicting performance, role of structure, drawing of structure, prototype, testing criteria of performance.	3
7	Software of Design: Soft ware for packaging drafting, mould design, simulation of performance & manufacturing.	3
8	Economics of Design: Cost of development, material, processing, storage, handling, waste, transportation, insurance, and inventory.	4
9	Road Map of Package Design: Identification of design opportunity, explore value and market place, correlate with strategy, identify customer requirement and translate to voice and prioritize concept	10
10	Concept Development: Boundaries of design, flow of design, potential of design, criticality of design, understanding of variability, capability & impact of variability, minimize complexity, cost, maximize performance and adaptability, compare response and reduce noise in response; Optimization of details, control details to robustness, certify and document requirement, identification of implementation .	10
Total		42

List of practical

1. Experiment on design of food packaging
2. Experiment on design of pharmaceutical packaging
3. Experiment on design of health care products packaging
4. Experiment on design of cosmetic products packaging
5. Experiment on design of detergents and soaps
6. Design of packaging using computer aided programme.

11. Suggested Books:

S. No.	Name of Book / Authors	Year of Publication
1.	Julius Wiedemann, "Packaging Design Book", Taschen	2010
2.	"An International Survey of Package Design", Edited Walter Herdeg, Publisher Garphic press.	1984
3.	Structural Package Design by The Pepin Presson.	2007
4.	Kai Yang and Basem El Haik, "Design for Six Sigma: A Roadmap for Product Development", McGraw – Hill.	2008
5.	"Designing Sustainable Packing Design", Scott Boylston Laurence king	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PPN-547** Course Title: **Converting Processes for Packaging**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To introduce the students with the concepts of converting operation for packaging

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Paper and Board Converting: Wetting and adhesion; Corrugating production of corrugated board, adhesives for corrugating, factors affecting gluing behavior, requirements of the linerboard and fluting medium, testing of corrugated board; Laminating, paper laminates;	7
2.	Coating: Aqueous and solvent coatings; Extrusion coating, processes and equipment, coating plastics, substrates and main applications such as liquid packaging, flexible packaging, and photographic papers; Hot Melt Coating	6
3.	Web Fed Converting Operations: Flexible packaging line; Tape machines, industrial wrappings, unit operations in un-winders and re-winders; Tension control, edge guiding	3
4.	Injection Molding: Working principles of injection molding machine, temperature control, injection systems, starting and shut down procedures, process variables reaction injection molding.	4
5.	Blow Molding: Process, principles, and types product processing technology.	3
6.	Compression Molding: Machine descriptions, principles of operations, molding parameters; Optimization of processing parameters and troubleshooting; Common molding faults and their correction.	3
7.	Processing: Equipment and machinery for processing of packaging	3

	materials, principle, technology and operation of equipment, economics of packaging.	
8.	Transfer Molding Processes: Machine operations, principles, applications for product processing , vacuum resin transfer molding.	2
9.	Miscellaneous Processing Technologies: Principles and operations of casting, thermoforming, rotational molding and foam processing machines and processing of plastic products by these processes.	5
10.	Tooling & Molds Tool making processes: Die and die forming, equipment and methods materials for mold making, designing and drafting practice, design details for compression molds, transfer molds, blow and extrusion dies, typical exercises in mold design and production, two plate mold, three plate mold, hot runner mold, insulated runner mold, runners, gates, mold making, mold cooling.	6
	Total	42

11. Suggested Books:

S. No.	Name of Book / Authors	Year of Publication
1.	Belofsky H., “Plastics: Product, Design and Process Engineering”, Hanser-Gardner.	1995
2.	Griskey R., “Polymer Process Engineering”, Chapman and Hall.	1988
3.	Lee N.C., “Understanding Blow Molding”, Hanser Gardner.	2000
4.	Linder E. and Unger P., “Injection Molds’, Hanser Gardner.	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

- NAME OF DEPTT./CENTRE: **Department of Paper Technology**
1. Subject Code: **PPN-552** Course Title: **Smart Packaging**
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. Credit : **3** 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Prerequisite : **Nil**
9. Objective: To impart knowledge of logistic and supply chain management in business atmosphere.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction: packaging smartly, smart packaging, intelligent packaging, active packaging .smart packing of food and pharmaceutical products	8
2	Smart Packaging Benefit: Improved communication of product information, communication of product history and condition after packaging, increased integrity and activity of product, response to change in product atmosphere, product authenticity and act to counter to theft, appropriate communication of disposal, seal integrity,	8
3	Driver for Smart Packaging: Customer convenience, improved shelf life, communication on state of product, disposal of packaging, economics of smart packaging	4
4	Smart Packaging and its Active Ingredients Chemistry: Freshness indicator, time-temperature indicator, thermo chromic material, temperature indicator and controller, moisture absorber, moisture regulator, oxygen scavenger and carbon dioxide emitter, ethanol emitter, oxygen producer, amine, aldehyde scavenger, ethylene oxide absorber, microbial inhibitors	10
5	Smart Packing Structure and Chemistry of Products: Fruits and vegetable packaging, meat, fish and pouty product, beverages, spray household and cosmetic packaging, pharmaceutical and health care packaging	10
6	Issues Related Smart Packaging: Safety and regulation issue related to unreliable indicators, migration of packing material to products	2
Total		42

11. Suggested Books:

S. No.	Name of Book / Authors	Year of Publication
1.	Yam, K. L., "Encyclopedia of Packaging Technology", John Wiley & Sons.	2009
2.	Brody, A. L., "Active Packaging for Food Applications", CRC Press.	2001

3.	Kerry, J., and Butler, P., "Smart Packaging Technologies for Fast Moving Consumer Goods", John Wiley & Sons.	2008
4.	Active and Intelligent Food Packaging: Legal & Safety Concern by Dainelli, D; Nathalie Gontardb, Dimitrios Spyropoulosc, Esther Zondervan-van den Beukend, Paul Tobbacke (2008). Trends in Food Science & Technology 19 (1): 167–177, Retrieved 12 Nov 2014.	1997
5.	Soroka, W., "Illustrated Glossary of Packaging Terms", Institute of Packaging Professionals.	2008
6.	Katsumoto, Kiyoshi, "Oxygen Scavenging Layer Consisting Of Oxidizable Compound, Second, Separate Layer Consisting of Oxidation Catalyst", Katsumoto, Kiyoshi.	1997
7.	Cichello, Simon, "A Guide to Oxygen Absorbers", Retrieved March 2010.	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

- NAME OF DEPTT./CENTRE: **Department of Paper Technology**
1. Subject Code: **PPN-554** Course Title: **Optoelectronics in Packaging**
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. Credit : **3** 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Prerequisite : **Nil**
9. Objective: To impart knowledge of optoelectronics in packaging
10. Details of Course:

S. No.	Contents	Contact Hours
1	Present Status and Challenges in Optoelectronics: Detection of defects in packing, application in food packaging, application in F-tablets and other pharmaceuticals packing, application in health care products packing.	8
2	Methodology: Thermal, imaging, spectroscopy, optical sorting, biosensor, bio-luminance, polymerase chain reaction, eliza.	9
3	Probes: Temperature, pH, spectro-chip, fibre fluorescence, lens selection, evanescence , hostile environment, opto-chemical sensor	9
4	Designing and Development Optoelectronic Devices: Silicon sensors designing, nano sensors designing , spectroscopic sensors , luminance	9
5	Regulation & Packing Technology: FDA, food and drug cosmetic act, national regulation	7
Total		42

11. Suggested Books:

S. No.	Name of Book / Authors	Year of Publication
1.	Zirong Tang, Tielin Shi, Frank G. Shi, "Wiley Encyclopedia of Electrical and Electronics Devices", John Wiley & Sons.	2010
2.	Alan R. Mickelson, Nagesh R. Basayanthally, Yung Cheng Lee, "Optoelectronic Packaging", Wiley Interseience Series.	2006
3.	Oksana Ostroverkhovai, "Handbook of Organic Material for Optical and Opto-Electronic Devices", Woodhead Publishing Limited .	2006
4.	Leonid Kazoysky, "Optical Fiber Communication System". Publisher: Artech House Publishers	1996
5.	Kit L. Yam, "The Wiley Encyclopedia of Packaging Technology", Wiley and Sons.	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PPN-556** Course Title: **Robotics and Automated Packaging**

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

8. Prerequisite : **Nil**

9. Objective: To impart knowledge of robotics and automated packaging

10. Details of Course:

S. No.	Contents	Contact Hours
1	Robotics and Process Control Systems in Packaging: Basic principles & technologies of robotics and process control in food, pharmaceuticals and other industries, recent innovation, future scope	5
2	Probes in Robotics and Process Control: Various probes like thermal, optical, spectroscopic, imaging.	10
3	Machine Vision, Control and Integration: Machine vision, various sensors and integration, wireless control, data acquisition, integration and supervisory control.	10
4	Design & Development of Automated and Robotics Packaging System: Fundamental of design and development, fundamental of robotics, fundamental of automations, road map of design and development of automated system and robotics in packing industry	10
5	Application of Automation and Robotics in Packaging: Sorting, processing industry like fresh food product, poultry and meat, sea food, confectionery, thermal processing, low temperature and chilling application.	7
Total		42

11. Suggested Books:

S. No.	Name of Book / Authors	Year of Publication
1.	Robotics and Automation in Food Industry: Current and Future Technology Edited by D. Caldwell, Wood head Publisher	2013
2.	Industrial Robotics; Programming, Simulation and Applications edited by Low Kin Huat Publisher, Literature Verlag.	2011
3.	Robotics Zation Feasibility Study and Packaging / Containerization Feasibility Study Robert James Didocha Publisher Engineering Experiment Station Georgia Institute of Technology.	2006
4.	Robotics Meat, Fish and Poultry Processing Edited by Khodabandehloo Publisher, Springer.	1983

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PPN-558** Course Title: **Food and Pharmaceutical Packaging**

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

8. Prerequisite : **Nil**

9. Objective: To impart knowledge of food and pharmaceutical packaging.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction: Food packaging, pharmaceutical packaging, criticality and need.	2
2	Function of Packaging: Physical protection, barrier properties, compatibility, permeability, sterilizability, security convenience.	5
3	Factor Effecting Food and Pharmaceutical Packaging: External factor, climate/environment, temperature, pressure, humidity, microbes, air/ gases; Internal factors; product chemistry and compatibility to packaging, environment and microbial contamination/sterility.	5
4	Packaging Property & Standard Testing Procedure: Dimension, weight, coat weight, thickness, density, integrity, accelerated aging test and degradation, internal pressure, compatibility with product, permeation / barrier property, oxygen and other gas transmission property, porosity, puncture and seal test, vacuum leak, water resistance, water permeation and absorption, printing and coating performance, tensile strength in dry and wet conditions and mechanical weak point, seal strength, tear strength, wet burst test, cleanliness, chloride contents, sulphate contents, conditioning and flexural durability.	7
5	Processing of packaging material for food and pharmaceutical; Processing of sterile and non sterile packing material, GMP.	3
6	Sterilization & Testing: Process of sterilization using gamma rays, electron beam, ethylene oxide, low temperature oxidative sterilization and high temperature sterilization; Standard testing of sterilized packing material.	3
7	Typical Food Packing Structure & testing: Green vegetable, fruits, spices, prickles, milk, oil, fats and butter, beverages and confectionary, raw meat and uncooked food, semi cooked , cooked foods.	7
8	Typical Pharmaceutical Packaging Structure & Testing: Tables, liquids , gels, pastes, protein, enzymes, vaccines & other biological fluids, advanced controlled release pharmaceuticals.	3
9	Health Care Packaging: Disposable, medical textile, impacts and artificial packaging.	3
10	Packing waste and waste policy	4
Total		42

11. Suggested Books:

S. No.	Name of Book / Authors	Year of Publication
1.	Gordon L. Robertson, "Food Packaging: Principles and Practice", 2 nd edition, CRC Press	2006
2.	Jung H. Han, "Innovations in Food Packaging, Food Science and Technology", Academic press	2005
3.	Richard Coles, Derek McDowell and Mark J. Kirwan, "Food Packaging Technology", CRC Press	2003
4.	Edward Bauer, "Pharmaceutical Packaging Handbook", CRC Press	2009
5.	A. Kaushik, "Text book of Pharmaceutical Packaging", CRC Press	2011

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PPN-560** Course Title: **Hazardous Material Packaging**

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

8. Prerequisite : **Nil**

9. Objective: To impart knowledge of hazardous material packaging

10. Details of Course:

S. No.	Contents	Contact Hours
1	Hazardous materials: Explosive, dangerous gases, dangerous liquids, dangerous solids, oxidisers, peroxides, toxic and infectious materials, radioactive materials, corrosive materials, miscellaneous hazardous materials.	8
2	Classification of Hazardous Materials: MSDS of hazardous materials, compatibility classification dot grouping of hazardous materials, selection of packing materials, specification of packing material according to class.	8
3	Global Regulations: UN recommendation on the transport of dangerous goods, IATA dangerous goods regulation, international maritime goods code, globally harmonised system of classification and labelling of chemicals.	5
4	Regulation on Packing Material of Dangerous Materials: information and marking on packing material as per regulation on packing transport and storage of hazardous materials.	3
5	Customer Service and Logistics: Importance of customer service, component of customer service, measuring customer service.	2
6	Regulation on Size and Weight of Dangerous Material Packaging: Bulk container, non bulk container and intermediate bulk container.	4
7	Packaging Recommendation for Dangerous Goods and Testing: Packaging recommendation for class 4, 5, 6, and 8 and testing of packaging material for dangerous goods	4
8	Safety in Packaging and Moving of Dangerous Materials: Personal safety and during handling of dangerous material, precaution during moving and handling of dangerous material, emergency assistance and spill assistance	4
9	Route Map of Packing Hazardous Materials: Identification of hazard, segregation as per hazard, section of packing material and size as per hazard, marking of packing material as per regulation, packing and moving, responding to emergency, example of packaging hazardous material	4
Total		42

11. Suggested Books:

S. No.	Name of Book / Authors	Year of Publication
1.	Shipper's Guide to Loading and Securement of Hazardous Materials/Dangerous Goods in Intermodal Equipment-Highway, Rail and Water, Institute of Packaging Professionals	1999
2.	ASTM D4919-03 Standard Specification for Testing of Hazardous Materials Packaging.	2006
3.	Gazette of India: Extraordinary Part-II (3(i)) Ministry of Environment and Forest, Notification 8 th July 2011	2009
4.	Dangerous good regulations (DGR) .,IATA	2009
5.	Transport of Dangerous Goods Regulation, Canada , 28 th Oct ,2009	2009
6.	Eugene Meyer, Kindle, Chemistry of Hazardous Materials (6 th Edition)	2013

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PPN-562** Course Title: **Industrial Packaging**

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

8. Prerequisite : **Nil**

9. Objective: To impart knowledge of industrial packaging

10. Details of Course:

S. No.	Contents	Contact Hours
1	Aim of Industrial Packing: History of industrial packaging, classification of industry and packaging; Industrial packaging and its relation in heavy industry, consumer product, food industry; Pharmaceutical and health industry packing .	10
2	Materials, Operations and Present Trends in Industrial Packaging: Material used in industrial packaging, operation in industrial packaging, development of operation based on industry in industrial packing, industrial packing trends and innovation.	10
3	Industrial Packaging: handling, transportation, regulations, handling norms of industrially packed products, transportation and logistics methods of industrially packed goods, regulation in industrial packaging	5
4	Recent Trends: Networking and computer in industrial packaging, industrial packaging and automation in palletizing, industrial packaging container loading and robotics.	10
5	Design, Developments and Application of Industrial Packaging: Introduction to designing methods of industrial packaging, introduction to new process development of developing packaging material for industrial packaging, some application of industrial packaging products, future prospect of industrial packaging products	7
Total		42

11. Suggested Books:

S. No.	Name of Book / Authors	Year of Publication
1.	Walter Soroka , “Fundamental of Packaging Technology”” 4 th edition , Destech Publication.	2009
2.	Walter F. Friedman & Jerome , J. Kipness , “Industrial Packaging”, John wiley & sons	1960
3.	The Wiley Encyclopaedia of Packaging Technology, 2 nd Edition, Edited by Aaron L. Brody and Kenneth S. Marsh , Wiley –Inter science.	1997
4.	The Wiley Encyclopaedia of Packaging Technology , 3 rd Edition , Edited by Kit L. Yam, John wiley & Sons	2009
5.	James Z.R. Brights, Walter Fred Friedmen, Jerome J. Kipnees, “ Industrial Packaging : Material Handling and Packaging”, Literary Licensing .	2013

11. Suggested Books:

S. No.	Name of Book / Authors	Year of Publication
1.	Fundamental of packaging Technology – fourth edition , Destech Publication.2009	2009
2.	Industrial Packaging , Publication : Walter F Friedman & Jerome , J Kipness , John wiley & sons , 1960	1960
3.	The Wiley Encyclopaedia of packaging Technology , Second Edition , Edited by Aaron L Brody , Kenneth S Marsh , Wiley –Inter science , 1997	1997
4.	The Wiley Encyclopaedia of packaging Technology , Third Edition , Edited by Kit L Yam, 2009, John wiley & Sons	2009
5.	Automation World , magazine , Summit Media group, Inc, USA Packaging world magazine , Summit Media group, Inc, USA	
6.	Industrial Packaging : Material Handling and Packaging, James ZR brights, Walter Fred Friedmen, Jerome J Kipnees , Publisher Literary Licensing , 2013	2013

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PPN-563** Course Title: **Logistics and Supply Chain Management**

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. Credit: **3**

6. Semester: **Spring**

7. Subject Area: **PEC**

8. Prerequisite : **Nil**

9. Objective: To impart knowledge of logistic and supply chain management in business atmosphere

10. Details of Course:

S. No.	Contents	Contact Hours
1	Concept of Logistics: Distribution packaging-a systems approach, scope and definition, historical prospective, importance of logistics and distribution, logistics and supply chain structure.	4
2	Overview of Supply Chain Management: introduction, nature and concept of supply chain management, contribution of supply chain management, supply chain management system, supply chains specific to product groups and major differences.	4
3	Integrated Logistics and Supply Chain: The total logistic concept planning, the financial impact of logistics, globalization and integration, competitive advantage through logistics, logistics and supply chain management; Multi modal systems and their impact on packaging requirements	4
4	Strategic Supply Chain Management : Introduction to strategic supply chain management, supply chain in value chain perspective, strategic role of supply chain management –architecture	4
5	Customer Service and Logistics: Importance of customer service, component of customer service, measuring customer service.	4
6	Customer Value, Service and Channel Strategies in Supply Chain : Consumer value, customer service element & cost, gap analysis & service measurement	4
7	Key Issues, Challenges, Planning and Process : Key issues and challenges related to logistics, external environment , manufacturing and supply, planning for logistics with parameter to pressure for changing , design, product characteristics, product life cycles, packing , logistics process tools and technique	4
8	Value of Information and Order Management in Logistics and	4

	Supply Chain: Introduction, nature, concept and components of order management, market intelligence, demand forecast	
9	Transportation and Fleet Management: Location of transport supply, elements of transport, selection of transport and mode of transport, containerization.	4
10	Warehousing and Material Management, Procurement Management: Principle of ware housing, strategy, operation, storage and handling, pallet movement and ware housing design, cross docking, tracking distribution losses and evaluation distribution packaging.	4
11	Strategic Sourcing and Out-sourcing Management, Performance Measurement of Logistics and Supply Chain: Introduction, strategy of supply chain management, supply chain in value chain, customer value and supply chain.	2
Total		42

11. Suggested Books:

S. No.	Name of Book / Authors	Year of Publication
1.	D. K. Aggarwal, "Supply Chain Management", Publisher: Macmillan	2010
2.	Alen Rushton, Phil Croucher, Peter Baker, "Hand Book of Logistics and Distribution", Publisher: Kogan Page	2006
3.	James B. Ayers, Handbook of Logistics and Distribution", Publisher: Auerbach.	2006
4.	F. Robert Jacobs, Richard Chase, "Operation and Supply Chain Management", McGraw Hill	2014
5.	C. John Langley, Robert A. Novack, Brian J. Gibson, John J. Coyle, "Logistic Approach to Supply Chain Management", Cengage Learning India Pvt. Ltd.	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PPN-564** Course Title: **Sustainable Packaging**

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

8. Prerequisite : **Nil**

9. Objective: To impart knowledge of sustainable packaging

10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction: Definition of sustainable packing, criteria of sustainable packaging, cost, analysis of cost, analysis of life cycle of packaging, example of sustainable packaging used in industry , introduction to compass.	10
2	Life Cycle Analysis: Life cycle analysis, sustainable packing, waste management, producer responsibility, design for environment, streamlined life cycle analysis, recycling, carbon foot print.	10
3	Compass: Design process, consumption matrix, emission brief, packaging waste and its use, life cycle of packaging, how compass is helpful?	5
4	Costing and Sustainable Packaging: Opportunity analysis, present cost, specification analysis, automation probability , purchase of raw material	5
5	Price and Sustainable Packaging: Analysis of consciousness of customer towards green, readiness of customer to go green at higher cost, product positioning and greenness, market placement, pricing matrix.	10
6	Sustainable Packing and Software: Scenario based analysis, comparative analysis, cube utilization, integrated reporting engine.	2
Total		42

11. Suggested Books:

S. No.	Name of Book / Authors	Year of Publication
1.	Scott Boylston, "Designing Sustainable Packaging", Publisher: Laurence King Publishing.	2009
2.	Wendy Jedlicka, "Packaging Sustainability: Tools, Systems and Strategies for Innovative Package Design, Publisher: Wiley.	2012
3.	Verghese Karli, Lewis, Helen, Fitzpartrick, Leanne, "Packaging for Sustainability", Publisher: Springer.	2008
4.	Philips M. Parkar, "The 2011-2016 Outlook for Sustainable Packaging Services in India", Icon Group International.	2011
5.	Kem – Laurin Kramer, "User Experience in the Age of Sustainability", Publisher: Morgan Kaufmann.	2012

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

- NAME OF DEPTT./CENTRE: **Department of Paper Technology**
1. Subject Code: **PPN-565** Course Title: **Industrial Design**
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. Credit: **3** 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Prerequisite : **Nil**
9. Objective: To impart knowledge of industrial design
10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction: Definition of industrial design , history of industrial design, difference between industrial design and other aspect of product design, overlapping of product design and industrial design.	10
2	Component of Industrial Design: Aesthetic, ergonomics, functionality and /or usability.	4
3	Utility of Industrial Design: Marketability, brand development, improved production process.	3
4	Approach to Industrial Design: Opportunity analysis, concept development using CAD, prototype developments, optimization of details, industrial CT scan and CAD model.	5
5	Industrial Design & Product Improvement: Value addition ,value creation, value estimation in marketing, brand building, reduction in cost of production	5
6	Industrial Design and IPR: What is innovative design? newness in design, steps to approach for IPR.	5
7	Example of Iconic Industrial Design, its Value and Point of Sale: I pod of apple, Lurrelle Guild, vacuum cleaner, chair by Charles Eames and Russel Wright, coffee urn, 35 mm photography, first truck with a cab-over-engine configuration, Pacer, Gremlin, Matador coup, Jeep cherokee of automotive industry, electric razors, electrolux refrigerators, Le Creuset French ovens, model 1300 Volkswagen Beetle, electric guitars, calculator Olivetti Divisumma by Marcello Nizzoli, Western Electric Model 302 telephone etc	10

11. Suggested Books:

S. No.	Name of Book / Authors	Year of Publication
1.	Pulos, Arthur J., "The American Design Adventure 1940-1975", Cambridge, Mass: MIT Press	1988
2.	de Noblet, J., "Industrial Design", Publisher A.F.A.A.	1993
3.	Adrian Forty, "Objects of Desire: Design and Society Since 1750", Thames Hudson.	1992
4.	Maurice Barnwell, "Design, Creativity and Culture", Black Dog,	2011
5.	Denis A. Coelho, "Industrial Design – New Frontier", InTech. Open Access Publisher.	2011
6.	Jeffrey Meikle, "Industrial Design engineering in America", Temple University Press	1979
7.	Maurice Barnwell, "Design Evolution: Big Bang to Big Data", Publisher Barnwell,	2014

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PPN-566** Course Title: **Lamination and Functional Packing**

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

8. Prerequisite : **Nil**

9. Objective: To impart knowledge of lamination and functional packing

10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction: Lamination in packaging, advantage of lamination in packaging, application of laminated structure in packaging.	5
2	Laminated Structure in Packaging: laminated packaging of fruits, vegetables and food, beverage and confectionery, oils and fat, pharmaceuticals, biological fluids and health care.	10
3	Function of Laminated Structure in Packaging: Seal security and improved mechanical property of packaging material, barrier, controlled permeability of oxygen, water vapour etc., insulation and temperature control, surface compatibility of packaging material and product	5
4	Testing of Laminated Structure and Functional Coating: tensile strength, seal strength, burst strength, vapour permeability, gas permeability, conditioned testing, tape test, thickness test and density test etc.	5
5	Introduction to Functional Coating: chemistry of functional coating, fundamental, classification, mechanism of application like polyurethane dispersion, wax dispersion, acrylic dispersion, silicon nitride, tri peptide etc	5
6	Application of Functional Coating: Mechanism of performance of functional coating in the field of application of oil barrier, aroma preservation, cold seal, adhesion promoter, slip agent, blood compatibility and improved biomechanics, improved bio fouling etc	5
7	Lamination and Coating Machining: Water based, solvent based, solvent free coating and laminate manufacturing machine	7
Total		42

11. Suggested Books:

S. No.	Name of Book / Authors	Year of Publication
1.	Kit L. Yam, "The Wiley Encyclopaedia of Packaging Technology", 3 rd edition John wily & Sons Publication.	2010
2.	Shrikant Athayale, "Handbook of Printing and Packaging and Lamination",	2006
3.	Sina Ebnesajjad, "Plastic Film in Food Packaging : Materials, Technology and Application", Elsevier Science	2006
4.	Edward Bauer, "Pharmaceutical Packaging Handbook", CRC Press	2009
5.	J. M. Lagaron, "Multifunctional and Nanoreinforced Polymer for Food Packing", Woodhead Publication	2011
6.	Elizabeth A. Balwin, Robert Hagenmeir, Jinhe Ba, "Edible Coatings and Film to Improve Food Quality", CRC Press.	2011
7.	Aristippos Gennadios, "Protein – Based Film and coating", CRC Press	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PPN-567** Course Title: **Economics of Packaging**

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

8. Prerequisite : **Nil**

9. Objective: To impart knowledge of economics of packaging.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction: General need of packaging, benefit of packaging, cost of packaging, strategy of business and alignment of it to packaging, marketing & packaging of product. brand representation and packaging , packaging performance and functional requirement.	5
2	Introduction to Economics of Packaging: Packaging in a market economy, economy and commercial role of packaging communication.	5
3	Purchase Decision, Sale price and Cost: Packaging and purchase decision, pricing method in retail, distributor and direct consumer sale, effect of packing cost on sale price and contribution margin.	2
4	Price Point Based on Packaging: Material price, value addition perceived by customer due to packaging, competitor pricing strategy due to packing material, packaging material production cost, production losses, other losses, packing material quality control and assurance cost, transportation cost, alternate method of price quotation.	4
6	Packing Material Cost Evaluation: Vendor development, quantity and quality based cost, logistic and lead time and other commercial terms.	3
7	Design and Development Cost of Packing Material: Design cost, tooling, samples, sample evaluation, testing, test marketing, specifications, preparation, quality control, verification, certification and validation cost, start up cost.	4
8	Capital Investment and One Time Cost: Production machine, quality control instrument and accessory, tooling, dies, special moulds, and gravure cylinders etc.	4
9	Material costs: Basic unit price, special packing, freight, packaging materials storage and handling, sampling and inspection costs.	4
10	Packaging Processing Cost: Labour cost, distribution cost, utility, right off inventory cost, and practical examples.	7
11	Circular Economics of Packaging Materials: Introduction, structuring of circular economy of circular economy, retail and circular economy.	2
12	Economic Impact of the Packaging and Packaging Waste Classes: Packaging waste and waste management cost, Green dot scheme, economic aspect of recycling packaging material.	2
Total		42

11. Suggested Books:

S. No.	Name of Book / Authors	Year of Publication
1.	Gerald Stone, "Core Economics+ Business Case for Packaging", Publisher Worth Pap	2011
2.	William E. Brown, "Plastics in Food Packaging, Properties, Fabrication, Design", Marcel Dekkar	1992
3.	Paul Krugman, Robin Wells, Margaret Ray, David Anderson, "Microeconomics in Modules and Business Case in Packaging", Publisher: worth.	2011
4.	Brijesh K. Tewari, Tomas Norton, Nicholas M. Holden, "Sustainable Food Processing", John Wiley & Sons	2014
5.	Scott A. Morris, "Food and Package Industry", John Wiley & Sons.	2011

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

- NAME OF DEPTT./CENTRE: **Department of Paper Technology**
1. Subject Code: **PPN-568** Course Title: **Nanotechnology Application In packaging**
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. Credit: **3** 6. Semester: **Spring** 7. Subject Area: **PP**
8. Prerequisite : **Nil**
9. Objective: To impart knowledge of Nanotechnology application in packaging.
10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction: Nanotechnology, nanomaterials, nanostructure , nano and micro scale materials and its properties and variation, application of nano material in packaging, synthesis of nanomaterials: top down, bottom up approach; nanofabrication: thin film, nanowire, carbon nanotubes.	10
2	Function of Nanomaterial in Packaging: Physical protection, barrier properties, compatibility, permeability, sterilizability, security convenience.	5
3	Applications of Nanotechnology: Nanotechnology in printing, nanotechnology in coating, nanotechnology in electronics, optoelectronics, and photonics packaging, low and high- materials for micro- and nano-electronics packaging, nanotechnology in supply chain/security, nanotechnology in paper-based packaging, social and environmental impacts of nanotechnology in packaging, life cycle analysis and economical feasibility of nanocomposites in barrier packaging market.	10
4	Nanomaterials in Packaging: Clay, silver, silicate etc.	3
5	Polymers, Nanocomposites and Ink in Packaging and its Processing: PP, PE, nylon and polyamide, EVOH, PLA and copolymers, starch, nanoink composition, testing and evaluation of performance.	5
6	Some Example of Nanopackaging materials: Nanotechnology and food packaging, electronic packaging, health care packaging.	2
7	Nanotechnology, Testing, Regulation & Safety: Toxicity and food packaging, instrumental method of testing, premarket approval, safety regulation and safety aspects covered in existing regulations, regulations that need modification, nanotechnology and future packaging.	7
Total		42

11. Suggested Books:

S. No.	Name of Book / Authors	Year of Publication
1.	Leslie Pray, Ann Yaktine, Rapporteurs, "Nanotechnology in Food Products", National Academics Press.	2009
2.	Ian Barnett, "The Nanotechnology Opportunity in Food and Drinks Packaging", Datamonitor Consumer.	2011
3.	Amar K. Mohanty, Manjusri Misra and Hari Singh Nalwa, Manjusri Misra, "Packaging Nanotechnology Hardcover", American Scientific Publishers.	2006
4.	Bhusan, "Spinger Handbook of Nanotechnology", 2 nd Revision, Springer.	2011
5.	M Lagarón, "Multifunctional and Nanoreinforced Polymers for Food Packaging", Woodhead Publishing.	2011

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

- NAME OF DEPTT./CENTRE: **Department of Paper Technology**
1. Subject Code: **PPN-570** Course Title: **Advance analytical Techniques**
2. Contact Hours: **L : 3 T : 0 P : 2/2**
3. Examination Duration (Hrs.): **Theory : 3 Practical : 0**
4. Relative Weightage: **CWS : 20 PRS : 20 MTE : 20 ETE : 40 PRE : 0**
5. Credit: **3** 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Prerequisite : **Nil**
9. Objective: To impart knowledge of advance Analytical techniques
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to advanced characterization Techniques: brief discussion on importance, history, current and prospective applications	2
2	Spectroscopic Characterization: Vibrational spectroscopy (IR and Raman spectroscopy), UV-visible and photoluminescence, ESCA, atomic absorption spectra, NMR, mass spectroscopy. Elemental analysis: CHNSO, Inductively coupled plasma optical emission spectroscopy.	10
3	Phase, Structural and microstructure Characterization : Introduction to X-rays, crystal structures, structural factor, principle of X-ray diffractions, single phase analysis, multi-phase analysis, estimation of particle size and strain, studying nano/meso-structures by XRD. Introduction to optical, fluorescence and confocal microscopy; Electron microscopy, Construction details of electron microscopes e.g. SEM, TEM and STM and their detailed working principle to study different nano/micro/meso structures; Principle and usage of atomic force microscopy (AFM).	12
4	Electrical and Thermal Properties: Conductivity measurement via two and four probe method of ceramic, polymer and metals, Dielectric properties, Dielectric Constant, Dielectric loss, Advanced techniques for thermal characterization; TGA, DSC,DMA,TMA etc, shielding effect.	10
5	Polymer and Packaging characterization: Mechanical performance of polymeric material in packaging, permeability, structure reaction between structure and permeability, polymeric and cellulogic materials	5
6	Application in Packaging: performance and analysis of packaging material, Application of characterization in packaging: Food packaging, Cosmetic and Nutraceutical packaging , Pharmaceutical & Health care packaging, electronic packaging etc	3

	Total	42
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List of Practicals:

1. Spectroscopic characterization of given material (inorganic/organic/packaging material) like FTIR, NMR
2. Structural and morphological analysis of amorphous/crystalline material by XRD/ FESEM
3. Thermal properties of polymer/ceramic by TGA, DTA etc.
4. Electrical properties of polymeric and packaging material by two probe /four probe method
5. Evaluation of dielectric properties of material (Dielectric constant, Dielectric loss)
6. Surface properties by Atomic Force Microscopy of polymeric thin/thick films

11. Suggested Books:

S.No.	Name of Books/Authors	Year of publication
1	Richard K. Ulrich , William D. Brown, “Advanced Electronic Packaging, 2 nd Edition”, Wiley-IEEE Press	2006
2	Jack Cares, “Analytical Instrumentation Handbook”, 3 rd Edition, CRC Press	2004
3	Richard Coles, Mark J. Kirwan, “Food and Beverage Packaging Technology” 2 nd Edition, Wiley-Blackwell	2011
4	Hobart H. Willard, Lynne L. Merritt Jr, John Dean, “Instrumental Methods of Analysis (Chemistry) Hardcover”, Wadsworth Publishing Co Inc	1988
5	Yam K L, “Encyclopedia of Packaging Technology”, John Wiley & Sons	2009
6	Lockhart, H., and Paine, F.A., "Packaging of Pharmaceuticals and Healthcare Products", Lockhart H and Paine F A ,Publisher Blackie	2006
7	Dehoff, R.T. and Rhines, F.N., “Quantitative Microscopy”, McGraw Hill	2000
8	Silverstein, Webster & Kiemle, “Spectrometric identification of organic compounds” 7 th Ed. John Wiley and Sons	1986
9	Speyer, R., “Thermal Analysis of Materials”, CRC Press	2005
10	K. Nakamoto, “IR and Raman spectra of inorganic and coordination compounds” 4 th Ed., John Wiley and Sons	1968
11	J. D. Winefordner, “Raman spectroscopy in chemical analysis” Vol. 157, John Wiley and Sons	1993

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPT/CENTRE : **Department of Polymer and Process Engineering**

1. Subject Code: **PP-918** Course Title: **Data Mining Applications in Ecommerce**

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: **Both** 7. Subject Area : **DEC**

8. Pre-requisite: **Nil**

9. Objective: To understand the role of data mining in Ecommerce environment.

10. Details of Course:

S. No.	Contents	Contact hours
1.	Introduction: Overview of data mining, functionalities, data pre-processing, cleaning, integration, transformation, reduction and discretization.	5
2.	Association Analysis: Market basket analysis, frequent pattern mining, mining association rules, correlation analysis, constraint based association mining.	4
3.	Classification and Prediction: Introduction to classification and prediction, classification by decision tree, bayesian classification, rule-based classification, lazy learners, regression analysis for prediction, evaluating accuracy of classifier/predictor.	4
4.	Cluster Analysis: Data types for cluster analysis, hierarchical clustering, centroid-based clustering, distribution-based clustering, density-based clustering, constraint based clustering, outlier analysis.	4
5.	Web Mining: Introduction to web mining, mining data streams, link analysis, social network analysis.	6
5.	Introduction to Ecommerce: Origin and growth, infrastructure, business models, security and payment systems.	4
6.	Ecommerce Marketing and Advertising: Consumer behaviour and purchase decisions, marketing and advertising strategies and tools.	5
7.	Applications: Introduction to data mining softwares, advertising on web, recommendation systems, behavioural analysis, personalization system, stock market analysis, security analysis and portfolio management, financial Performance Analysis.	10
	Total	42

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Jiawei H., and MichelineK., “Data Mining: Concepts and Techniques”, Morgan Kaufmann Publishers.	2011
2.	Russell M., “Mining The Social Web”, O’reilly Publishers.	2013
3.	Ian H.W., Eibe F., and Hall M., “ Data Mining: Practical Machine Learning Tools and Techniques”, 3 rd Ed., The Morgan Kaufmann Series in Data Management Systems.	2011
3	Laudon K., Traver C., “E-commerce: Business. Technology. Society”, Pearson.	2013
4.	Hanson W., and Kalyanam K., “ Internet Marketing &Ecommerce”, 2 nd Ed., Cengage Learning.	2012
5.	Linoff G., and Berry M., "Data Mining Techniques: For Marketing, Sales, and Customer Relationship Management”, 3rd Ed., Wiley.	2011