Syllabus - Packaging Tech (updated)

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Name of DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPC-521** Course Title: **Packaging Principles, Processes and Sustainability**

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

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

4. Relative Weight : **CWS 25-35 PRS 20 MTE 20-30 ETE 40-50 PRE 0**

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

8. Pre-requisite: **Nil**

9. Objective: To 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 customer's 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

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	Process flow from filling to cartooning; 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, 3rd 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", 3rd ed., CRC Press,	**2012**
4.	Walter Soroka, "Fundamentals of Packaging Technology" Institute of Packaging Professionals	**1999**

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Name of DEPTT./CENTRE: **Department of Paper Technology**

1. Subject Code: **PPC-523** Course Title: **Packaging Materials**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To 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	2
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	6
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	3
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,	6
5.	**Introduction to Polymer:** Classification and nomenclature, Average molar mass and distributions, Size and shape, elastomers, Fibres and plastics,	2

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Head of Department
Paper Technology

	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	3
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, P ackaging for electronic goods, commodity materials, Medicines and food products.	3
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.	3
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.	2
	Total	**42**

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

Head of Department
Paper Technology

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**

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

1. Subject Code: **PPC-525** 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 20-35** **PRS 0** **MTE 20-30** **ETE 40-50** **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

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	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**

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

1. Subject Code: **PPC-527** Course Title: **Package Performance**
2. Contact Hours: **L:0** **T: 0** **P: 6**
3. Examination Duration (Hrs.): **Theory : 0** **Practical : 6**
4. Relative Weightage: **CWS : 15-30** **PRS : 20** **MTE : 15-25** **ETE : 30-40** **PRE : 0**
5. Credit : **3** 6. Semester: **Autumn** **7.** Subject Area: **PCC**
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

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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, Sterlizibility, Temperature and Child resistance; Medical packaging, Grading of medical packaging, Barrier property, Compatibility with product, Sterilizibility 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" 2nd 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

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

1. Subject Code: **PPC-529** Course Title: **Packaging Design**

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

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

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

5. Credit : **2** 6. Semester: **Autumn** 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, Software 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 behavioral 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:** Software 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

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Paper Technology

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

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

1. Subject Code: **PPC-531** 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 : 20-35 PRS : 0 MTE : 20-30 ETE : 40-50 PRE : 0**

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

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, Sterilizibility, 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**

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11. Suggested Books:

S. No.	Name of Book / Authors	Year of Publication
1.	Gordon L. Robertson, "Food Packaging: Principles and Practice", 2nd 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

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

1. Subject Code: **PPL-517** 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 : 20-35 PRS : 0 MTE : 20-30 ETE : 40-50 PRE : 0**
5. Credit : **3** 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Prerequisite : **Nil**
9. Objective: To impart knowledge 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

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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

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

1. Subject Code: **PPL-518** 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 : 20-35 PRS : 0 MTE : 20-30 ETE : 40-50 PRE : 0**
5. Credit : **3** 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Prerequisite : **Nil**
9. Objective: To impart knowledge 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, Rode 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

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NAME OF DEPT/CENTRE : **Department of Paper Technology**

1. Subject Code: **PPL-519** Course Title: **Distribution Packaging Dynamics**
2. Contact Hours: **L :3** **T:0** **P: 0**
3. Examination Duration (Hrs.): **Theory : 3** **Practical : 0**
4. Relative Weightage: **CWS: 20-35** **PRS: 0** **MTE : 20-30** **ETE : 40-50** **PRE : 0**
5. Credits: 3 6. Semester: **Spring** 7. Subject Area : **PEC**
8. Pre-requisite: **Nil**
9. Objective: To understand the physical, mechanical and environmental hazards on package during Distribution
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction to Distribution Packaging**, Overview of distribution packaging dynamics, Importance of distribution packaging in supply chain management, Historical perspective and evolution of distribution packaging Types of distribution packaging materials and their properties, Environmental considerations in distribution packaging	3
2	**Packaging Design for Distribution** Principles of packaging design for distribution, Functional requirements of distribution packaging, Role of package testing in design optimization, Design considerations for different modes of transportation (e.g., land, sea, air)	9
3	**Packaging Testing and Evaluation** Importance of testing in distribution packaging, Standards and regulations governing distribution packaging testing, Testing methods for assessing package performance (e.g., compression, vibration, drop), Laboratory vs. real-world testing scenarios Interpretation and analysis of testing results	12
4	**Distribution Packaging Materials** Overview of materials commonly used in distribution packaging, Properties and characteristics of various packaging materials (e.g., corrugated cardboard, plastics, wood), Selection criteria for choosing appropriate materials, Emerging trends and innovations in distribution packaging materials, Sustainable packaging materials and their impact on distribution dynamics	10
5	**Distribution Packaging Optimization** Strategies for optimizing distribution packaging efficiency, Packaging optimization techniques to minimize costs and environmental impact, Role of computer-aided design (CAD) and simulation tools in packaging optimization, Supply chain considerations in packaging optimization	5
6	**Advances in Distribution Packaging** Emerging technologies shaping the future of distribution packaging, Predictive analytics and artificial intelligence in packaging design and optimization, Innovations in sustainable packaging solutions, Global trends impacting distribution packaging dynamics (e.g., e-commerce, circular economy), Challenges and opportunities in adapting to future distribution packaging trends	3
	Total	42

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S. No.	Name of Book / Authors	Year of Publication
1.	Goodwin, D., & Young, D. Protective packaging for distribution: design and development. DEStech Publications, Inc.	2011
2.	Yam, K. L. (Ed.). The Wiley encyclopedia of packaging technology. John Wiley & Sons.	2010
3.	Encyclopedia of Packaging Technology. ISBN:9780470541388, 0470541385 Editor:Kit L. Yam	2009
4.	Packaging and Transportation Forensics, Reducing Risk and Liability By S. Paul Singh, Jay Singh	2015

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

1. Subject Code: **PPL-520** Course Title: **Sustainable Packaging and Life Cycle Assessment**

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

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

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

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

8. Prerequisite : **Nil**

9. Objective: To impart knowledge 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**

Head of Department
Paper Technology

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

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Paper Technology

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PPL-521** 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 : 20-35** **PRS : 0** **MTE : 20-30ETE : 40-50PRE : 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

Head of Department
Paper Technology

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 8th July 2011	2009
4.	Dangerous good regulations (DGR) .,IATA	2009
5.	Transport of Dangerous Goods Regulation, Canada , 28th Oct ,2009	2009
6.	Eugene Meyer, Kindle, Chemistry of Hazardous Materials (6th Edition)	2013

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Paper Technology

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PPL-522** 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 : 20-35 PRS : 0 MTE : 20-30 ETE : 40-50 PRE : 0**

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

8. Prerequisite : **Nil**

9. Objective: To impart knowledge 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"' 4th edition , Destech Publication.	2009
2.	Walter F. Friedman & Jerome , J. Kipness , "Industrial Packaging", John wiley & sons	1960
3.	The Wiley Encyclopaedia of Packaging Technology, 2nd Edition, Edited by Aaron L. Brody and Kenneth S. Marsh , Wiley –Inter science.	1997
4.	The Wiley Encyclopaedia of Packaging Technology , 3rd 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

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Paper Technology

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PPL-523** Course Title: **Lamination and Functional Coating**

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

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

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

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

8. Prerequisite: **Nil**

9. Objective: To impart knowledge 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 heath 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, Slvent based, solvent free coating and laminate manufacturing machine	7
	Total	**42**

Head of Department
Paper Technology

S. No.	Name of Book / Authors	Year of Publication
1.	Kit L. Yam, "The Wiley Encyclopaedia of Packaging Technology", 3rd 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", Elservier Science	2006
4.	Edward Bauer, "Pharmaceutical Packaging Handbook", CRC Press	2009
5.	J. M. Lagaron, "Multifunctional and Nanoreinforeced 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

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PPL-524** 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 : 20-35 PRS : 0 MTE : 20-30 ETE : 40-50 PRE : 0**

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

8. Prerequisite : **Nil**

9. Objective: To impart knowledge 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, Sterilizibility, 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

Head of Department
Paper Technology

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", 2nd Revision, Springer.	2011
5.	M Lagarón, "Multifunctional and Nanoreinforced Polymers for Food Packaging", Woodhead Publishing.	2011

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Paper Technology

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PPL-525** Course Title: **Economics in Packaging**

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

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

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

5. 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**

Head of Department
Paper Technology

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

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Paper Technology

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PPL-526** Course Title: **Advanced Packaging Materials Characterization**
2. Contact Hours: **L : 3** **T : 0** **P : 2/2**
3. Examination Duration (Hrs.): **Theory : 3** **Practical : 2**
4. Relative Weightage: **CWS : 15-30 PRS : 20** **MTE : 15-35 ETE : 30-40** **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

Head of Department
Paper Technology

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, 2nd Edition", Wiley-IEEE Press	2006
2	Jack Cares, "Analytical Instrumentation Handbook", 3rd Edition, CRC Press	2004
3	Richard Coles, Mark J. Kirwan, "Food and Beverage Packaging Technology" 2nd 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., "Quantitaive Microscopy", McGraw Hill	2000
8	Silverstein, Webster & Kiemle, "Spectrometric identification of organic compounds" 7th 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" 4th Ed., John Wiley and Sons	1968
11	J. D. Winefordner, "Raman spectroscopy in chemical analysis" Vol. 157, John Wiley and Sons	1993

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Paper Technology

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PPL- 527** Course Title: **Business Law**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To equip students with a comprehensive understanding of legal principles and regulations essential for effective management and compliance within the packaging industry.

1 0. Details of Course:

S. No.	Contents	Contac Hours
1.	**Introduction to Business Law**, Overview of business law, Sources of business law Importance of Business Law in Packaging Technology Industry, Legal Systems and Legal frameworks. Introduction to contract law	4
2.	**Essentials of Contract Law**, Definition and elements of a contract, Offer and acceptance, Consideration and intention to create legal relations, Capacity to contract, legality of object and agreement, Various types of contracts in the packaging technology industry.	5
3.	**Formation and Discharge of Contracts**, Formation of contracts, express and implied contracts, Validity and invalidity of contracts, factors affecting the validity of contracts, Discharge of contracts, Breach of contract and remedies	4
4.	**Business Entities and Corporate Law** Types of business entities, Sole proprietorship, Partnership, Corporation, Limited liability company (LLC), Formation and characteristics of corporations, Corporate governance, Liability of corporate officers and directors, Corporate compliance and ethics	6
5.	**Legal Aspects of Intellectual Property** Overview of intellectual property law, Types of intellectual property: Patents, Trademarks, Copyrights, Trade secrets, Protection and enforcement of intellectual property rights, Intellectual property issues in packaging technology, Licensing and technology transfer, Intellectual property litigation	5
6	**Regulatory Compliance and Consumer Protection** Regulatory frameworks in the packaging technology industry, Environmental regulations and sustainability, Product liability and safety regulations, Labeling and packaging regulations, Consumer protection laws, International trade regulations and compliance	5
7	**Employment Law and Human Resources** Employment contracts and agreements, Workplace discrimination and harassment laws, Occupational health and safety regulations, Employee benefits and compensation, Termination and severance, Employee rights and employer responsibilities	6
8	**Digital Transformation and E-Commerce Regulations** Data privacy and cybersecurity laws, Artificial intelligence and automation: legal implications, Blockchain technology and smart contracts, Sustainability and corporate social responsibility (CSR) in business law, Future directions in business law and packaging technology	6
Total		**42**

12.Suggested Books:

Head of Department

S. No.	Name of Book / Authors	Year of Publication
1.	Beatty, J. F., Samuelson, S. S., & Abril, P. S. (2019). Introduction to business law. Cengage Learning.	2019
2.	Sagar, D. (2006). Fundamentals of ethics, corporate governance and business law. Elsevier.	2006
3.	Eckersley, P., Harris, L., & Jackson, P. (2003). E-business Fundamentals. Routledge.	2003
4	Yam, K. L. (Ed.). (2010). The Wiley encyclopedia of packaging technology. John Wiley & Sons.	2010

Head of Department
Paper Technology

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PPL-528** 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 : 20-35PRS : 0** **MTE : 20-30ETE : 40-50 PRE : 0**
5. Credit: **3** 6. Semester: **Spring** 7. Subject Area: **PEC**
9. Prerequisite : **Nil**
10. Objective: To impart knowledge of logistic and supply chain management in business atmosphere
11. 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

Head of Department
Paper Technology

	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 Souring 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**

12. 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", Ceneage Learning India Pvt. Ltd.	2009

Head of Department
Paper Technology

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PPL-529** 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 : 20-35 PRS : 0 MTE : 20-30 ETE : 40-50 PRE : 0**

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

8. Prerequisite : **Nil**

9. Objective: To impart knowledge 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, Lurelle 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
Total		42

Head of Department
Paper Technology

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

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Paper Technology

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PPL-530** 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** **20-35** **PRS** **0** **MTE** **20-30** **ETE** **40-50** **PRE** **0**

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

9. Pre-requisite:

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

11. 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

Head of Department
Paper Technology

	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, fleoxography 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**

12. 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" 4th ed., Delmar Publishers	**1996**
3.	Noemer E.F., "The Handbook of modern halftone photography" Perfect Graphic Arts.	**1982**
4.	Harald Johnson, "Mastering Digital Printing, 2nd ed." Cengage Learning PTR	**2004**

Head of Department
Paper Technology

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

1. Subject Code: **PPL-531** Course Title: **Advanced numerical methods and statistics**

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective: To enable students to employ sophisticated mathematical and statistical techniques to analyze data, optimize processes, and make informed decisions within the packaging industry.

1 0. Details of Course:

S. No.	Contents	Contac Hours
1.	**Introduction to Numerical Methods** Overview of numerical methods in engineering and science, Error analysis and numerical stability, Root finding methods: Newton-Raphson, Secant, Bisection methods, Interpolation techniques: Lagrange interpolation, Newton's divided differences, Numerical differentiation and integration: Finite difference methods, Simpson's rule, Trapezoidal rule	5
2.	**Optimization Techniques** Unconstrained optimization: Gradient-based methods, Conjugate gradient method, Constrained optimization: Lagrange multipliers, Penalty function method Linear programming: Simplex method, Sensitivity analysis, Nonlinear programming: Quasi-Newton methods, Genetic algorithms	5
3.	**Regression Analysis** Linear regression: Simple linear regression, Multiple linear regression Nonlinear regression: Curve fitting techniques, Model selection criteria: AIC, BIC, Regression diagnostics: Residual analysis, Influential observations, Applications in packaging technology: Predictive modeling, Quality control	6
4.	**Time Series Analysis** Stationarity and trend analysis, Autoregressive (AR), Moving Average (MA), and Autoregressive Integrated Moving Average (ARIMA) models, Seasonal decomposition methods: Seasonal ARIMA (SARIMA) models, Forecasting techniques: Exponential smoothing, Box-Jenkins approach, Applications in packaging industry: Demand forecasting, Inventory management	7
5.	**Experimental Design** Principles of experimental design: Randomization, Replication, Blocking Completely Randomized Design (CRD), Randomized Complete Block Design (RCBD), Factorial experiments: Main effects, Interaction effects, Response surface methodology (RSM): Central Composite Design (CCD), Box-Behnken Design, Analysis of Variance (ANOVA) for experimental data	6
6	**Monte Carlo Simulation** Basics of Monte Carlo simulation, Generating random numbers: Uniform, Normal distributions, Monte Carlo integration, Applications in packaging technology:	7

	Reliability analysis, Risk assessment	
7	**Advanced Topics in Statistics** Bayesian statistics: Bayes' theorem, Bayesian inference, Bootstrap methods: Resampling techniques, Machine learning fundamentals: Supervised and Unsupervised learning, Applications in packaging technology: Predictive maintenance, Quality assurance	6
Total		**42**

11. Suggested Books:

S. No.	Name of Book / Authors	Year of Publication
1.	Gilbert Strang, Linear Algebra and Its Applications (4th Ed.), Wellesley Cambridge Press (2009).	2009
2.	Philips, G. M.,Taylor,P. J. ; Theory and Applications of NumericalAnalysis (2nd Ed.), Academic Press, 1996.	1996
3.	Gourdin,A. and M Boumhrat;Applied Numerical Methods.Prentice Hall India, New Delhi,(2000)	2000
4	Gupta,S.K.; Numerical Methods for Engineers. Wiley Eastern, New Delhi, 1995	1995

Head of Department
Paper Technology

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

8. Pre-requisite: **Nil**

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

10. Details of Course:

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

Head of Department
Paper Technology

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

11. Suggested Books:

S. No.	Name of Book / Authors	Year of Publication
1.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 4: Papermaking Chemistry (Ed. Neimo L.)", Finnish Paper Engineers' Association and TAPPI.	1999
2.	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 8: Papermaking Part 1, Stock Preparation and Wet End (Ed. Paulapuro H.)", Finnish Paper Engineers' Association and TAPPI.	2000
3.	Kocurek M. J., "Pulp and Paper Manufacture, Volume 6: Stock Preparation (Ed. Hagemeyer R. W. and Manson D. W.)", TAPPI Press.	1992
4	Smook G. A. "Handbook for Pulp and Paper Technologists", 7th Ed., TAPPI Press.	1989
5	Casey J. P. "Pulp and Paper Chemistry and Chemical Technology", Vol. 1, 3rd Ed., John Wiley and Sons.	1984
6	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 6: Chemical Pulping (Ed. Gullichsen J and Fogelholm C-J.)", Finnish Paper Engineers' Association and TAPPI.	1999
7	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 5: Mechanical Pulping (Ed. Sundholm J.)", Finnish Paper Engineers' Association and TAPPI.	1999
8	Gullichsen J. and Paulapuro H., "Papermaking Science and Technology, Book 7: Recycled Fiber and Deinking (Ed. Göttsching L. and Pakarinen, H.)", Finnish Paper Engineers' Association and TAPPI.	2000
9	Kocurek M. J., "Pulp and Paper Manufacture, Volume 3: Secondary Fibers and Non-wood Pulping (Ed. Hamilton F. and Leopold B.)", TAPPI Press.	1987
10	McKinney R.W.J., "Technology of paper Recycling", Blackie and Academic Professional.	1995

Head of Department
Paper Technology

11	Twede, Diana, Susan EM Selke, Donatien-Pascal Kamdem, and David Shires. Cartons, Crates And Corrugated Board: Handbook of Paper and Wood Packaging Technology. DEStech Publications, Inc, 2014.	**2014**
12	Kirwan, M. J. (Ed.). (2012). Handbook of Paper and Paperboard Packaging Technology. John Wiley & Sons.	**2012**

Head of Department
Paper Technology

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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

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

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

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

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

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

8. Pre-requisite: **Nil**

9. Objective:

10. Details of Course:

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

Head of Department
Paper Technology

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

Suggested Books:

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

Head of Department
Paper Technology