SEMESTER WISE COURSE STRUCTURE & EVALUATION SCHEME

for

M. TECH. DEGREE PROGRAM
IN
CHEMICAL TECHNOLOGY
PAINT TECHNOLOGY

(Effective from the session 2023-24)

DEPARTMENT OF PAINT TECHNOLOGY
SCHOOL OF CHEMICAL TECHNOLOGY
HARCOURT BUTLER TECHNICAL UNIVERSITY
KANPUR-208002
UTTAR PRADESH

Department of Chemical Technology-Paint Technology

Vision

The department of paint technology aspires to achieve excellence in teaching-learning, research, and innovation in Paint and allied areas.

Mission

The missions of the Department of Chemical Technology- Paint Technology are:

- **M1 :** To develop state-of-the-art facilities to impart technical knowledge and skill to the graduate & postgraduate students for plastic and allied industries and research organizations
- **M2 :** To be a center of research and innovation for the betterment of society in a sustainable manner.
- **M3 :** To develop state-of-the-art technologies for testing and consultancy for industry and society.
- **M4 :** To cultivate strong ethical values to be successful professionals and to become life-long learners.

Program Educational Objectives (PEOs)

The Program Educational Objectives (PEOs) of M.Tech. (Chemical Technology) - Paint Technology program are:

- **PEO1 :** To produce graduates and postgraduates who will be able to meet the requirements and challenges at national & international levels in the field of formulation, manufacture, and application of paints and allied products.
- **PEO2 :** To inculcate in students the fundamental and molecular concepts related to resins, polymers, pigments, and additives to enable them to develop novel technologies to meet the global standards of eco-friendliness & sustainability.
- **PEO3 :** To produce technologists with high moral values and professional ethics, who can work with industry hand-in-hand for mutual benefits and to sensitize them for job creation for the society, especially the rural community.

Program Specific Outcomes:

- **PSO1 :** Students should be able to apply the acquired knowledge in the professional world related to the formulation, manufacture, and application of paints, coatings, and allied products and should be sensitized technocrats towards using indigenous resources and infrastructure to develop novel technologies compatible with the startup mission of India.
- **PSO2 :** Graduates should be able to handle research and development assignments in industry and should be welcome candidates for higher studies in high-profile national and international institutes/universities with a strong concern for the environment and social issues.

Annexure –I

HARCOURT BULTER TECHNICAL UNIVERSITY KANPUR
SCHOOL OF CHEMICAL TECHNOLOGY
DEPARTMENT OF CHEMICAL TECHNOLOGY (PAINT TECHNOLOGY)
Semester wise Course Structure
M. Tech. Chemical Technology (Paint Technology)

(Applicable from Session 2023-2024 for new entrants)
Year I, Semester I

(A Stream Only for students having B.Tech. in Paint Technology background)
(B Stream Only for students having B.Tech. in other than Paint Technology background)
(C Stream Only for students of M.Sc. (Chemistry/Applied Chemistry /Industrial Chemistry) background)

"A Stream"

S. No.	Course Type	Subject Code	Course Title	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1.	PCC	NPT 501	Advances in Chemistry and Technology of Film Formers	4	3	0	2	15	20	15	50	50	100
2.	PCC	NPT 503	Advanced Chemical Reaction Engineering	4	3	1	0	30	20	-	50	50	100
3.	PCC	NPT 505	Pigmentation of Surface Coatings	4	3	1	0	30	20	-	50	50	100
4.	PEC	NPT 507 NPT 509	Artificial Intelligence in Chemical Engineering Water-reducible Coatings	4	3	1	0	30	20	-	50	50	100
		Total		**16**	**12**	**3**	**2**				**200**	**200**	**400**

OR

"B & C Stream"

Sr. No.	Course Type	Subject Code	Course Title	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1.	PCC	NPT 513	Technology of Resins and Polymers	4	3	1	0	30	20	-	50	50	100
2.	PCC	NPT 515	Chemistry and Technology of Pigments	4	3	0	2	15	20	15	50	50	100
3	PCC	NPT 517	Technology of Surface Coatings	4	3	1	0	30	20	-	50	50	100
3.	PEC	NPT 519 NPT 521	Technology of Surfactants & Coating Additives Safety, Health and Environmental hazards in Paint Industry	4	3	1	0	30	20	-	50	50	100
		Total		**16**	**12**	**3**	**2**				**200**	**200**	**400**

HARCOURT BULTER TECHNICAL UNIVERSITY KANPUR
SCHOOL OF CHEMICAL TECHNOLOGY
DEPARTMENT OF CHEMICAL TECHNOLOGY (PAINT TECHNOLOGY)
Semester wise Course Structure
M. Tech. Chemical Technology (Paint Technology)

(Applicable from Session 2023-2024 for new entrants)

Year I, Semester II
For all streams

Sr. No.	Course Type	Subject Code	Course Title	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1.	PCC	NPT 502	Modern Evaluation Techniques of Surface Coatings	4	3	1	0	30	20	-	50	50	100
2.	PCC	NPT 504	Modern Manufacturing Techniques of Surface Coatings	4	3	1	0	30	20	-	50	50	100
3.	PCC	NPT 506	High Performance Coatings	4	3	0	2	15	20	15	50	50	100
4.	PEC	NPT 508 NPT 510 NPT 512	Statistical Design of Experiments Advances in Printing Inks Advances in Packaging Technology	4	3	1	0	30	20	-	50	50	100
		Total		**16**	**12**	**3**	**2**				**200**	**200**	**400**

HARCOURT BULTER TECHNICAL UNIVERSITY KANPUR
SCHOOL OF CHEMICAL TECHNOLOGY
DEPARTMENT OF CHEMICAL TECHNOLOGY (PAINT TECHNOLOGY)
Semester wise Course Structure
M. Tech. Chemical Technology (Paint Technology)

(Applicable from Session 2024-2025 for new entrants)

Year II, Semester III
For all streams

Sl. No.	Course Type	Subject Code	Course Title	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1.	PEC	NPT 601 NPT 603	Advances in Surface Treatment & Coating Application Eco-friendly & Specialty Coatings	4	3	1	0	30	20	-	50	50	100
2.	OEC	OPT 601	Corrosion Control using Organic Coatings	3	3	0	0	30	20	-	50	50	100
3.	Seminar	NPT 605	Seminar	1	0	0	2	-	50	-	50	50	100
4.	Dissertation-I	NPT 607	Dissertation-I	8	0	0	16	-	50	-	50	50	100
		Total		**16**	**6**	**1**	**18**	**-**			**200**	**200**	**400**

*Dissertation to be continued in fourth semester.

HARCOURT BULTER TECHNICAL UNIVERSITY KANPUR
SCHOOL OF CHEMICAL TECHNOLOGY
DEPARTMENT OF CHEMICAL TECHNOLOGY (PAINT TECHNOLOGY)
Semester wise Course Structure
M. Tech. Chemical Technology (Paint Technology)

(Applicable from Session 2024-2025 for new entrants)
Year II, Semester IV
For all streams

Sl. No.	Course Type	Subject Code	Course Title	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1.	Dissertation / Project	NPT 602	Dissertation/ Project	16	0	0	32	-	50	-	50	50	100
		Total		**16**	**0**	**0**	**32**	**-**			50	50	100
Total credits				**64**	**30**	**08**	**52**				650	650	1300

SEMESTER – I

For 'A' Stream

NPT-501: Advances in Chemistry & Technology of Film-formers

L	T	P	C
3	0	2	4

OBJECTIVE: The objective of this course is to enable the students understand:
Dependence of properties of resins and polymers on their structure and chemistry.
Phenolic resins and amino resins as co-cure resins.
Epoxy resins and epoxy esters formulations and their uses.
Polyurethane resins for use in abrasion resistant coatings.
Silicone resins and acrylic resins for heat and UV resistant, and uses in water borne coatings

Course Outcome

On the successful completion of the course, students will be able to:

CO1	Study chemistry and prepare phenolic and amino resins	Apply
CO2	Study chemistry and prepare epoxy resins	Apply
CO3	Study various coating systems based on PU resins and their applications	Apply
CO4	Study Silicone resins their modifications and applications in surface coatings	Apply
CO5	Study Vinyls and acrylics and their applications in surface coatings	Apply

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	2	-	1	-	2	2	2	3
CO2	3	2	2	2	2	-	2	-	2	2	2	3
CO3	3	2	1	1	1	2	2	-	2	2	2	3
CO4	3	2	1	1	1	-	2	-	2	2	2	3
CO5	3	2	1	1	1	-	2	-	2	2	2	3
Avg	3.0	2.17	1.67	1.67	1.67	0.33	2.0	0.0	2.0	2.0	2.0	3.0

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Module-I: Binders/Film-formers/Media/Vehicles, Resins & Polymers, Natural (Fossil & Recent) Resins, Semi Synthetic & Synthetic Resins, Structure-property relationship of Rosin/Colophony modifications, Maleic Resins.

Cellulose Derivatives (esters, ethers, Water-soluble), Degree of Substitution, Structure-property relationship.

Natural Rubber, Rubber Resins, Synthetic Rubbers, Resin Dispersions

Formaldehyde Resins (from Formalin, Paraformaldehyde, Hexamine) and (from Phenols, Amines, Ketones) as Principal Binders for Co-Cure resins, Stoving & Cold Curing Compositions

Module-II: (a) Polyesters (Saturated & Unsaturated)- Formulation, Molecular Structure, Structure-Property Relationship, Hydrolytic stability, Air Inhibition, and its prevention/Cure, Hyperbranched

polyesters, Formulation of High Solids, Radiation Curable and Water Soluble polyesters

(b) Alkyds- Chemistry, Classification, Formulation, Formula calculation for Monoglyceride & Fatty Acid process, Gelation tendency, Carother's equation, Excess Hydroxyls, Tailor-making of alkyds, Various modifiers for alkyd resins; Vinylated, Silicone-modified, Polyamide-modified/Thixotropic alkyds, Commercial plant for alkyd production and its components, Continuous production of alkyds, Uses/Application of various alkyds

Module-III: (a) Epoxy Resins- Various polyols and their influence on properties, Special/Novel epoxies, UV- resistant epoxies, Experimental determination of Epoxy value and Hydroxyl value, Various curing agents, Calculation of phr for curing agents as Amines & Reactive polyamides, New developments in hardeners for epoxy resins, Curing mechanisms, 1K & 2K Coating Systems, High Solids Coatings.

Water-based Coatings- Emulsions, Dispersions & Cathodically Electrodepositable (CED) Coatings

(b) Polyamides- Polyamines & Polyacids, Dimerized Fatty acids as polyacids, Reactive & Non-reactivepolyamides, Epoxy- amine adducts

Module-IV: (a) Polyurethanes- Blocked & Polymeric isocyanates, Castor oil as a polyol, Aliphatic isocyanates, Activated prepolymers, Classification of PU coatings, 1K & 2K Coatings,

NCO/OH ratio, Polyurethane Dispersions, Isocyanate hazards, Non-isocyanate Chemistry

(b) Silicones- Silicone Oils, greases/waxes & Resins, Structure-property relationship, Phenyl & Vinyl Silicones for high-temperature applications, Formulation of Coatings for various temperature Conditions,Application technology, Silicone additives

Module-V: (a) Various Vinyl monomers, Homopolymers & Copolymers, Reactivity Ratios, Control onthe composition of copolymers, Properties and Applications of various Vinyl copolymers

(b) Acrylics- Acrylic vs. Vinyl monomers, Reactive/functional acrylic monomers, Solution & Dispersionacrylics, Thermoplastic & Thermosetting acrylics, Tg & MFFT, Water Soluble TSAs

Acrylic Emulsions, additives for emulsion formulation, Formulation & Manufacture of Emulsions, Process variables for manufacture, Emulsion testing, Uses/application of emulsions in Architectural, Industrial Coatings, and other fields

Module-VI: Lab Experiments

Preparation & Testing of:
1. Spirit Soluble Maleic Resins
2. Water Soluble alkyds
3. Water Soluble epoxy esters
4. Micro-emulsion
5. Aqueous Dispersion of resins
6. High Solids Coatings
7. Copolymers of the desired Composition

Instrumental Techniques for Resin Analysis:
8. Chromatographic Techniques for Resin Analysis- GC/GLC/HPLC/GPC
9. Spectroscopic Techniques- NMR/FTIR/Mass/XRF
10. Thermal Techniques- DTA/TGA/TMA/DSC

References:

1. Introduction to Paint Chemistry and principles of paint technology, IV Ed; by J. Bentley and G.P.A.Turner, Champan & Hall

2. A Manual for Resins for Surface Coatings Vol. I & II, II Ed; Ed. By P.K.T. Oldring and G. Hayward,SITA Pub, 1987

3. Basics of Paint Technology (Part-I), I Ed.,by V.C. Malshe and M.A. Sikchi; 2002

4. The Chemistry of Organic Film Formers, by D.H. Solomon, R.E. Krieger Pub. 1977

5. Surface Coatings, Vol. I (Raw Materials & Their Uses), III Ed, prepared by OCCA, Australia,Champan & Hall, 1993

6. Organic Coatings: Science & Technology, Vol. I & II; by Z.W. Wicks Jr., F.H. Jones, John Wiley &Sons, 1993

7. Surface Coatings: Science & Technology, II Ed., Ed. By Swaraj Paul, John Wiley & Sons, 1985

8. Resins for Surface Coatings- Chemistry, Properties and Applications, Ed. By D.Stoye and WernerFrietag, Hanser Pib. 1996

NPT 503: Advanced Chemical Reaction Engineering

For 'A' Stream

L	T	P	C
3	1	0	4

Course Outcomes:

OBJECTIVE: To learn advanced topics of classical thermodynamics with emphasis on basic concepts, laws, and thermodynamic relationships and to familiarize students with knowledge of advanced thermodynamics especially in chemical engineering related fields.

Students completing the course will be able to

CO1	Perform Legendre transformation of Energy equation and derive Maxwell relations.	Understand, Apply,
CO2	Calculate phase equilibrium conditions (BUBL P, BUBL T, DEW T and DEW P) for non-ideal mixtures using the gamma-phi approach and Evaluate equilibrium constant and Gibbs free energy change of a chemical reaction by applying criterion of equilibrium.	Apply, Evaluate
CO3	Calculate the effect of curvature on thermodynamic properties such as vapour pressure and solubility.	Analyze, Evaluate
CO4	Calculate changes in U, H, and S for ideal gases, and also for non-ideal gases through the use of residual properties and colligative properties such as Boiling point elevation, freezing point depression.	Understand, Apply, Evaluate
CO5	Demonstrate introductory understanding to various concepts of statistical thermodynamics	Understand, Apply,

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	-	-	-	-	-	-	-	1
CO2	3	3	3	2	-	-	-	-	-	-	-	1
CO3	3	3	3	3	-	-	1	-	-	-	-	1
CO4	3	3	2	2	-	-	-	-	-	-	-	-
CO5	3	3	2	3	-	-	-	-	-	-	-	1
Avg	3	3	2.4	2.2	0	0	1	0	0	0	0	1

Syllabus

Module1:

Introduction to Thermodynamics and statistical mechanics, Internal energy, First law of thermodynamics, Intensive and extensive properties Concept of entropy, Second law of thermodynamics: Extremum principles of Energy and Entropy., Legendre transforms of energy and reformulation of second law in terms of the Legendre transforms, Maxwell relations, Maximum work theorem.

Module 2:

Conditions of phase equilibrium and its applications, Gibbs Duhem relations, Gibbs phase rule, Conjugate variables, Criteria for stability and its implications. Chemical reactions: condition of equilibrium for a reaction mixture, Equilibrium constants, Heat of reaction Thermodynamics of fluid-fluid interfaces: Dividing surface, surface excess quantities, condition of equilibrium at interfaces, Kelvin equation, Gibbs adsorption isotherm, Thermodynamics of fluid-solid interfaces: condition of equilibrium with respect to dissolution and growth of solids.

Module 3:

Classical mechanics: Lagrangian formulation, Constants of motion, Hamilton's principle, and phase space, concept of statistical ensemble, Statistical independence of macroscopic bodies, Liouville equation, Measurements and ensemble averages. Micro-canonical, and Grand- canonical ensembles. Gibbs entropy formula and Boltzmann entropy formula, Partition functions,Fluctuations and stability.

Module 4:

Ideal gas: Analytical derivations of the partition functions of ideal gas in various ensembles and thermodynamic properties, Ideal solid: Analytical derivation of partition function, heat capacity, Non-ideal gases, Virial equation of state, Second virial coefficient, Liquids: Distribution functions, pair correlation function g(r) and experimental measurement of g(r) by diffraction, Mean-field theory and perturbation theory.

Module 5:

Dilute solutions and colligative properties: Derivation of Raoults law, Henry's law, Van't Hoff's formula for osmotic pressure. Boiling point elevation, freezing point depression Introductory Quantum Statistical mechanics: Schrödinger Wave equation, Degeneracy, Partition functions. Ideal gas of polyatomic particles, Molecular partition functions, Einstein and Debye theory of perfect crystals.

Suggested Text Books

1. Herbert B. Callen, Thermodynamics and an Introduction to thermo statistics, JohnWiley and Sons, 1985.
2. McQuarrie D. A. and Simon, J. D., Molecular Thermodynamics, Viva Books,Pvt. Ltd., 2004

Suggested Reference Books

1. David Chandler, Introduction to modern statistical mechanics, Oxford University Press,1987

NPT 505: Pigmentation of Surface Coatings

For 'A' Stream

L	T	P	C
3	1	0	4

OBJECTIVE: The objective of this course is to enable the students
To understand various properties of organic pigment.
To understand basics of colour and colour- mixing.
To understand manufacturing of Classical Azo pigments and dyes.
To understand manufacturing of Blue pigment.

Course Outcome

On the successful completion of the course, students will be able to

	Study chemistry of colour, colour-mixing and its applications in aesthetics, psychology and safety	Apply
CO2	Study Industrial Organic pigments, raw materials and chemical reactions for their synthesis	Understand, Apply
CO3	Classify and prepare various AZO pigments	Understand, Apply
CO4	Study Metallic, Functional and Effect pigments and their applications in surface coatings	Understand
CO5	Study High performance and Composite pigments and identify organic pigment by analysis	Understand, Analyze

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	1	1	2	3	-	2	3	2	2	3
CO2	3	2	1	2	-	-	-	-	1	-	1	1
CO3	3	1	1	1	-	-	-	-	1	-	2	1
CO4	3	-	-	-	-	-	-	-	2	-	2	3
CO5	3	-	-	-	-	-	-	-	2	-	2	3
Avg	3.0	0.6	0.6	0.67	0.4	0.6	0.0	0.4	1.8	0.4	1.8	2.2

1:Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Module-1: Pigmentation of paints for the protection and decoration of common substrates:
Pigmentation of Masonry Coatings, requirements for masonry coatings, flat finishes, gloss finishes, traffic paints, concrete floor coatings. ***Paints for ferrous metals***: pigmentation of automotive finishes; automotive coating system, pigment selection, automotive colour Pigmentation of metal coil coatings, pigmentation of coatings for Marine and ship services. Pigmentation of coating for structural steel. ***Paint for nonferrous metals:*** pigmentation of coatings for zinc and lead substrates, pigmentation of paints for nonferrous metals other than zinc and lead. Pigmentation of trade sales paints for Wood substrates.

Module-2: Pigmentation of pains that provide special properties (functional paints): Pigmentation of antifoulants, pigmentation of electrocoating, pigmentation of flame-resistant and intumescent paints, pigmentation of heat resistant paint, pigmentation of fluorescent paints. Pigmentation of joint filler. ***Pigmentation of inks***; pigmentation of commercial printing inks, pigmentation of carbon paper inks,

pigmentation of machine communication inks. Pigmentation of paper goods.

Module-3: Pigmentation of elastomers: Pigmentation of White elastomers, pigmentation of coloured elastomers, pigmentation of black elastomers (carbon black reinforcement). ***Pigmentation of plastics***; pigmentation of white plastic, pigmentation of coloured plastics, pigmentation of black plastics.

Module-4: Pigmentation of ceramics*:* economics and historical background, pigmentation of glass; coloured glass, glass colours. Pigmentation of clayware. Pigmentation of porcelain enamels: sheet iron porcelain enamels, aluminium porcelain enamels, cast iron porcelain enamels. Pigmentation of concrete and mortar.

Module-5: Pigmentation of Miscellaneous Items: Pigmentation of cosmetics, Pigmentation of markers, Pigmentation of magnetic tapes, Pigmentation of foodstuffs (certified pigments), Pigmentation of textiles, Pigmentation of adhesives. Pigmentation of artists' colours. Pigmentation of vacuum metalized finishes. Pigmentation of photoconductive coating (electrostatic printing).

REFERENCE BOOKS:

1. Pigment Hand Book Volume I and II edited by Temple C. Patton. JWS
2. Organic Coating Technology, Volume II by H F Payne, JWS
3. The Chemistry and Physics of Organic Pigments, by L.S.Pratt, Westfield
4. Basics of Paint Technology Volume I and II by V C Malshe and Meenal Sikchi
5. Industrial Organic Pigments by Dr. Willy Hurbst
6. Gerhard Pfaf, Inorganic Pigments, ISBN 978-3-11-048450-2, CPI books GmbH, 2017

NPT-507 Artificial Intelligence in Chemical Engineering

For 'A' Stream

L	T	P	C
3	1	0	4

OBJECTIVE: This course provides an in-depth understanding of the applications of Artificial Intelligence (AI) in the field of Chemical Engineering. It aims to equip M.Tech. Chemical Engineering students with the necessary knowledge and skills to leverage AI techniques for solving complex problems in process design, optimization, control, and data analysis. The course covers various AI algorithms and methodologies and explores their practicalimplementation in chemical engineering applications. Through lectures, case studies, and hands-on exercises, students will develop a strong foundation in AI concepts and gain practical experience in applying AI techniques to chemical engineering problems.

Course Outcomes:

Students completing the course will be able to

CO1	Introduce the fundamental concepts of Artificial Intelligence and its relevance to chemical engineering.	Remember, Understand
CO2	Familiarize students with various AI techniques and algorithms applicable to chemical engineering problems.	Understand, Apply
CO3	Develop an understanding of AI-driven modeling, optimization, control, and data analysis techniques.	Understand, Apply
CO4	Provide hands-on experience with implementing AI algorithms using software tools commonly used in the chemical engineering industry.	Apply, Evaluate, Create
CO5	Encourage critical thinking and problem-solving skills through the application of AI techniques to real-world chemical engineering scenarios.	Create, Design

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	2	3	-	-	-	-	-	1	2
CO2	3	3	3	2	3	-	-	-	-	-	1	2
CO3	3	2	2	3	2	-	-	-	-	-	1	2
CO4	3	3	2	2	2	-	-	-	-	-	-	2
CO5	3	3	2	3	3	-	-	-	-	-	-	2
Avg	3	2.8	2.2	2.4	2.4	0	0	0	0	0	1	2

Syllabus

Module 1

Introduction to the field of Artificial Intelligence

Historical development and current trends in AI, Relevance of AI in chemical engineering applications, Understanding the basic concepts of machine learning, supervised, unsupervised, and reinforcement learning, Applications of machine learning in chemical engineering, Data preprocessing and feature engineering for AI

applications, Introduction to statistical analysis for AI in chemical engineering, Software tools for AI in chemical engineering.

Module 2

AI Techniques for Modeling and Simulation

Supervised learning algorithms: regression, classification, and ensemble methods, Unsupervised learning algorithms: clustering and dimensionality reduction, Neural networks and deep learning for modeling chemical processes, Model validation and performance evaluation techniques, Introduction to AI modelingsoftware.

Module 3

AI for Data Analysis and Predictive Modeling

Time-series analysis and forecasting using AI, Anomaly detection and fault diagnosis in chemical processes,AI-based predictive modeling for process performance and quality prediction, Handling big data in chemical engineering applications, Software tools for AI data analysis and predictive modeling.

Module 4

AI in Process Safety and Sustainability

AI applications in hazard identification and risk assessment, Predictive maintenance and reliability analysis using AI, AI-driven approaches for energy efficiency and sustainability in chemical processes, Integration of AI techniques with safety management systems

Module 5

Case Studies and Practical Implementation

Analysis and discussion of case studies showcasing AI applications in chemical engineering. Practical implementation of AI algorithms using software tools

Ethical considerations and challenges in AI implementation in chemical engineering

Suggested Text Books

1. Edgar, Thomas F., and Davis L. South. Artificial Intelligence in Chemical Engineering. Wiley,2019.
2. Shmueli, G., and Bhushan G. Machine Learning for Chemical Engineering: Data Analysis, Modeling, and Prediction. Wiley, 2019.

Suggested Reference Books

1. Spiegel, M. R. Advanced Mathematics for Engineers and Scientists, SchaumOutline Series,McGraw Hill, 1971.
2. David M. Reklaitis and Ananth Y. Annaswamy, Data Driven Chemical Engineering, John Wiley &Sons, 2017.
3. Weifeng Z. and Huaixiu Z., Artificial Intelligence in Process Engineering by, Springer, 2019.

NPT 509: Water Reducible Coatings

For 'A' Stream

L	T	P	C
3	0	0	3

OBJECTIVE: The objective of this course is to enable the students understand:
To understand fundamental aspects of water-soluble & water-reducible coating systems
Polymerization techniques for aqueous systems
Concept of film formation of water borne coatings
Different type of waterborne coatings
Defects of water borne coatings and new development

Course Outcome

On the successful completion of the course, students will be able to:

CO1	Understand fundamental aspects of water-soluble & water-reducible coating systems	Understand
CO2	Understand polymerization techniques for aqueous systems	Understand and Apply
CO3	To analyze film formation properties of water borne coatings	Analyze
CO4	Evaluate various types of water borne coatings and dispersion	Evaluate
CO5	To analyze problems of water borne coatings and new developments	Apply and Analyse

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	2	1	2	1	1	2	2	2
CO2	3	2	2	2	2	1	2	1	1	2	2	2
CO3	3	2	2	2	2	1	2	1	1	2	2	2
CO4	3	2	2	2	2	1	2	1	1	2	2	2
CO5	3	2	2	2	2	1	2	1	1	2	2	2
Avg	3.0	2.0	2.0	2.0	2.0	1.0	2.0	1.0	1.0	2.0	2.0	2.0

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *if there is no correlation, put "-"*

Syllabus

Module- I: Introduction to water-soluble & water-reducible coating systems- Fundamental aspects: water as a substitute for organic solvents, merits & demerits of water as a solvent; Introduction to water- borne, water-based, water-dilutable, water-thinnable, water-reducible and water-soluble coatings; differences in physical and application characteristics of aqueous dispersions, suspensions, emulsions, colloids and latexes; water solubility by salt formation. Bunte salts, Ionomers: application of water soluble systems, Thickeners or rheological additives, Dispersing agents, introducing non-ionic groups Zwitterion intermediates, colloidal systems.

Module-II: Aqueous dispersions or emulsions- Introduction to chain-growth and step-growth polymerization; Addition, Condensation, Bulk, Suspension, Emulsion, Gas phase, Block and Graft, Ionic polymerization; Co-polymerization; Addition polymer dispersions; Condensation polymer dispersions; Dispersion of addition-condensation polymers. Long life water based coatings for exterior for large structures, Siliconized crosslinkable dirt and water repellent coatings.

Module-III: Film Spreading and Film formation by water-borne coatings-Concept of surface tension, contact angle and spreading; measurement of surface tension, surface chemistry of water; functions of surfactants; practical surfaces for painting; wood, metals, plastics.

Module-IV: Types of Water-borne coatings / dispersions- Water soluble polymers: natural & synthetic, Acrylic dispersions; Vinyl acetate dispersions ; Epoxy resin dispersions; Poly-urethne (PU) dispersions; Alkyd dispersions; other systems; their properties and uses; Film formation by 'emulsion' paints, process of coalescence. Bunte salt polymers for aqueous coatings

Module-V(a): Problems with Water-borne Coatings: properties of water; Flammability & Toxicity, Melting / Freezing Point, Surface Tension, Film defects, Evaporation rate, Rusting of ferrous substrate, Degradation of paint by microbes, Toxicity of Waterborne coatings and specific problems, Quality of water, Effluent from waterborne Coatings

(b) New developments (Silicone Emulsion Paints)- Introduction to Silicate and Silicate emulsion paints, Primers based on siloxanes, Water absorption and Gas permeability of Building and surface coating materials, Silicone masonry water repellants: preparation & properties of Methyl silicone resins : permeability of water vapour, CO_2, Resistance to water, weather & durability, method and field of application.

References and suggestive readings:

1. Waterborne Coatings, Surface Coatings 3:By: Alan D Wilson, John W. Nicholson, Havard J Prosser.
2. Surface Coating Technology: By: Swaraj Paul.
3. Coating Formulations, 2nd edition, by Bodo Muller & Ulrich Poth, Vincentz Network
4. Paint & Surface Coatings, Theory & Practice: By; R Lambourne & T.A Strivens, Woodhead PublishingLtd.
5. Organic Coatings, Science and Technology: By Frank N. Jones, Nichols & Pappas,4th Edition, Wiley
6. Waterborne& Solvent Based Epoxies and Their End User Applications, By: Dr P Oldring.
7. Organic coating technology vol. II By H.F. Payne
8. Basics of Paint Technology (Part II), By: Malshe & Sikchi

NPT-513: Technology of Resins & Polymers

For 'B' & 'C' Stream

L	T	P	C
3	1	0	4

OBJECTIVE: The objective of this course is to enable the students understand:
Sources of various natural resins and their modifications for their use in coatings.
The fundamental concepts of resinification /polymerization to prepare synthetic resin.
Synthetic polyesters and alkyd resins: preparation, properties and applications.

Course Outcome

On the successful completion of the course, students will be able to

CO1	Study the functionality, degree of polymerization and molecular weight and their determination. Study rosin and shellac and modify them for use in surface coatings	Understand, Apply
CO2	Study natural high polymers and their application in surface coatings	Apply
CO3	Properties and applications of polyester resins, Formulate and evaluate Alkyd resins and carry out calculations for making tailor made alkyds	Apply
CO4	Study chemistry and prepare phenolic, amino and epoxy resins	Apply, Evaluate
CO5	Study various coating systems based on PU, Silicone resins their modifications and Vinyls and acrylics resins and their applications	Understand

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	1	-	1	-	2	-	2	2
CO2	3	1	-	-	-	1	1	-	2	-	-	2
CO3	3	2	2	2	2	1	1	-	-	-	1	2
CO4	3	3	3	3	3	-	2	-	1	2	3	3
CO5	3	-	-	-	-	-	2	-	-	-	-	1
Avg	3.0	1.33	1.17	1.17	1.0	0.33	1.17	0.0	0.83	0.33	1.0	1.67

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *if there is no correlation, put "-"*

Syllabus

Unit-I: (a) Polymers, Resins & Gums; Resinous State; Classification of Resins & Polymers;
(b) Rosin- Origin, Composition, Properties, Testing, Modifications & Uses; Rosin Esters; Maleic Resins;
(c) Lac/Shellac- Origin, Composition, Properties, Testing, Modifications & Uses

Unit-II: (a) Waxes, Glues, Pitches & Bitumens;
(b) Cellulosic polymers- Ethers & Esters; Nitrocellulose, Properties & Uses; Water Soluble Cellulose derivatives;
(c) Rubber Resins- Sources, Composition, Properties, Testing, Modifications & Uses; Chlorinated Rubber Resins; Cyclized Rubber Resins

Unit-III: (Polyester, Alkyds & functional Resins):

(a) Polyesters- Functionality of molecules, Carother's Equation Saturated & Unsaturated polyesters; Formulation; Curing; Applications; Recent trends- High Solids, Radiation Curable, Water Soluble, Hyperbranched polyesters

(b) Alkyds- Raw materials, Classification; Chemistry, Oil length, Formulation & Calculations, Manufacture, Properties & Modifications, Applications, Water-soluble alkyds, Recent Trends

(c) Functional monomers and polymers for functional coatings. Ion exchange resin, manufacture and use.

Unit-IV: (Formaldehyde Resins & Epoxy Resins):

(a) Phenol-Formaldehyde Resin- Formalin & Paraformaldehyde, Pure & Reduced Phenolics, Resoles & Novolacs, Oil soluble & Oil reactive phenolics, production, properties, cure & applications

(b) Amino Resins- Urea-formaldehyde & Melamine- formaldehyde resins, production, properties, cure & applications

(c) Epoxy Resins- Raw materials, Chemistry, Production, Epoxide Equivalent & Hydroxyl Equivalent, Curing agents & their amounts, One-pack & Two-pack coatings, Epoxy Esters, Polyamide Resins, and their uses as curing agents

Unit-V: (Polyurethanes, Silicones & Acrylics):

(a) Polyurethanes- Polyisocyanates & Polyols, Castor oil as a polyol, Isocyanate hazards, NCO/OH ratio, Classification of polyurethanes, Urethane Oils, Uralkyds, PU Dispersions

(b) Silicones- Alkali & Alkyl silicate binders, Silicone Resins- MDTQ structures, Chemistry, production, properties & applications

(c) Acrylics- Vinyl & Acrylic Monomers, Chloro & Fluoro Polymers, Vinyl esters, acetals and vinyl copolymers. Thermoplastic & Thermosetting Acrylics, Tg & MFFT, Water-borne Acrylics, Vinyl & Acrylic Emulsions/Latexes

References/Suggested Readings:

1. Organic Coating Technology, Volume-I; by H.F.Payne
2. Introduction to Paint Chemistry; by G.P.A.Turner
3. Surface Coatings, Volume-I; ed. By OCCA Australia
4. The Chemistry of Organic Film-formers; by D.H.Solomon
5. A Manual for Resins for Surface Coatings; by P.K.T.Oldring

NPT 515: Chemistry and Technology of Pigments
For 'B' & 'C' Stream

L	T	P	C
3	0	2	4

OBJECTIVE: The objective of this course is to educate the students about
Properties of extenders and pigments
Characterization (testing and evaluation) of properties of pigments and extenders.
Manufacturing of Natural and Synthetic Pigments
Role of extenders and pigments in paints, printing inks, leather, plastics, rubbers etc.

Course Outcome
On the successful completion of the course, students will be able to

CO1	Understand the Colour Chemistry and various properties of pigments	Understand, Apply
CO2	Study the manufacturing processes and properties of extenders and white pigments	Understand,
CO3	Study the manufacturing processes and determine various properties of coloured and black pigments	Apply, Create
CO4	Study the manufacturing, properties and application of various organic pigments	Understand, Apply
CO5	Study the Metallic, Functional and Effect Pigments	Apply, Create
CO6	Analyze and evaluate the extenders and pigments	Analyze, Evaluate

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	-	2	2	-	-	-	1	-	2	2
CO2	3	2	-	-	-	2	1	-	1	-	1	2
CO3	3	2	3	3	2	1	2	2	2	1	2	2
CO4	3	2	-	3	-	-	2	-	1	-	1	2
CO5	3	2	2	2	2	1	2	2	2	1	2	3
CO6	3	3	3	2	2	2	-	-	2	2	3	2
Avg	3.0	2.0	1.33	2.0	1.33	1.0	1.17	0.67	1.5	0.67	1.83	2.17

1:Slight(Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Module-I: Colour Chemistry and Pigment Properties

Colour Phenomena, Auxochromes and chromophores, colour spectroscopy,hue, value and chroma, delta E. Light spectrum, light sources, selective absorption and scattering of light, primary and complementary colours, Kubelka-Munk equation and concept of K/S, colour blindness, Introduction to colour index name and number. Colour coding systems.

Properties and evaluation of pigments such as primary crystal structure, secondary crystal structure, primary pigment particles, aggregates, agglomerates, particle size and distribution, surface area by bet techniques, pigment particle shape, refractive index and hiding power, oil absorption, specific gravity and bulking value, UV and IR absorption, light fastness, resistance to heat, water, alkali and acid, corrosion inhibition, toxicity, reducing power, tinting strength, flooding and floating, settling, volatile and water-soluble matter, residue on sieve, bleeding and other chemical properties.

Module-II: Extenders and White Pigments

General methods of manufacturing of natural and synthetic inorganic pigments. Manufacturing, applications and merits and demerits of nano pigments Extender pigments; source, manufacture, properties and uses of extenders pigments such as carbonates, sulphates, silicas and silicates and miscellaneous extenders

White pigments: Titanium dioxide, zinc oxide, zinc sulphide, zinc phosphate, lithopone, basic lead carbonate, sulphate, silicate, Antimony oxide, calcium plumbate, zirconium oxide and silicate, potassium titanate, TiO_2 substitutes.

Module-III: Inorganic Coloured and Black Pigments

Colour pigments: Source, manufacture, properties and uses of natural and synthetic iron oxides, lead chromates, silico-chromates and molybdate, chrome green, chromium oxide, cadmium pigments, 14russian and ultramarine blue, mercuric sulphide, cobalt blue, cadmium pigments, synthetic inorganic complexes and mixed pigments e.g. Sprinel pigments etc.

Black Pigments: Source, manufacturing, properties, and uses, such as carbon black and their technical characterization e.g. Particle size, crystal size, shape & distribution, surface area, oil absorption and structure of the aggregate, graphite, copper chrome complex, iron oxide, aniline and logwood, etc.

Module –IV: **Organic Pigments and Dyestuffs**

Comparison of organic and inorganic pigments, Definition of dyes, pigments dyestuffs, toners and lakes. Industrial Organic Pigments Raw materials: coaltar distillation products, mordants and precipitants. Chemical reactions for synthesis of various intermediates from benzene, naphthalene and anthracene etc. Classical AZO Pigments Classifications and general method of preparation of synthetic organic azo pigments. Classification and description of various types of azo pigments, diazotization and coupling, di- and tetra azo compounds, and other related colourants such as azoic, etc. Basic and acid dyes pigments: permanent and fugitive type of dyes and pigments, anthracene and Anthraquinone and vat colour pigment, Phthalocyanine blue and green metal-free phthalocyanine

Module-V : Metallic, Functional and Effect Pigments

Source, manufacture, properties and uses of metallic pigments, Anti-corrosive pigments, functional and miscellaneous pigments such as cuprous and mercuric oxides, barium metaborate. Special effect pigments e.g. Pearlescent, nacreous, phosphorescent, fluorescent and luminescent, IR reflecting pigments, thermochromic pigments, polymeric pigments, transparent pigments, miscellaneous polycyclic organic pigments, Introduction to high performance pigments & dyes, high performance azo, Polycylic pigments, Composite and mixed pigments.

Module-VI: Laboratory experiments Testing and evaluation of general properties of pigments and extender, preparation of pigments and extenders. Analysis of pigments and extenders.

References:

5. Pigment Hand Book Volume I edited by Temple C. Patton. JWS
6. Organic Coating Technology, Volume II by H F Payne, JWS
7. The Chemistry and Physics of Organic Pigments, by L.S.Pratt, Westfield
8. Basics of Paint Technology, by V C Malshe and Meenal Sikchi,

NPT-517: Technology of Surface Coatings

For 'B' & 'C' Stream

L	T	P	C
3	1	0	4

OBJECTIVE: The objective of this course is to enable the students:
To understand the basic concepts about paints, their ingredients, functions of various ingredients and classification of paints.
To understand composition and properties of various ingredients.
To understand the methodology of formulation and manufacture of paints.
To understand the methods of testing of paints and their raw materials.
To understand about surface preparation and application of paints on various surfaces.

Course Outcome

On the successful completion of the course, students will be able to:

CO1	Understand the basic concepts about paints, their ingredients, and functions of ingredients and classification of paints.	Understand
CO2	Understand the composition and properties of various raw materials for paints.	Understand
CO3	Learn the process of formulation and manufacture of paints.	Apply
CO4	Test the paints and their raw materials.	Apply
CO5	Prepare and paint various types of substrates	Apply

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	-	1	1	-	-	1	1	2
CO2	3	-	-	-	-	2	2	-	1	-	1	2
CO3	3	2	2	2	2	1	2	1	2	2	2	3
CO4	3	2	-	3	1	2	1	1	2	2	2	2
CO5	3	2	2	2	1	2	3	2	2	3	3	2
Avg	3.0	1.2	0.8	1.4	0.8	1.6	1.8	0.8	1.4	1.6	1.8	2.2

1:Slight (Low) 2: Moderate (Medium) 3: Substantial (High), *if there is no correlation, put "-"*

Syllabus

Module-I: Basics concepts

Paint definition, paints and their general ingredients, functions of ingredients, classifications of paints, drying/curing mechanism of paints.

Module-II: Raw materials for paints and coatings

Drying oils, modified drying oils, natural resins, synthetic resins, extenders & prime pigments, inorganic & organic pigments, dyes & pigments, true solvents, latent solvents & diluents, chemical composition & properties of solvents, effects of volatile solvents on film properties, drying catalysts (driers), plasticizers, additives for solvent-borne & water-borne paints

Module-III: Formulation and manufacture of coatings

Formulation principles for organic coatings (paints, varnishes & lacquers), calculations involved in paint formulations, steps in paint manufacture dispersion equipment & machinery used in paint manufacture.

Module-IV: Testing of raw materials & paints

Testing of pigments, extenders, oils, resins, solvents, testing of liquid paints, evaluation of paint films for physical, mechanical, optical properties; chemical resistance and corrosion resistance

Module-V: Surface preparation and paint application

Different steps involved in the preparation and chemical pre-treatment of surfaces, different application techniques, electrostatic spraying, electro-deposition, common paint defects and their prevention & cure, recent trends in paints & paint application, safety & health hazards in paint industries

References:

1. Organic Coating Technology, Vol. I & II; by HF Payne.
2. Outlines of Paint Technology; by WM Morgans.
3. Surface Coatings, Vol. I & II; by OCCA, Australia.
4. Basics of Paint Technology (Part I & II); by Malshe & Sikchi.
5. IS:33-.1992, IS:3493.1978, IS:74.1979, IS:101.1964, IS:2932, IS:2074

NPT – 519: Technology of Surfactants & Coating Additives
For 'B' & 'C' Stream

L	T	P	C
3	1	0	4

OBJECTIVE: The objective of this course is to enable the students
To understand various types of paint additives used
To understand Wetting & dispersing agents, defoamers and adhesion promoters used in paints.
To understand biocides and heat stabilizers
To understand corrosion inhibitors, driers and additives used for special functions in paints
To study theory, types and properties of surfactants

Course Outcome
On the successful completion of the course, students will be able to

CO1	Understand various additives used in paints.	Understand
CO2	Understand various wetting & dispersing agents, defoamers and adhesion promoters used in paints and their evaluation	Understand, evaluate
CO3	Understand general characteristics of biocides, heat and light stabilizers	Understand
CO4	Understand general characteristics of corrosion inhibitors, driers and additives for special function	Understand, evaluate
CO5	study the theory, types and properties of surfactants	Understand, Evaluate

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	-	-	2	1	1	1	1	1	2
CO2	3	2	2	1	1	2	2	2	1	2	2	2
CO3	3	2	3	2	1	2	2	2	1	2	2	2
CO4	3	2	3	2	1	2	2	2	1	2	2	2
CO5	3	2	2	2	2	2	2	2	1	1	2	2
Avg	3.0	2.0	2.2	1.4	1.0	2.0	1.8	1.8	1.0	1.6	1.8	2.0

1:Slight(Low) 2: Moderate (Medium) 3: Substantial (High)*If there is no correlation, put "-"*

Syllabus

Unit-1: Introduction to surfactants and their properties
Surface active agents: Theory of surface action; effect and behavior of surface-active agents on the interfaces; solid-liquid, gas-liquid, liquid-liquid and interfaces formed by three phases e.g. solid, liquid, and gas and two immiscible liquids. Bulk properties of surfactant solutions and methods of their measurements: micelle properties; foaming; wetting, emulsification, dispersion; and detergency; measurement of critical micelle concentration; foaming power and foam stability, wetting power, emulsifying power, stability of the dispersion, and detergency.

Unit-2: Classification of surfactants
Anionic Surfactants: Soaps and other Carboxylates, Sulfonation and Sulfation, Sulfates, Sulfonates, Other Anionic Surfactants Nonionic Surfactants: Nonionic Surfactant Types, Ethoxylated Alcohols and

Alkylphenols, Fatty acid Esters, Nitrogenated Nonionic Surfactants, Cationic Surfactants: Linear Alkyl-amines and Alkyl-ammoniums, Other Cationic Surfactants, Nitrogenated Surfactants with a second hydrophile. Other Surfactants: Amphoteric Surfactants, Silicon Surfactants, Fluorinated Surfactants, Polymeric Surfactants, Bio-surfactants, Novel surfactants, Association Polymers, Hybrid and gemini surfactants, reactive auxiliaries

Unit-3: Manufacturing of surfactants and Introduction to coating additives

Plants and manufacturing processes of surfactants: of anionic surfactants viz. alcohol sulfates, alkyl aryl sulfonates, olefin sulfonates, sulfated and sulfonated oils, alpha methyl esters, etc., non-ionic surfactants viz. Poly-ethoxy ethers and esters, poly-hydroxy surfactants, and cationic surfactants, e.g. quaternary ammonium compounds.

Coating Additives: Definition, nomenclature, role, the scope of incorporation, dosage, side/adverse effects of the use of additives

Unit-4: Coating Additives for solvent thinned paints

Wetting and dispersing agents, Polymeric dispersants and their application in scale control, paint dispersion, cement and clay industries, anti-settling, anti-sag, bodying agents/ thickeners, anti-skinning agents, anti-flood & anti-float agents, biocides (bactericides and fungicides), thixotropic agents, leveling and flow control, mar and slip aids, adhesion promoters, heat and light-stabilizers, metal carboxylates (driers), Waxes and surfactants

Unit-5: Coating Additives For water- thinned /latex (emulsion) paints

Surface active agents (dispersing agents and stabilizers), anti-foam agents/defoamers, protective colloids, and thickeners, Biocides (in-can and dry-film) preservatives, Algaecides, pH buffers, coalescing aids, wet-edge additive, base-tinter compatibilizers, freeze-thaw stabilizers, sequestering agents, miscellaneous- organoclays and silicone additives.

References and suggested readings:

1. Surfactants: Types and Uses by Jean-Louis Salager
2. Surfactant Science and Technology by Drew Myers
3. Surfactants and Interfacial Phenomena by Milton J. Rosen
4. Surfactants and Polymers in Aqueous Solution by Holmberg and Jonsson
5. Polymer Surfactants by Piirma, Irja
6. Additives for Coatings by Johan Bieleman
7. Handbook of Coating Additives by Leonard J Calbo
8. Additives in Water-borne Coatings by Gerry Davison and Bruce Lane
9. Chemistry and Technology of Polymer Additives by Al-Malaika
10. Determination of Additives in Polymers and Rubbers by Al-Malaika

NPT-521: Safety, Health and Environmental Hazards in Paint Industry

For 'B' & 'C' Stream

L	T	P	C
3	1	0	4

OBJECTIVE: The objective of this course is to enable the students understand:
Study of Plant Safety is an essential requirement of the coating industries.
Knowledge of plant safety is indispensable while working in plant to prevent accidents and damages.
A safety management, audit and risk analysis skill prepares the plant operators and managers to emerge to a safe protocol and minimize potential damages to personnel, process equipment, and the environment.
This course will give an overview of the safety regulations and practices, plant hazards and their control, risk management principles and techniques and accident analysis.
The environmental aspects of paint industry are also discussed to clear the comprehensive approach of the subject objective.

Course Outcome

On the successful completion of the course, students will be able to:

CO1	Introduction and Identification of key concepts of safety, hazards, risk assessment and its management in process plant and study various regulation of SHE	Understand, Evaluate
CO2	Develop understanding of severity of incidents and importance of toxicological studies	Analyze, Remember
CO3	Understand Key elements of a safety and Health Management System.	Understand, Apply
CO4	Understand storage and handling of hazardous substances	Remember, Apply
CO5	Study the plant safety based on environmental protection by various hazards	Understand, Apply, Analyze

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	2	1	2	1	1	2	2	2
CO2	3	2	2	2	2	1	2	1	1	2	2	2
CO3	3	2	2	2	2	1	2	1	1	2	2	2
CO4	3	2	2	2	2	1	2	1	1	2	2	2
CO5	3	2	2	2	2	1	2	1	1	2	2	2
Avg	3.0	2.0	2.0	2.0	2.0	1.0	2.0	1.0	1.0	2.0	2.0	2.0

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Module I: Occupational safety, health and environment management system, bureau of Indian standards on safety and health: 14489-1998 and 15001-2000, ILO and EPA standards. Laws of safety: Clean Air Act, Occupational Health and safety Act (OSHA, 1970), Toxic Substances Control Act (TSCA,1976), Resource Conservation and Recovery Act (RCRA, 1976), Comprehensive Environmental Response Compensation and Liability Act (CERCLA, 1980), Superfund Amendments and Reauthorization Act (SARA, 1986), Clean Water Act (CWA,1977), National Environmental Policy Act (NEPA,1969), REACh Compliance (Registration, Evaluation and Authorisation of Chemicals), Food and Drug Administration (FDA)

Module II: Sections of MSDS, classification and labelling of chemicals: Numbering system, Classification system, Determination of classification, Classification and labelling for transport (conveyance), Labelling requirements, Supply and conveyance requirements, Control of hazardous substances, Major accident hazards:

Module III: Key elements of a safety and Health Management System- Policy & commitment, Planning, Implementation and Operation, Measuring Performance, Auditing and Reviewing performance Initial Safety and health Management System Review, Safety and health Management System model, safety and Health policy- Developing a workplace Safety and Health Policy , Planning – safety and Health objectives and Targets, performance standards, Implementation and Operation – structure and responsibilities- management responsibilities, individual responsibilities, Safety Consultation.

Module IV: Personal protective equipments (PPEs), Explosion and fire protection, VOC regulation, limit value of emission, toxicity, Flammability, Explosive and oxidizing properties, Threshold limit values and biological exposure indices, MAK values, Community exposure limits, 5S, Storage and handling of hazardous substances

Module V: Environmental protection: Integrated pollution prevention and control, Recycling and Disposal, Waste-Gas Purification, Waste Disposal, Waste water, Electrical hazards, Biologic hazards, Cold exposure, Noise, Areas for improvement.

Text Books:

1. Chemical Safety in the workplace, Guidance Notes on Paint Spraying and Related Coating Processes, Ist edition, 2003
2. A. Goldschmidt, H. J. Streitberger, BASF Handbook on Basics of Coating Technology, ISBN 3866309031, 2nd revised edition, 2007

References Books:

1. D. Stoye, W. Freitag, Paints, Coatings and Solvents, ISBN 3527288635, 2nd edition, Wiley-VCH, 1998.
2. R. Lambourne and T. A. Strivens, Paint and Surface Coatings - Theory and Practice, ISBN: 185573348 X, Woodhead Publishing, 2nd edition, 1999

SEMESTER – 2 (For All Streams)
NPT-502: Modern Evaluation Techniques of Surface Coatings

L	T	P	C
3	1	0	4

OBJECTIVE: The objective of this course is to enable the students
To understand relevance, process, and of analysis, and introduction to various analytical techniques
To understand the basic principles, instrumentation and applications of IR and Mass spectroscopy.
To understand the principles, instrumentation and applications of Electron Microscopy
To understand the principles, instrumentation and applications of DSC, TGA, DTA, and X-ray photoelectron spectroscopy.
To understand application of various analytical techniques in production, quality control, and investigation of paint film failures.

Course Outcome

On the successful completion of the course, students will be able to:

CO1	Study the process of analysis of paints interpretation of data	Analyze
CO2	Study the principles and application of IR and Mass Spectroscopy	Apply
CO3	Study the principles, instrumentation and applications of Electron Microscopy	Apply
CO4	Apply the principles of DSC, TGA, DTA, and X-ray photoelectron spectroscopy.	Apply
CO5	Apply the analytical techniques in production, quality control and investigation of paint film failures.	Apply

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	3	3	1	1	1	2	3	3	2
CO2	3	3	2	3	3	1	1	1	2	3	2	2
CO3	3	3	2	3	3	1	1	1	2	3	2	2
CO4	3	3	2	3	3	1	1	1	2	3	2	2
CO5	3	3	3	3	3	2	3	1	2	3	3	2
Avg.	2.8	2.8	2.0	3.0	3.0	1.2	1.4	1.0	2.0	3.0	2.4	2.0

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Unit-I: Relevance of modern analytical techniques to paint analysis, Process of analysis: plausibility check, comparison with databases and interpretation with respect to the analytical problem. Introduction to different analytical techniques

Unit-II: Infrared spectroscopy – Characteristic absorptions, Instrumentation, Plotting of spectra, Quantification, Surface infrared spectroscopy – Attenuated Total Reflectance (ATR-FTIR), FTIR, near infrared (NIR) spectroscopy.
Mass spectrometry – Basic principle, Instrumentation, Spectral evaluation, Quantification, Imaging and its applications, GCMS and LCMS.

Unit-III: Optical light microscopy, Scanning electron microscopy: Secondary electrons, Back-scattered electrons, Characteristic X-ray radiation, Resolution, Instrumentation, Sample condition, Information depth

Electron microanalysis: Quantification, Detection limits and its application.
Transmission Electron Microscopy (TEM): Types of contrast, optics, pigment particle size and identification, Electron spin resonance and particle size analysis.
X-ray photoelectron spectroscopy: Information depth, Lateral resolution, Information retrieval, Quantification, Instrumentation, Applications, Technical Data, and Performance of selected methods.

Unit-IV:
DSC (Differential Scanning Calorimetry), TGA (Thermo Gravimetric Analysis) and DTA (Differential Thermal Analysis), Dynamic Mechanical Analyser (DMA) in characterization of coating.
Rheological studies; Rheometer, Dynamic, oscillatory, creep, structure recovery, temperature sweep, time-temperature superposition.
Unit-V: **Application of analytical techniques**
Quality control: Binders, Solvents, Pigments and fillers.
Production control: Analysis of filter residues, SEM/EDX analysis of filter residues, FT-IR analysis of filter residues, Analysis of fogging residues, Investigation of the degree of crosslinking in 2-pack paints, Investigation of paint additive migration.
Investigation of paint failures: Adhesion and wetting problems, Paint delamination, Investigation of paint cratering, Investigation of paint blistering, Stains and deposits on painted surfaces.

Reference Books:

1. Paint Analysis by Roger Dietrich
2. Pigment Hand Book Part 1, 2, 3 by Patton
3. Paint Film Defects by Hess
4. Coatings Technology Handbook by Arthur A. Tracton
5. High performance Pigment by Huge M. Smith
6. Surface Coatings: Raw materials and their usage by Oil and Colour ChemistsAssociation.

NPT-504: Modern Manufacturing Techniques of Surface Coatings

L	T	P	C
3	1	0	4

OBJECTIVE: The objective of this course is to enable the students understand
The role and dosage of additives and principles of coating formulation.
The Pigment-Binder geometry, PVC and CPVC of paints.
The principles of coating manufacture.
The production planning, safety and health hazards, related to paint manufacture.

Course Outcome

On the successful completion of the course, students will be able to

CO1	Study various Heavy Duty Machines for paint manufacturing	Apply
CO2	Study media mills, ball mill, sand mill, pebble mill	Apply
CO3	Study various High speed Machines for paint manufacturing	Apply
CO4	Study various High speed Machines	Apply
CO5	Use computer software in formulation of resins and paints	Apply
CO6	Apply knowledge of properties of all the raw materials for formulating and preparing different types of paints. Apply paints by various methods	Apply, Create

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	2	2	2	2	2	2	-	2	3
CO2	3	2	2	1	1	1	1	2	2	-	2	3
CO3	3	2	2	2	2	2	1	1	2	1	2	2
CO4	3	2	2	-	2	3	3	3	3	3	3	3
CO5	3	2	2	2	3	-	-	-	2	2	2	3
CO6	3	2	3	2	3	1	1	1	2	2	2	2
Avg	3.0	2.0	2.33	1.5	2.17	1.5	1.33	1.5	2.17	1.33	2.17	2.67

1:Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Unit-1: Heavy Duty Machines

Rotor breakers, cage impactors, Heavy-duty mixtures, double blade mixers, sigma mixture, Warner & Pflauder sigma kneaders, pug mills, edge runner roller mills, Hammer mills, jet mills, Rotostator. Roll mills: Two roll mills, Triple roll mills; Vertical and horizontal construction, material balance, power input, Mill base compositions, dry pans, and chaser mills, toothed and cage disintegrator shredders,

Unit-2: Media mills

Ball and Pebble mills (batch and continuous): Advantages & disadvantages, physical factors affecting the performance of ball mill, critical & optimum speed of ball mill.Types of grinding media and practical considerations for ball mills and other mills Attritors and Bead Mills, autogenous tumbling mills, vibratory mills

Unit-3: High-Speed Machines

Fine grinding hammer mills, pin mills, Sand Mills: Vertical and Horizontal type (Pressurized and Normal); description, types of sand, selection of grinding media, impeller unit, mill base composition, production rates & economic considerations, advantages & disadvantages of sand mill, Dyno Mill, Basket Mill

Unit-4: Dispersers

High-speed disc disperser: description; size, positioning & speed of disperser blades, mill base rheology, power input, Twin-shaft disperser, Cowles dissolvers, Kady Mills. High speed stone and colloid mill: Description, stone grit size, mill base composition. High-speed impingement mill: Description, mill base composition, order of addition, Dispermat

Unit-5: Other machines

Extruders, Ultrasound dispersion, Evaluation of dispersion, Wood pulp beaters, buhrstones
Blake and overhead jaw crushers, primary, secondary, and cone gyratory crushers, fluid energy super fine mills: centrifugal jet, opposed jet, jet with anvil, fluidized bed jet

References and suggested readings:

1. Organic Coating Technology, Vol II by H.F. Payne
2. Surface Coatings, Vol II by, OCCA, Australia
3. Outlines of Paint Technology by W. M. Morgan
4. Testing of Organic Coatings by Norman I. Gaynes
5. Basics of paint technology Part-2 by V.C. Malshe
6. Organic Coatings Analysis by Konstandt
7. Organic Coatings: Science and Technology Vol 01 by Jones, Wicks, and Pappas
8. Surface Coatings by Swaraj Paul
9. Paint Flow and Pigment Dispersion: A Rheological Approach to Coating and Ink Technology by T C Patton

NPT-506: High-Performance Coatings

L	T	P	C
3	0	2	4

OBJECTIVE: The objective of this course is to enable the students understand and apply.
Various types of powder coatings and their applications.
Various types of coatings for underground pipelines and their applications.
Various types of coatings for marine and shipping applications.
Various types of coil coatings and their applications.
Coatings for automotive industry.
Testing and evaluation of various high performance coatings.

Course Outcome
On the successful completion of the course, students will be able to:

CO1	Learn about various types of powder coatings, their application, curing and testing	Apply
CO2	Learn about various types of coatings for underground pipelines, and their application	Apply
CO3	Learn about various types of coatings for marine and shipping applications, and their application	Apply
CO4	Learn about various types of coil coatings, and their application	Apply
CO5	Learn about various types of coatings for automotive industry, and their application	Apply
CO6	Test various high performance coatings	Evaluate, Apply

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	2	1		2	2	3	2	1	2	3
CO2	3	2	2	2	1	1	2	2	2	1	1	3
CO3	3	2	2	2	1	2	2	1	2	1	2	2
CO4	3	1	2			2	2	2	2	1	2	2
CO5	3	2	2	1	2	2	2	1	2	1	2	2
CO6	3	2	2	2	2	2	2	1	2	1	2	2
Avg.	3.0	1.67	2.0	1.33	1.0	1.83	2.0	1.67	2.0	1.0	1.83	2.33

1:Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Unit-I: Powder Coatings & their importance. Industrial thermoplastic & thermosetting powder coatings, parameters influencing powder coating properties, thermosetting powder coatings. Polymers used in powder coatings, thermoplastic powder coating based on vinyl, polyolefins, nylon polyesters, etc., thermosetting powder coating based on epoxy, urethane, acrylic, etc. Curing reaction, monitoring of curing process, cross linkers used in thermosetting powder coatings.
Test methods for powder coatings,

Unit-2 Coating for underground pipe lines- Importance of pipe line. Pipe lines and corrosion. Need and characteristics of pipe line coatings. Coal tar coating, single- layer fusion bounded epoxy coatings. Dual-layer FBE Coatings. Three layer polyethylene/polypropylene coatings.

Unit-3 Coatings for marine and shipping applications
Introduction, Types of application, coating for corrosion protection, coatings for antifouling protection,

inspection, monitoring and maintenance, future trends.

Unit-4 Coil coatings
Introduction, coil coating process, types of metal substrates used in coil coating (steel, aluminum, etc.), Cleaning and pretreatment processes, Composition and properties of coil coating materials, , Application techniques, uses, future of coil coating.

Unit -5 Organic coatings for automotive industry - Types of automotive coating. Sequence for automobile body cells. Detailed methodology of primers, base coat, top coats. Metallic finishes. Anti Scratch and anti Mar coatings. Special coating for plastic and other non metallic components

Unit 6: Testing and evaluation of: Dry Film Thickness, Wet Film Thickness, Scratch hardness, Rub resistance, Acid resistance, Alkali resistance and Corrosion resistance, Salt Spray resistance, Water vapor permeability.

Reference Books:

1. A Guide to High-performance Powder Coating by Bob Utech
2. User's Guide to Powder Coating, Fourth Edition, by Nicholas Liberto
3. Beginning Powder Coater's Handbook: An Introduction to powder Coating by Tracy Norris.
4. Surface Coatings, Raw Materials & their usage-Vol-II by Chapman & Hall.
5. High-performance organic coatings Edited by Anand S. Khanna

NPT-508 Statistical Designs of Experiments

L	T	P	C
3	1	0	4

OBJECTIVE: The aim of the course is to give competences in the field of applied statisticalmethods for work concerning planning and analysis of experiments, regression analysis, optimization of processes and multivariate analysis.

Course Outcome:

Students completing the course will be able to

CO1	Understand the importance of randomization and replication of experimental data set.	Understand, Apply
CO2	Estimate statistical variance and perform analysis of variance, regression analysis, correlation analysis on a given experimental data	Apply, Evaluate
CO3	Design full factorial and fractional factorial experiments and analyse the data	Analyse, Evaluate, Apply
CO4	Develop nested designs, block designs and response surface designs	Understand, Evaluate
CO5	Recognize what design was followed and perform the appropriate analysis given the description of how a set of data was collected.	Analyse, Apply, Evaluate

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	1	-	-	-	-	-	-	-
CO2	3	3	2	2	1	-	-	-	-	-	-	-
CO3	3	2	3	3	2	-	-	-	-	-	-	-
CO4	3	3	3	2	1	-	-	-	-	-	-	-
CO5	3	3	2	3	2	-	-	-	-	-	-	-
Avg	3	2.6	2.4	2.2	1.4	0	0	0	0	0	0	0

Syllabus

Module 1

Introduction to statistics for engineers: Simplest discrete and continuous distributions, Statistical inference, Statistical estimation, tests and estimates on statistical variance,Analysis of variance, Regression analysis (Simple linear, multiple, polynomial, nonlinear), Correlation analysis (Correlation in linear regression, correlation in multiple linear regression)

Module 2

Design and analysis of experiments: Introduction to design of experiments, Preliminaryexamination of subject of research, Screening experiments

Basic experiment-mathematical modeling: Full factorial experiments and fractional factorial experiments, Second-order rotatable design (Box-Wilson design).

Module 3

Orthogonal second order design (Box Benken design), D-optimality, Bk-designs and Hartleys second order design.

Statistical analysis: Determination of experimental error, Significance of the regressioncoefficients, Lack of fit of regression models

Module 4

Experimental optimization of research subject: Problem of optimization, Gradientoptimization method, canonical analysis of response surface.

Module 5

Mixture design `composition-property: Screening design `composition-property', Simplex lattice design, Scheffe simplex lattice design, Simplex centroid design, Extreme vertices design, D-optimal design, Draper-Lawrence design, Factorial experiments with mixture, Full factorial combined with mixture design.

Suggested Text Books:

1. Z. R. Lazic, Design of experiments in chemical engineering: A practical guide, Wiley, 2005.

NPT-510: Advances in Printing Inks

L	T	P	C
3	1	0	4

OBJECTIVE: The objective of this course is to enable the students
To understand various types of printing processes, substrates and inks used
To evaluate various raw materials used in printing inks
To understand ink characteristics and formulate letterpress and lithographic inks
To formulate inks for various applications
To solve various ink related problems

Course Outcome
On the successful completion of the course, students will be able to

CO1	Understand various printing processes, types of substrates and inks used.	Understand
CO2	Understand various ink raw materials, their properties, testing and evaluation, and applications.	Understand
CO3	Understand general characteristics of Letterpress and Lithographic printing inks and formulate these inks for various applications. Analyze various ink related problems and solve them	Apply, Analyze
CO4	Understand general characteristics of Flexographic, Gravure and Screen printing inks and formulate these inks for various applications. Analyze various ink related problems and solve them	Apply, Analyze
CO5	Understand manufacture and quality control of printing inks. Guidelines for health safety and environment and apply it.	Understand, Analyze, Evaluate

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	-	-	2	1	1	1	1	1	2
CO2	3	2	2	1	1	2	2	2	1	2	2	2
CO3	3	2	3	2	1	2	2	2	1	2	2	2
CO4	3	2	3	2	1	2	2	2	1	2	2	2
CO5	3	2	2	2	2	2	2	2	1	1	2	2
Avg	3.0	2.0	2.2	1.4	1.0	2.0	1.8	1.8	1.0	1.6	1.8	2.0

1:Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Module I: Printing Processes

Different printing processes such as offset, flexographic printing, gravure printing, screen printing, digital printing, Intaglio printing, etc. Developments in printing processes for different metallic and non-metallic substrates.

Module II: Raw Materials for Printing Inks

Testing and evaluation of raw materials for use in printing inks: pigments, dyestuffs, oils,resins (natural and synthetic), solvents, plasticizers, waxes, driers, miscellaneous additives (chelating agents, anti-oxidants, surfactants, deodorants, defoaming agents, laking agents), raw materials for radiation curing systems (pigment selection, prepolymers, reactive diluents, photo-initiators, additives, and inhibitors).

Module III: Paste Inks

Letterpress inks: general characteristics, types of presses, letterpress ink formulation, ink- related problems and their possible solutions, lithographic inks: general characteristics, Modern formulation techniques of Paste inks, inks for packaging, ink-related problems, and their possible solutions, web-offset inks for paper and board. Formulation of printing inks for different applications: metal decorating inks, two-piece can decoration inks, dry-offset inks.

Module IV: Liquid Inks

Gravure inks, general characteristics, formulating principles, Modern formulation techniques of Liquid ink, inks and varnishes for specific end-use applications, printing ink faults. Flexographic inks: general characteristics of the inks, formulating principles. Flexo and Gravure inks for flexible packaging; Screen inks: general characteristics, screen inks for paper, plastics, textiles; Inks for electronics industry; ultra-violet and electron-beam curing inks; edible and soluble packaging inks; daylight-florescent inks.

Module V:

Rheology of printing inks; testing and quality control of printing inks. Evaluation of printing inks. Special purpose inks: MICR inks, security inks, sublimation inks, Lamination inks, extrusion inks. Recent developments in inks. Health, safety, and environment.

Reference Books:

1) Printing Ink Manual – by RJ Pierce & RH Leach
2) Printing Inks: Formulation Principles, Manufacture & Quality Control Testing Procedures – by Ronald E.Todd
3) Chemistry & Technology of Water-based Inks- by Laden
4) Ink Technology for Students & Printers – by EA Apps

NPT-512: Advances in Packaging Technology

L	T	P	C
3	1	0	4

OBJECTIVE: The objective of this course is to enable the students understand
To understand concept of packaging and utility of coating and printing in packaging.
To analyze properties of polymers for their utility in packaging of vanity of products.
To know various sources of waste generation and the and its managements.
To understand the recycling techniques used for various paint industries.

Course Outcome
On the successful completion of the course, students will be able to

CO1	Understand the concept of packaging and utility of coating and printing in packaging, laws and regulations, package disposal, eco-friendly packaging	Understand
CO2	To develop and design packages	Apply
CO3	Understand the different packaging materials, their degradability and recyclability	Apply
CO4	Know various wastes generated during painting processes	Understand
CO5	Manage waste generated during painting processes, global policies and regulations	Apply

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	2	-	-	2	1	1	1	-	1	2
CO2	3	2	2	-	-	3	2	2	1	-	1	2
CO3	3	2	2	-	-	3	2	2	2	-	1	2
CO4	3	2	-	-	-	1	2	1	2	-	2	2
CO5	3	2	2	2	-	1	3	1	3	2	3	2
Avg	3.0	1.6	1.6	0.4	0.0	2.0	2.0	1.4	1.8	0.4	1.6	2.0

1:Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Module I: Introduction to Packaging.Elements of packaging & its influence on customers, scope, and functions of a package. Materials used for packaging: paper and paperboards; films and foils; metals andplastics; wood; miscellaneous other materials. Comparison of metal & plastic packaging.

Module II: Criteria and selection of packing material, Requirements of packaging surfaces for Paints andallied products viz. Compatibility with the material to be packed, properties of various packaging materials and their specifications & essential components for selection of packaging materials, essential criteria for selection of packaging materials, Different packaging and sealing machine for liquid / semisolid packaging of paint. Eco-friendly alternative to plastic packaging.

Module III: Forms of packaging: Folded cartons/boxes; corrugated board boxes, metal containers, aerosols. Tubes, cans, and different forms of plastics, types of polymers used as packaging materials & auseful commercial blend of polymers packaging.

Module IV: Printing of packaging surfaces, Requirements of Printing and evaluation of printed surfaces, co-extrusion, extrusion Coatings and laminations of the packaging surfaces, types, and properties of coatings and limitations, different types of laminating machines. Typical laminates film's constructions and its benefits & application.

Module V: Packaging of various products of Paints & Coatings. Multilayer packaging Food packaging & its environmental impacts. Limitation of solid waste management practices. Types of packaging material and environmental issues, advantages, and disadvantages. Minimizing environmental impact. Physical & chemical tests of packing materials.

Reference Books and suggested readings:

1. Journal of Applied Packaging Research.
2. Journal of Indian Food Industry.
3. Central Food Technological Research Institute Mysore.
4. Qenos Technical Guides.
5. Journal of Food Science & Technology.
6. Journal of pharmaceutical & Scientific Innovation.
7. Journal of Indian Food Industry.

SEMESTER – III (For all streams)

NPT – 601: Advances in Surface Treatment and Coating Application

L	T	P	C
3	1	0	4

OBJECTIVE: The objective of this course is to enable the students understand and apply
Different contaminants and their removal from different surfaces.
Chemical pretreatment and different chemical conversion coatings
Different paint application techniques
Different paint and paint film defects and remedies to overcome them

Course Outcome
On the successful completion of the course, students will be able to

CO1	Understand the different methods of preparing surfaces for painting	Understand
CO2	Apply the knowledge of pretreatment methods to ferrous and non-ferrous substrates	Apply
CO3	Learn about various methods of application of paints	Apply
CO4	Apply the knowledge of processes and equipment of paint application, effluent treatment and waste management	Apply
CO5	Analyze various paint defects and take remedial actions to overcome the same	Analyze, Apply
CO6	Apply knowledge of paint application by brush, spray and powder coating	Apply

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1	-	1	1	1	1	-	-	-	2
CO2	3	2	2	2	1	1	1	1	2	-	2	2
CO3	3	2	2	-	-	1	1	1	2	1	2	2
CO4	3	2	2	1	1	2	2	1	2	2	2	2
CO5	3	2	2	2	2	1	-	1	2	-	2	2
CO6	3	2	3	2	-	2	1	1	2	-	2	1
Avg	3.0	1.83	2.0	1.17	0.83	1.33	1.0	1.0	1.67	0.5	1.67	1.83

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Unit-1: Objective, methods, and equipment of surface preparation

Objectives of surface preparation, surface preparation methods: hand cleaning, power cleaning, flame cleaning, abrasive blasting; classification, selection & equipment, BS and ISO standards chemical cleaning: solvent, acidic, alkaline, emulsion cleaning equipment for surface preparation: immersion, vapour, wiping & spray, operating conditions, bath analysis & control. Surface preparation for new & previously painted surfaces. Surface preparation methods for plastic substrates:

Unit-2: Pretreatment and conversion coating

Pretreatments of ferrous metal substrate: degreasing, de-rusting, pickling; compositions, operating conditions, bath analysis & control. Pretreatments of non-ferrous metal substrates: anodizing chemical

conversion coatings: phosphate coatings; classification, advantages & disadvantages of Zn and Fe phosphating, bath make-up & maintenance, operating parameters, tri-cationic treatment, Nanotechnology in surface treatment, eco-friendly in situ phosphating, chromate conversion coating: classification, coatingprocess.; rinsing, accelerator, and passivation.

Oxsilan – The eco-friendly solution for ZnPh replacement: Chemistry, Process comparison: Oxsilan vs.ZnPh, Cost advantages

Unit-3: Coating application methods

Architectural paint application: Brush, roller Industrial Paint application: Spray methods- air-assisted spray, airless spray, air-assisted airless spray, high volume low-pressure spray, multi-component guns, electrostatic spray, transfer efficiency, dual feed spray, paint circulation system, spray booth, Bell application, robot painting,

Unit-4: Paint Application in Automobiles

Automation in the Paint Application, Painting Robot, Atomizer, Paint Color Changer, Paint Dosing Technology for Liquid Paints, Paint Supply Systems for the Industrial Sector, Paint Mixing Room, Circulation Line System, Supply Systems for Special Colors, Voltage Block Systems with Color-ChangePossibility, sealing and underbody protection in automobiles

Unit-5: Other industrial paint application

Roller coating (coil coating), dip coating, flow coating, curtain coating, dip spin coating, calender coating,knife coating, silk-screen

Powder coating application: fluidized bed, electrostatic fluidized bed, electrostatic powder spray Electrodeposition: anodic/ cathodic deposition, commercial ED installation, throwing power, bath control, ultra-filtration, variables, advantages & disadvantages, bath parameters, line monitoring, common paint film defects in CED. Plasma coating, chemical vapour deposition, physical vapour deposition, auto deposition

References and suggested readings:

1. Organic Coating Technology, Vol II by H.F. Payne
2. Surface Coatings, Vol II by, OCCA, Australia
3. Outlines of Paint Technology by W. M. Morgan
4. Automotive Paints and Coatings by Streitberger and Dossel
5. Basics of paint technology Part-2 by V.C. Malshe
6. Organic Coatings Analysis by Konstandt
7. Organic Coatings: Science and Technology Vol 01 by Jones, Wicks, and Pappas
8. Surface Coatings by Swaraj Paul
9. The Application of Surface Coatings by C.J.A.Jaylor, S. Marks

NPT-603: Eco-friendly & Specialty Coatings

L	T	P	C
3	1	0	4

OBJECTIVE: The objective of this course is to enable the students understand:
Eco System & Management.
The fundamental concepts of various Architectural Coatings& their Formulations
The Eco-friendly Coatings e.g. High Solids, Radiation curable and water based etc.
The Powder Coatings.

Course Outcome
On the successful completion of the course, students will be able to

CO1	Understand Eco-friendly system	Understand
CO2	Select the raw materials and formulate the eco-friendly paint using green engineering and green chemistry principles	Apply
CO3	Formulate architectural coatings	Apply
CO4	Formulate eco-friendly coatings for various surfaces	Apply
CO5	Formulate powder and specialty coatings	Apply

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	2	1	-	1	2	3	2	3	2	3
CO2	3	2	2	1	1	2	3	2	2	2	2	2
CO3	3	1	-	-	1	2	2	2	2	1	1	2
CO4	2	1	1	-	1	2	2	2	2	2	2	3
CO5	1	1	1	-	1	2	2	2	1	1	1	2
Avg	2.4	1.2	1.2	0.4	0.8	1.8	2.2	2.2	1.8	1.8	1.6	2.0

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

(b) **Unit-I:** (a) Eco-system (Ozone layer/Carbon neutral materials/ Biodegradability of materials/ Green materials); Environmental issues related to conventional coatings, such as Volatile Organic Compounds (VOCs) and Hazardous Air Pollutants (HAPs); Elimination and Reduction of VOCs from Coatings, Restriction on lead content in architectural coatings; Safety Health & Environment (SHE) management; Renewable raw materials for coatings.

(c) Water-borne Coatings- Water (based/soluble/thinnable/dilutable/reducible) Coatings; Water as a substitute for Organic Solvents; Merits & Demerits of Water as a Coating solvent, Water-soluble Coatings; Emulsions & Emulsion-based Coatings; Role of Surface Active Agents in their formulations; Aqueous Dispersion Coatings; Rheology of Water-borne Coatings; Recent Developments; Cement putty: innovative ingredients like RDP resins, cellulose ethers;,

(d) Cathodic Electrodeposition (CED) Coatings- Theoretical aspects of Electrodeposition; CED Versus AED processes; Chemistry of CED Binders; Electrochemistry of Application Process; Cure Mechanisms; Throwing Power; Practical Aspects, Testing & Evaluation of CED Coatings; Bath parameters and Bath Control; Current Trends

Unit-II: (a) High Solids Coatings- Concept; Binders & Reactive Diluents; Formulation; Curing; Merits &Demerits; Production; Properties/Evaluation; Uses & Application; Current Trends
(b) Powder Coatings- Formulation; Classification; Production; Properties & Evaluation; Parameters influencing properties; Curing; Uses; Application Techniques, such as Electrostatic spraying, Fluidization& Electrofluidization etc.; Recent Developments

Unit-III: Radiation Curable Coatings- Fundamentals, various Radiations, Radiation cure Mechanisms;

(a) Ultraviolet (UV) Curing- Formulation, Monomers/Oligomers, Photoinitiators & Sensitizers, UV initiated Cationic cure of epoxy resins Merits & Demerits, Testing & Evaluation, Uses & Applications, Recent Trends

(b) Electron Beam (EB) Curing- EB generators, Formulation, Merits & Demerits, Testing & Evaluation,Uses & Applications, Recent Trends

Unit-IV: Special-Purpose Coatings- Automotive Coatings & Refinishing; Aircraft Coatings; Marine & Ship Coatings; Coatings for Appliances (Metal Containers, Can Coatings); Coatings for Electronic Appliances; Coil Coatings; Coatings for Plastics, Papers, Leather, Textiles, etc.; Coatings for Swimming Pool, Coatings for Rail-road Bridges; Coatings for Chemical plants & refineries; Coatings for Nuclear Power Plants, Road marking paints. Signs and their manufacture,

Unit-V: Specialty Coatings- Corrosion-resistant Primers (Red oxide-zinc chromate, zinc phosphate, zinc-rich - inorganic & organic, Wash/Etch primers); New developments in automotive coatings; High performance/Heavy-duty Coatings; Heat Resistant Coatings; Conversion Coatings; Self-stratifying Coatings; Smart Paints; Nano-technology inOrganic Coatings.

References and suggested readings:

1. Organic Coating Technology, Volume II; by H.F. Payne
2. Surface Coatings, Volume II by; OCCA Australia
3. Outlines of Paint Technology; by W. M. Morgan
4. Basics of paint technology, Part-2; by V.C. Malshe
5. Surface Coatings; by Swaraj Paul
6. Automotive Paints and Coatings; by Streitberger and Dossel
7. Powder coatings Volume I & II; by Hester

OPT 601: Corrosion Control through Organic Coatings

L	T	P	C
3	0	0	3

OBJECTIVE: The objective of this course is to enable the students understand:
Study of Plant Safety is an essential requirement of the chemical process industries.
Knowledge of plant safety is indispensable while working in plant to prevent accidents and damages.
A safety management, audit and risk analysis skill prepares the plant operators and managers to emerge to a safe protocol and minimize potential damages to personnel, process equipment, and the environment.
This course will give an overview of the safety regulations and practices, plant hazards and their control, risk management principles and techniques and accident analysis.
The environmental aspects of various industries are also discussed to clear the comprehensive approach of the subject objective

Course Outcome
On the successful completion of the course, students will be able to

CO1	Understand the various aspects of corrosion, its mechanism, and classification	Understand
CO2	Apply the knowledge of surface preparation for better corrosion resistance	Understand
CO3	Understand the composition of anticorrosive coatings, Binders used for high performance paints	Understand, Apply
CO4	Know the types of corrosion inhibitive pigments and the barrier mechanism	Apply
CO5	Apply the knowledge of corrosion Inhibitors, Introduction to liquid organic corrosion inhibitor to improve salt spray test	Apply, Analyze

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	-	-	1	1	-	-	1	1	2
CO2	3	2	2	2	1	-	2	-	-	2	2	2
CO3	3	1	2	1	1	1	1	-	-	2	2	2
CO4	3	1	2	2	-	2	2	1	-	-	2	3
CO5	3	2	2	3	3	2	2	2	1	2	2	3
Avg	3.0	1.6	1.8	1.6	1.0	1.2	1.6	0.6	0.2	1.4	1.8	2.4

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Module-1 Corrosion control
Definition of corrosion. Economic and functional aspects of corrosion. Classification of corrosion- C1---C5 environmental conditions. Uniform, galvanic. Crevice, pitting, intergranular, selective leaching, stress and erosion corrosion. Role of permeability of oxygen and water in polymers for corrosion control.

Module-2 Surface preparation
Surface preparation and its importance in inhibiting the corrosion for metal. Methods of surface preparations Hand cleaning, Power tool cleaning Solvent wiping and de greasing, alkali and acid cleaning. Paint removers:- Alkali and solvent base paint removers, flammable, Non-flammable type.

Module 3:-Composition of Anti corrosive coatings
Epoxies; Ultra violet degradation, variety of Epoxy paint, Acrylics: Copolymers, Polyurethanes: moisture cur, chemical cure Block isocyanates, Water-Borne polyurethane, Alkyds: Immersion behaviour, brittleness,

Chlorinated rubber: DE hydro chlorination. Epoxy esters, Silicone base: Inorganic base Zinc-Rich primes.

MODULE -4:-Corrosion Inhibition

Corrosion Inhibitors, Electrical studies, Inhibition mechanism, Types & Properties of Inhibitors, Introduction to liquid organic corrosion inhibitor to improve salt spray test
Corrosion-Inhibiting pigments: Types of pigments, Zinc phosphate, types of zinc phosphate, Aluminium triphosphate, Ferrities, types of chrome pigments, Barium meta borate, Molybdates, Silicates, Iron Oxide, Non-metallic barrier pigments, Metallic Pigments, Health Issues

MODULE -5: Assessment of corrosion
Corrosion testing : Planning and preparation; destructive and non-destructive methods; physico-chemical methods-immersion, humidity, salt spray, special property tests for SCC, IGC etc.; electrode potential measurements, polarization measurements, electrochemical impedance spectroscopy, cyclic voltametry; merits and demerits of various test methods; NACE test methods

Reference Books and Suggested Readings

1. Corrosion Engineering by Mars G. Fontana- McGraw Hills Book Co.
2. An Introduction to Science of Corrosion and its inhibition, by S.N. Banerjee, Oxonion Press Pvt. Ltd.
3. Organic Coating Technology, by H.F.Payne
4. Surface Coating Technology by Swaraj Paul
5. Surface Coatings, Vol. II by OCCA, Austrailia
6. Good Painting Practices by J. Bigoos
7. Corrosion Control Through Organic Coatings by, Amy Forsgren, Taylor and Francis, Boca, Tratan, London, New York.

NPT-605: Seminar

L	T	P	C
0	0	2	1

The seminar, the power-point presentation shall be prepared on surface coating-oriented and advanced topics with references of journal papers. The Presentation is to be planned for 15 minutes including a question-answer session of five minutes. The marks will be awarded basedon the relevance and knowledge content; language and the way of presentation of the seminar.

NPT-607: Dissertation I

L	T	P	C
0	0	16	8

The students shall be undertaking a research project for 1 year either in a leading Industry/research Institution or in the department. The research work will be guided by one supervisor from the respective industry/institution and one supervisor from the department. The student will have to submit an interim report at the end of the third semester and make a presentation in the Department. The evaluation will be made based on the thesis, the presentation, and the viva-voce, as per university guidelines. The report may include the aspects of the literature review, identification of the problem, PERT chart, and work done. A comprehensive oral Viva-voce examination will be conducted to assess the student's, depth of understanding of the problem.

IV Semester

NPT-602: Dissertation/ Project

L	T	P	C
0	0	32	16

The students shall be continuing the research project, guided by one supervisor from the respective industry/institution and one supervisor from the department. The student will have to submit the final thesis at the end of the fourth semester and make a presentation in the Department. The final evaluation will be made based on the thesis, the presentation, and the viva voce, as per university guidelines. The thesis shall include the report of the third semester, methodology of work, and findings in the proper format. A comprehensive oral Viva-voce examination will be conducted to assess the student's, depth of understanding in the specified field and findings of his work, etc. An internal and external examiner shall be appointed by The University for the Conduction of viva voce under the University examination System.