SEMESTER WISE COURSE STRUCTURE & EVALUATION SCHEME

for

M. TECH. DEGREE PROGRAM
IN
CHEMICAL TECHNOLOGY
PAINT TECHNOLOGY
(Effective from the session 2019-20)

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 2020-2021 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)

Stream A													
Sr. No.	Course Type	Subject Code	Course Title	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1.	PCC	TPT 551	Advances in Chemistry and Technology of Film Formers	5	3	1	2	15	20	15	50	50	100
2.	PCC	TPT 553	Pigmentation of Surface Coatings	4	3	1	0	30	20	-	50	50	100
3.	PCC	TPT 555	Advanced Modelling and Simulation of Chemical Engineering Systems	4	3	1	0	30	20	-	50	50	100
4.	PEC	TPT 557	Advanced Chemical Reaction Engineering	4	3	1	0	30	20	-	50	50	100
		Total		**17**	**12**	**4**	**2**				**200**	**200**	**400**

OR

Stream B/C													
Sr. No.	Course Type	Subject Code	Course Title	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1.	PCC	TPT 559	Technology of Resins and Polymers	4	3	1	0	30	20	-	50	50	100
2.	PCC	TPT 561	Chemistry and Technology of Pigments	5	3	1	2	15	20	15	50	50	100
3.	PEC	TPT 563	Technology of Surface Coatings	4	3	1	0	30	20	-	50	50	100
4.	PCC	TPT 565	Industrial Stoichiometry	4	3	1	0	30	20	-	50	50	100
5.	*MC (Non Credit)	BMA 551	Engineering Mathematics	2	2	0	0	-	-	-	-	-	-
		Total		**17**	**12**	**4**	**2**				**200**	**200**	**400**

*Only for students of Non-mathematics background at graduation level

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 2020-2021 for new entrants)

Year I, Semester II

Sr. No.	Course Type	Subject Code	Course Title	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1.	PCC	TPT 552	Modern Evaluation Techniques of Surface Coatings	4	3	1	0	30	20	-	50	50	100
2.	PCC	TPT 554	Modern Manufacturing Techniques of Surface Coatings	4	3	1	0	30	20	-	50	50	100
3.	PCC	TPT 556	High Performance Coatings	5	3	1	2	15	20	15	50	50	100
4.	PEC	TPT 558 TPT 560	Advances in Printing Inks Advances in Packaging Technology	4	3	1	0	30	20	-	50	50	100
5.	MC (Non Credit)	TPT 562	Audit Course Critical review of research publication on one relevant Topic		0	2	0						
6.	MC (Non Credit)	TPT 564	Audit Course Research Methodology and IPR		0	1	0						
		Total		**17**	**12**	**4**	**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 2021-2022)

Year II, Semester III

Sl. No.	Course Type	Subject Code	Course Title	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1.	PCC	TPT 651	Technology of Surfactant & Coating Additives	4	3	1	0	30	20	-	50	50	100
2.	PEC	TPT 653 TPT 655	Advances in Surface Treatment & Coating application Eco-friendly & Specialty Coatings	4	3	1	0	30	20	-	50	50	100
3.	MC (Non Credit)	TPT 661	Audit Course Critical Review of Research Publications on one Relevant Topic		0	2	0						
4.	MC (Non Credit)	TPT 663	Audit Course Research Methodology and IPR		2	1	0						
5.	Dissertation/ Project	TPT 695	*Dissertation/Project	2	0	0	4	-	50	-	50	50	100
6.	Seminar	TPT 697	Seminar	4	0	0	8	-	50	-	50	50	100
		Total		**14**	**8**	**5**	**12**				**200**	**200**	**400**

*Dissertation to be continued in fourth semester.

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Semester wise Course Structure

M. Tech. Chemical Technology - Paint Technology
(Applicable from Session 2021-2022)

Year II, Semester IV

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	TPT 698	Dissertation/Project	12	0	0	24	-	50	-	50	50	100
		Total		**12**	**0**	**0**	**24**		**50**		**50**	**50**	**100**

SEMESTER - I

TPT-551: Advances in Chemistry & Technology of Film-formers

For 'A' Stream

L	T	P	C
3	1	2	5

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, 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- reactive polyamides, 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 on the composition of copolymers, Properties and Applications of various Vinyl copolymers

(b) Acrylics- Acrylic vs. Vinyl monomers, Reactive/functional acrylic monomers, Solution & Dispersion acrylics, 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 Werner Frietag, Hanser Pib. 1996

TPT 553: PIGMENTATION OF SURFACE COATINGS

L	T	P	C
3	1	0	4

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,

TPT 555: Advanced Modelling and Simulation of Chemical Processes

	L	T	P	C
Syllabus	**3**	**1**	**2**	**5**

Module1 (10 Lectures)

Fundamentals of mathematical modelling-Principles of formulations, Fundamental laws: Continuity equations, energy equation, equation of motion, transport equations, equation of state, equilibrium, chemical kinetics; Advantages and limitations of models and applications of process models of stand-alone unit operations and unit processes; Classification of models Simple vs. rigorous, lumped parameter vs. distributed parameter, Steady state vs. dynamic, Transport phenomena based vs. Statistical; Concept of degree of freedom for steady state and unsteady state systems.

Module 2 (8 Lectures)

Mathematical models of heat-transfer equipments: Double pipe heat exchanger, Shell & tube heat exchangers, Evaporators, Fired heaters, Partial condensers

Module 3 (6 Lectures)

Mathematical models of mass-transfer equipments: Batch and continuous distillation columns, Reactive distillation columns, packed absorption columns, Dehumidifiers

Module 4 (8 Lectures)

Mathematical models of reactors: Batch reactors, Continuous-stirred tank reactors, Plug-flow reactors, Industrial reactors-Ammonia converter, Sulphuric acid converter, Methanol reactor, FCC reactor, Claus reactor, etc.

Module 5 (8 Lectures)

Numerical methods: Linear and non-linear simultaneous algebraic equations, Ordinarydifferential equations-Initial-value problems & boundary-value problems, Partial-differential equations Different approaches to flow sheet simulation- Sequential modular approach, Simultaneous modular approach, Equation oriented approach; Review of thermodynamic procedures and physical property data banks.

Suggetsed Text Books:

1. Luyben, W.L., “Process Modeling, Simulation, and Control for Chemical Engineering”, Wiley.

2. M.M. Denn, “Process Modelling”, Wiley, New York, (1990).

3. Hussain Asghar, “Chemical Process Simulation”, Wiley Eastern Ltd., New Delhi, (1986)

4. C.D. Holland and A.I. Liapis, “Computer Methods for Solving Dynamic Separation Problems”, McGraw Hill, (1983).

Suggested Reference Books:

1. C.D. Holland, “Fundamentals of Modelling Separation Processes”, Prentice Hall, (1975)

2. S.M. Walas, “Modelling with Differential Equations in Chemical Engineering”, Butterworth, (1991)

TPT 557:Advanced Chemical Reaction Engineering

	L	T	P	C
Syllabus	**3**	**1**	**2**	**5**

Module 1 (6 Lectures)

Kinetics of heterogeneous catalytic reactions, rate equations, model discrimination, and parameter estimation. Module 2 (7 Lectures) Deactivating catalysts, mechanisms of catalyst deactivation, the rate and performance equations, design.

Module 3 (7 Lectures)

Mass Transfer and Reaction in a packed bed, Stoichiometric table, Pressure drop in a Reactor, Ergun's equation, Flow-through a packed bed.

Module 4 (10 Lectures)

Types of multiphase reactors, mass transfer reactors, mass transfer equations, Interfacial surface area, mass transfer between phases, multiphase reactor equations, equilibrium between phases, membrane reactors, falling film reactors, bubble column reactors.

Module 5 (10 Lectures)

Falling film catalytic wall reactor, trickle bed reactors, multiphase reactors with catalysts, other multiphase reactors, reactor-separator integration, catalytic distillation, chromatographic reactors, iron ore refining, petroleum refinery.

Suggested Text Books

1. O. Levenspiel, "Chemical Reaction Engineering, Wiley India, (1998).

2. G. F. Froment and K. B. Bischoff, "Chemical Reactor Analysis and Design", John Wiley and Sons, (1979).

Reference Books

1. H. S. Fogler, "Elements of Chemical Reaction Engineering",
2. 2nd edition, PrenticeHall, (2000). 2. Lanny D. Schmidt, "The Engineering of Chemical Reactions", 2nd edition, Oxford University Press, (2010).

Elective-I **TPT-559: Technology of Resins & Polymers**

L	T	P	C
3	1	0	4

For 'C' Stream + 'B' Stream

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: (Polyesters & Alkyds):
(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

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

TPT 561: CHEMISTRY AND TECHNOLOGY OF PIGMENTS

L	T	P	C
3	1	2	5

Module-I: Pigment Chemistry and Properties

Colour Phenomena, Chemical structures and their colour imparting behaviours. Auxochromes and chromophores. Influence of physical factors, bathochromic shift, colour psychology, colour spectroscopy, hue, value and chroma, delta E, aesthetics, and safety standards. Light spectrum, light sources, selective absorption and scattering of light, primary and complementary colours, colour mixing, dimensions of colour and colour systems, colour measurements, Kubelka-Munk equation and concept of K/S, colour blindness, etc.

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, colour, 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: Inorganic pigments and Extenders

Comparison of organic and inorganic pigments, general methods of manufacturing of natural and synthetic inorganic pigments size reduction; micronization, air classification mill, airjet mill, and surface treatment of pigments. Manufacturing, applications and merits and demerits of nano pigments Extender pigments; source, manufacture, properties and uses of extenders pigments such as carbonates, such as calcium carbonate, dolomite, whiting,calcite, silicates, such as china clay, talc, kaolin, mica, calcium magnesium silicate, silica, alumina, sulphates, such as barytes, blanc fixe, oxides, aluminates and miscellaneous extenders, etc. Extender mixtures, calcined pigments and extenders.

White and black pigments Titanium dioxide; source, manufacturing, properties, chemistry, surface treatment, various grades and their technical characterization, applications, and ecology. Manufacturing, properties and applications of zinc oxide, zinc sulphide, zinc phosphate, lithopone, basic lead carbonate, sulphate, silicate, etc. Antimony oxide, calcium plumbate, zirconium oxide and silicate, potassium titanate, etc., Source, manufacturing, properties, and uses of black pigments: such as carbon black, furnace black, thermal, gas channel, acetylene black, and their technical characterization e.g. Particle size crystal size shape and distribution surface area oil absorption and structure of the aggregate, graphite, copper chrome complex, iron oxide, aniline and logwood, etc.

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.

Module –III: Organic Pigments and Dyestuffs, Definition of dyes, pigments dyestuffs, toners and lakes. Industrial Organic Pigments Raw materials : coaltar distillation products, mordants and precipitants, bases for colour striking and lakes, miscellaneous salts and chemicals. 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 andAnthraquinone and vatcolour pigment.

Module-IV :Metallic, Functional and Effect Pigments

Source, manufacture, properties and uses of metallic pigments such as aluminium, zinc, copper alloys, stainless steel etc. Anti-corrosive pigments such as micaceous iron oxide, red lead, silicone chromate, zinc and strontium chromates, white molybdates, calcium plumbate, etc., 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, invisible pigments, etc. Module –V: High Performance and Composite Pigments Phthalocyanine blue and green metal-free phthalocyanine; quinacridones and other related pigments, miscellaneous polycyclic organic pigments etc. Introduction to high performance pigments & dyes, such as azo condensation, quinacridones, perylene, perinone, dioxazine-carbazole, phthalocyanines, di-keto pyrolopyrol (DPP), quinophthalones, anthraquinone, and vat pigments. Composite and mixed pigments. Testing and identification of organic pigments. Introduction to colour index name and number. Colour coding systems

Module-V: 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,

TPT-563: Technology of Surface Coatings

L	T	P	C
3	1	0	4

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

TPT: 565 Industrial Stoichiometry

L	T	P	C
3	1	2	5

Syllabus

Module 1
Dimensions, system of units, and their conversions, Mass and volume relations, Basic stoichiometric principles, limiting and excess reactants, Degree of completion, Conversion, selectivity, yield. Ideal gas law, Dalton's Law, Amagat's Law, Introduction to degrees of freedom analysis.

Module 2
Vapor pressure of liquids and solids, Vapor pressure plot (Cox chart), Vapor pressures of miscible and immiscible liquids and solutions, Raoult's Law, and Henry's Law. Humidity and saturation use of humidity charts for engineering calculations.

Module 3
Material balance without chemical reactions and its application to unit operations like distillation, absorption, etc. Material balance with chemical reaction, Recycle, bypass, and purging.

Module 4
Heat capacity of gases, liquids, and solutions Heat of fusion and vaporization. Steady-state energy balance for systems with and without chemical reactions. Calculations and application of heat of reaction combustion, formation, neutralization, and solution. Enthalpy-concentration charts. Orsat analysis Calculation of theoretical and actual flame temperatures

Module 5
Simultaneous material and energy balance. Introduction to Unsteady state material and energy balance.

Suggested Text-books

1. Hougen, O.A., Watson, K.M and Ragatz, R.A., " Chemical Process Principles Part-I ", John Wiley and Asia Publishing, 1970.
2. Himmelblau, D.M., "Basic Principles and Calculations in Chemical Engineering", sixth Edition, Prentice Hall Inc., 1996.
3. Felder, R.M. & Rousseau, R.W. "Elementary Principles of Chemical Processes ", 3rd edition. JohnWiley. (1999)
4. Bhatt, B.L., VORA, S.M., "Stochiomentry ", Tata McGraw-Hill, 1976.
5. Venkataramani, V., Anantharaman, N., Begum, K. M. MeeraSheriffa, "ProcessCalculations" , Second Edition, Prentice-Hall of India.
6. Sikdar, D. C., "Chemical Process Calculations", Prentice Hall of India.

SEMESTER – 2

TPT-552: Modern Evaluation Techniques of Surface Coatings

L	T	P	C
3	1	0	4

SYLLABUS

Unit-I: Newer developments in chemistry & synthesis of surface coating binders such as epoxies, urethanes, acrylics, silicones & others. [8]

Unit-II: Various formulations based on these binders for different applications. [10] Inorganic binders. Development in formulation & methods of manufacture of coatings such as radiation cure, automatic paints, OEM paints. Various functions & importance of ingredients used in the formulation.

Unit-III: Advances in methods of application & film formation of surface coatings. [6]

Unit-IV: Concept of eco-friendly pigment in surface coatings: Development in high solids, waterborne & such eco-friendly coatings compositions. [8]

Unit-V: Developments in Resin & Testing methods. Developments in pigments for typical end applications. [8]

Reference Books:

1. Introduction to Paint Chemistry by Turner.
2. Pigment Hand Book Part 1, 2, 3 by Patton
3. Encyclopedic Hand Book of Emulsions Technology by Sjoblom.
4. Paint Film Defects by Hess
5. Industrial Organic Pigments by W.Herbst
6. High-performance Pigments by Huge M. Smith
7. Application Properties of Pigments by A. Karnik
8. Coatings formulation: An international textbook by Bodo Muller, Urlich Poth.
9. Coatings Technology Handbook by Arthur A. Tracton
10. Paint and Coatings: Applications and Corrosion Resistance by Philip A.Schweitzer
11. Paints,Coatings and solvents by Dieter Stoye,Werner Freitag
12. Surface Coatings: Raw materials and their usage by Oil and Colour Chemists Association.

TPT-554: Modern Manufacturing Techniques of Surface Coatings

L	T	P	C
3	1	0	4

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

TPT-556: HIGH-PERFORMANCE COATINGS

L	P	T	C
3	1	2	5

SYLLABUS

Unit-I: Powder Coatings & other high-performance coatings & their importance. [8]

Unit-II: Industrial thermoplastic & thermosetting powder coatings, parameters influencing powder coating properties, thermosetting powder coatings. [8]

Unit-III: Polymer used in powder coatings, thermoplastic powder coating based on vinyl, polyolefins, nylon polyesters, etc., thermosetting powder coating based on epoxy, urethane, acrylic, etc. [8]

Unit-IV: Curing reaction, monitoring of curing process, crosslinkers used in thermosetting powder coatings. [8]

Unit-V: Technology of production of powder coating, application techniques, Test methods for powder coatings, Newer developments. [8]

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.

TPT-558: Advances in Printing Inks

L	T	P	C
3	1	0	4

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, formulation of offset 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, 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, etc. 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

TPT-560: Advances in Packaging Technology

L	T	P	C
3	1	0	4

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 and plastics; wood; miscellaneous other materials. Comparison of metal & plastic packaging. [8]

Module II: Criteria and selection of packing material, Requirements of packaging surfaces for Paints and allied 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. [8]

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 & a useful commercial blend of polymers packaging. [8]

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. [8]

Module V: Packaging of various products of Paints & Coatings. 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. [8]

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

TPT – 651: TECHNOLOGY OF SURFACTANT & COATING ADDITIVES

L	T	P	C
3	1	0	4

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

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, 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

TPT – 653: ADVANCES IN SURFACE TREATMENT AND COATING APPLICATION

L	T	P	C
3	1	0	4

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 insitu phosphating, chromate conversion coating: classification, coating process.; 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-Change Possibility, 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

TPT-655: Eco-friendly & Specialty Coatings

L	T	P	C
3	1	0	4

SYLLABUS

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, for their eco-friendliness; Safety Health & Environment (SHE) management.
(b) 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.
(c) 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, 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.

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

TPT 697: SEMINAR

L	T	P	C
0	0	8	4

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 based on the relevance and knowledge content; language and the way of presentation of the seminar.

TPT 695: DESERTATION/ PROJECT WORK

L	T	P	C
0	0	8	2

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, PET 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

TPT 698: DESRTATION/ PROJECT WORK

L	T	P	C
0	0	24	12

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.