SEMESTER WISE COURSE STRUCTURE

& EVALUATION SCHEME

for

B. TECH. DEGREE PROGRAMME

IN

CHEMICAL TECHNOLOGY

PAINT TECHNOLOGY

(Effective from the session 2022-23)

DEPARTMENT OF PAINT TECHNOLOGY

SCHOOL OF CHEMICAL TECHNOLOGY

HARCOURT BUTLER TECHNICAL UNIVERSITY

KANPUR-208002

UTTAR PRADESH

THE UNIVERSITY

VISION

"To achieve excellence in technical education, research and innovation"

MISSION

1. Imparting Knowledge to develop analytical ability in science and technology to serve the industry and society at large.

2. Equip and enable students with conceptual, technical and managerial skills to transform the organization and society.

3. Inculcating entrepreneurial philosophy and innovative thinking to promote research, consultancy and institutional social responsibility.

4. Serving people, society and nation with utmost professionalism, values and ethics to make development sustainable and quality of life.

THE PROGRAM

I. VISION

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

II. 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 students for paint and allied industries and research organizations
- **M2 :** To be a center of research and innovation for betterment of society in sustainable manner.
- **M3 :** To develop state-of-the-art technologies for testing, training and consultancy for industry and society.
- **M4 :** To cultivate strong ethical values to be a successful professionals and to become life-long learners.

III. PROGRAM EDUCATIONAL OBJECTIVES (PEOS)

Graduates of B.Tech. Chemical Technology-Paint Technology programme will:

- **PEO1 :** Be globally competent in the field of pigments, resins, paints and additives processing and allied areas to cater the need of country.
- **PEO2 :** Develop innovative designs, production of materials and processes for sustainable development of society.
- **PEO3 :** Serve the industry to meet the challenges in terms of quality assurance and standardization to with stand the global competitiveness.
- **PEO4 :** Discharge duties with professional attitudes and ethics.

IV. PROGRAM OUTCOMES (PO's) OF B.TECH. CHEMICAL TECHNOLOGY - PAINT TECHNOLOGY PROGRAM

B.Tech. Chemical Technology- Paint Technology Graduates of the program will be able to:

Program Outcomes (POs)		**Graduate Attributes(GAs)**
PO1	Apply the knowledge of mathematics, science engineering fundamentals and Engineering concepts for the solution of complex engineering problems	Engineering Knowledge
PO2	Identify formulate, review literature and analyze complex problems related to Chemical Technology- Paint Technology reaching substantiated conclusions using first principles of mathematics and engineering sciences	Problem Analysis
PO3	Design solution for complex problems in Chemical Technology- Paint	Design/ Development of

	Technology and design system components or process that meet the specified needs with appropriate consideration for the public health and safety, and cultural, societal and environmental considerations	solutions
PO4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions	Conduct Investigations of complex problems
PO5	Create, select and apply appropriate techniques, resources and modern engineering tools such as optimization techniques, simulations, including predication and modeling to complex process engineering problems with an understanding of their limitations.	Modern Tool Usage
PO6	Apply contextual knowledge with justification to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to engineering and Chemical Technology- Paint Technology professional practice	The Engineer & Society
PO7	Understand the impact of the professional engineering and Chemical Technology- Paint Technology solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development	Environment and sustainability
PO8	Apply ethical principles and commit to professional ethics adhering to the norms of the engineering and Chemical Technology- Paint Technology practice	Ethics
PO9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings	Individual and team work
PO10	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	Communication
PO11	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	Project management and finance
PO12	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	Life-long learning

V.PROGRAM SPECIFIC OUTCOMES (PSOS) FOR B. TECH. CHEMICAL TECHNOLOGY- PAINT TECHNOLOGY PROGRAM

PSO1 **:** To apply engineering knowledge to analyse the complex engineering problems in various streams such as development, manufacturing, processing and application areas of paint and allied industries, using modern tools.

PSO2 **:** To demonstrate the knowledge and need for sustainable development with high regard for ethical values, environmental and social issues and apply management principles to one's own work, as a member and leader in a team to manage projects and in multidisciplinary environments.

HARCOURT BULTER TECHNICAL UNIVERSITY KANPUR
SCHOOL OF CHEMICAL TECHNOLOGY
DEPARTMENT OF PAINT TECHNOLOGY
Semester wise Course Structure
B. Tech. Chemical Technology - Paint Technology
(Applicable from Session 2022-2023 for new entrants)
Year I, Semester-I

S. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1	BSC	Engineering Physics	NPH-101	4	3	0	2	15	20	15	50	50	100
2	BSC	Engineering Mathematics-I	NMA-101	4	3	1	0	30	20	-	50	50	100
3	ESC	Introduction to Electrical Engineering	NEE-101	4	3	0	2	15	20	15	50	50	100
4	ESC	Introduction to Mechanical Engineering	NME-101	4	3	1	0	15	20	15	50	50	100
5	HSMC	Professional Communication	NHS 101	4	3	0	2	15	20	15	50	50	100
6	ESC	Engineering Graphics	NCE-103	2	0	0	4	30	20	-	50	50	100
	Total Credits: 22												**600**

(Applicable from Session 2022-2023 for new entrants)
Year I, Semester-II

S. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1	BSC	Engineering Chemistry	NCY- 102	4	3	0	2	15	20	15	50	100	100
2	ESC	Introduction to Computer Science &Engineering	NCS-102	4	3	1	0	15	20	15	50	100	100
3	ESC	Introduction to Electronics Engineering	NET- 102	4	3	1	0	15	20	15	50	100	100
4	ESC	Introduction to Civil Engineering	NCE- 102	4	3	1	0	15	20	15	50	100	100
5	ESE	Introduction to Chemical Engineering& Chemical Technology	NCT- 102	4	3	1	0	15	20	15	50	100	100
6	ESE	Workshop Practice	NWS-102	2	0	0	4	-	20	30	50	100	100
	Total Credits: 22												**600**

BSC- Basic Science Course; ESC-Engineering Science Course; PCC-Program Core course; PEC-Program Elective Course; OEC-Open Elective Course; MC-Mandatory Course; HSMC-Humanities, Social Science & Management

Course

(Applicable from Session 2023-2024)
Year II, Semester-III

S. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1	BSC	Engineering Mathematics-II	NMA-201	4	3	1	0	30	20	-	50	50	100
2	ESC	Fluid Mechanics and Mechanical Operations	NCT-201	4	3	0	2	15	20	15	50	50	100
3	PCC	Introduction to Surface Coatings and their Components	NPT-201	4	3	1	0	30	20	-	50	50	100
4	PCC	Technology of Organic, Functional and Effect Pigments	NPT-203	4	3	1	0	30	20	-	50	50	100
5	PCC	Chemical Process Calculations	NPT-205	3	3	0	0	30	20	-	50	50	100
6	HSMC	Economics and Management	NHS-201	3	3	0	0	30	20	-	50	50	100
7	PCC	Introduction to Surface Coatings and their Components Lab	NPT-207	2	0	0	4	-	20	30	50	50	100
	Total Credits: 24												**700**

(Applicable from Session 2023-2024)
Year II, Semester-IV

S. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1	BSC	Modern Analytical Techniques	NCY- 202	4	3	1	0	30	20	-	50	50	100
2	ESC	Computer Oriented Numerical Methods	NMA-204	4	3	0	2	15	20	15	50	50	100
3	PCC	Technology of Natural Resins, Alkyds and Polyesters	NPT-202	4	3	1	0	30	20	-	50	50	100
4	PCC	Chemical Engineering Thermodynamics	NPT-204	4	3	1	0	30	20	-	50	50	100
5	PCC	Heat Transfer Operations	NPT-206	3	3	0	0	30	20	-	50	50	100
6	PCC	Technology of Inorganic Pigments and Extenders	NPT-208	3	3	0	0	30	20	-	50	50	100
7	PCC	Pigments and Extenders Lab	NPT-210	2	0	0	4	-	20	30	50	50	100
	Total Credits: 24												**700**

(Applicable from Session 2024-2025)
Year III, Semester-V

S. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1	PCC	Technology of Formulation and Manufacture of Coatings	NPT-301	4	3	0	2	15	20	15	50	50	100
2	PCC	Technology of Synthetic Resins and Polymers	NPT-303	4	3	1	0	30	20	-	50	50	100
3	PCC	Technology of Paint and Coating Additives	NPT-305	3	3	0	0	15	20	15	50	50	100
4	PCC	Mass Transfer Operations	NPT-307	3	3	0	0	30	20	-	50	50	100
5	PCC	Chemical Reaction Engineering	NPT-309	3	3	0	0	30	20	-	50	50	100
6	PCC	Technology of Synthetic Resins and Polymers Lab	NPT-311	3	0	0	6	-	20	30	50	50	100
7	HSMC	Entrepreneurship	NHS-351	2	2	0	0	30	20	-	50	50	100
	Total Credits: 22												**700**

(Applicable from Session 2024-2025)
Year III, Semester-VI

S.No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1	PCC	Instrumentation & Process Control	NPT-302	4	3	0	2	15	20	15	50	50	100
2	PCC	Technology of Surface Preparation, Treatments and Coating Applications	NPT-304	4	3	0	2	30	20	-	50	50	100
3	PCC	Characterization, Analysis and Evaluation of Coatings	NPT-306	3	3	0	0	30	20	-	50	50	100
4	PCC	Technology of Printing Inks and Coatings	NPT-308	3	3	0	0	30	20	-	50	50	100
5	PCC	Characterization, Analysis and Evaluation of Coatings Lab	NPT-310	3	0	0	6	-	20	30	50	50	100
6	PEC-I	**Program Elective –I** 1. Process Equipment Design 2. Process Modeling & Simulation 3. Process Optimization	NPT-322 NPT-324 NPT-326	3	3	0	0	30	20	-	50	50	100
7	OEC-I	Basic Paint Technology	OPT-302	2	2	0	0	30	20	-	50	50	100
	Total Credits: 22												**700**

(Applicable from Session 2025-2026)
Year IV, Semester-VII

SNo.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1	PEC-II	**Program Elective-II** 1. Technology of Architectural & Eco-friendly Coatings 2. Advanced Resins and Polymers 3. Radiation Curable Coatings	NPT-421 NPT-423 NPT-425	4	3	1	0	30	20	-	50	50	100
2	PEC-III	**Program Elective-III** 1. Technology of Industrial and Automotive Painting 2. Technology of Packaging 3. Safety, Health Hazards and Environment in Paint Industry	NPT-443 NPT-445 NPT-447	3	3	0	0	30	20	-	50	50	100
3	PEC-IV	**Program Elective-IV** 1. Corrosion Control Through Organic Coatings 2. Instrumentation Techniques for Characterization of Film Formers 3. Waterborne Coatings	NPT-461 NPT-463 NPT-465	3	3	0	0	30	20	-	50	50	100
4	Industrial Training	Industrial Training	NPT-481	2	0	0	4		20	30	50	50	100
5	OEC-II	Basics of Paint Manufacturing	OPT-401	2	2	0	0	30	20	-	50	50	100
6	Minor Project	Minor Project	NPT-491	6	0	0	12		50		50	50	100
7	Seminar	Seminar	NPT-471	2	0	0	4	-	50		50	50	100
	Total Credits: 22												**700**

(Applicable from Session 2025-2026)
Year IV, Semester-VIII

S. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1	PEC-V	**Program Elective-V** 1. High Performance Pigments 2. Specialty and Smart Coatings 3. Artificial Intelligence in Surface Coatings	NPT-422 NPT-424 NPT-426	4	3	1	0	30	20	-	50	50	100
2	OEC-III	Testing of Raw Materials and Paints	OPT-402	2	2	0	0	30	20	-	50	50	100
3	Project	Project	NPT-492	16	0	0	24	-	100	100	200	200	400
	Total Credits: 22												**600**

OEC

S. No.	Course Type	Course Title	Subject Code	Credits (L-T-P)	Sessional Marks				ESE	Total Marks
					MSE	TA	Lab	Total		
1	OEC-I	Basic Paint Technology	OPT-302	2(2-0-0)	30	20	-	50	50	100
2	OEC-II	Basics of Paint Manufacturing	OPT-401	2(2-0-0)	30	20	-	50	50	100
3	OEC-III	Testing of Raw Materials and Paints	OPT-402	2(2-0-0)	30	20	-	50	50	100

PEC-I

S. No.	Course Type	Course Title	Subject Code	Credits (L-T-P)	Sessional Marks				ESE	Total Marks
					MSE	TA	Lab	Total		
1	PEC-I	Process Equipment Design	NPT-322	3(3-0-0)	30	20	-	50	50	100
2	PEC-I	Process Modeling & Simulation	NPT-324	3(3-0-0)	30	20	-	50	50	100
3	PEC-I	Process Optimization	NPT-326	3(3-0-0)	30	20	-	50	50	100

PEC-II

S. No.	Course Type	Course Title	Subject Code	Credits (L-T-P)	Sessional Marks				ESE	Total Marks
					MSE	TA	Lab	Total		
1	PEC-II	Technology of Architectural & Eco-friendly Coatings	NPT-421	4(3-1-0)	30	20	-	50	50	100
2	PEC-II	Advanced Resins and Polymers	NPT-423	4(3-1-0)	30	20	-	50	50	100
3	PEC-II	Radiation Curable Coatings	NPT-425	4(3-1-0)	30	20	-	50	50	100

PEC-III

Sl. No.	Course Type	Course Title	Subject Code	Credits (L-T-P)	Sessional Marks				ESE	Total Marks
					MSE	TA	Lab	Total		
1	PEC-III	Technology of Industrial and Automotive Painting	NPT-441	3(3-0-0)	30	20	-	50	50	100
2	PEC-III	Technology of Packaging	NPT-443	3(3-0-0)	30	20	-	50	50	100
3	PEC-III	Safety, Health Hazards and Environment in Paint Industry	NPT-445	3(3-0-0)	30	20	-	50	50	100

PEC-IV

Sl. No.	Course Type	Course Title	Subject Code	Credits (L-T-P)	Sessional Marks				ESE	Total Marks
					MSE	TA	Lab	Total		
1	PEC-IV	Corrosion Control Through Organic Coatings	NPT-461	3(3-0-0)	30	20	-	50	50	100
2	PEC-IV	Instrumentation Techniques for Characterization of Film Formers	NPT-463	3(3-0-0)	30	20	-	50	50	100
3	PEC-IV	Waterborne Coatings	NPT-465	3(3-0-0)	30	20	-	50	50	100

PEC-V

Sl. No.	Course Type	Course Title	Subject Code	Credits (L-T-P)	Sessional Marks				ESE	Total Marks
					MSE	TA	Lab	Total		
1	PEC-V	High Performance Pigments	NPT-422	4(3-1-0)	30	20	-	50	50	100
2	PEC-V	Specialty and Smart Coatings	NPT-424	4(3-1-0)	30	20	-	50	50	100
3	PEC-V	Artificial Intelligence in Surface Coatings	NPT-426	4(3-1-0)	30	20	-	50	50	100

NPH-101: Engineering Physics

L	T	P	C
3	0	2	4

OBJECTIVE:

The objective of the course is to understand the basic concepts of nature around us and to synthesize the knowledge from different areas of physics for analysing and solving various critical problems.

Course Outcome (CO):

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

CO1	Understand and apply the principle of conservation of momentum, the theory of relativity.	K2, K1
CO2	Understand the basics of quantum mechanics and apply its principles to learn the phenomenon that occurs at subatomic dimensions.	K3, K1
CO3	Understand Maxwell's equations of electromagnetic theory with the aim to apply them in a communication system.	K5, K1
CO4	Apply the fundamentals of material science, especially to dielectric materials, semiconducting materials, nanomaterials, and Superconducting Materials.	K2, K1
CO5	Understand the statistical behavior of the constituent particles and apply the principles of statistical mechanics in the formation of materials and basics of LASERs	K4, K1

K1-Remember, K2- Understand, K3-Apply, K4-Analyse, K5-Evaluate, K6-Create

Course Articulation Matrix (CO-PO Matrix)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	2	1	2	-	-	-	-	-	3
CO2	3	3	1	2	1	2	-	-	-	-	-	3
CO3	3	3	1	2	1	2	-	-	-	-	-	3
CO4	3	3	3	2	1	3	3	-	-	-	-	3
CO5	3	3	2	3	3	3	-	-	-	-	-	3

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

SYLLABUS

UNIT- 1

Relativistic Mechanics:

Inertial and Non- Inertial Frames of references, Galilean transformation equations, Michelson Morley Experiment, Lorentz Transformation equations, Length contraction, Time dilation and its experimental evidence, Relativistic velocity addition formula, Relativistic variation of mass with velocity, Evidence of variation of mass with velocity, Einstein's Mass-Energy equivalence, examples from nuclear physics,Relativistic energy momentum relation.

UNIT- 2

Quantum Mechanics:

Dual nature of matter & radiation, Heisenberg's uncertainty Principle and their applications, wave packet concept, Davisson-Germer experiment, Postulates of quantum mechanics, Significance of wave function, Derivation of Schrodinger equation for time independent and time dependent cases.

Applications of Schrodinger wave equation for a free particle, Particle in a box (one dimensional and three dimensional cases), Simple harmonic oscillator (one dimensional case).

UNIT- 3

Electromagnetic Theory:

Ampere's law and Faraday's law of electromagnetic induction, Derivation of Maxwell's equations and their physical significance, Correction of Ampere's law by Maxwell, Concept of displacement current, Poynting theorem,

Maxwell's equations in free space & velocity of electromagnetic waves, Transverse character of the wave and orthogonality of **E, H** and **k** vectors, Maxwell's equation in dielectric medium andvelocity of e.m. wave, Comparison with free space, Maxwell's equations in conducting media & solution of differential equation in this case, penetration depth & its significance.

UNIT- 4

Statistical Mechanics & Lasers:

Macrostates and Microstates, Phase space, probability of distribution, most probable distribution, Maxwell-Boltzmann Statistics, Applications of Maxwell-Boltzmann Statistics, derivation of average velocity,RMS velocity and most probable velocity in the above cases, Bose-Einstein Statistics & its application in caseof black body radiation, distribution law of energy, Planck's radiation formula, derivation of Wien's law, Rayleigh-Jeans law and Stefan's law from Planck's radiation formula. Fermi – Dirac statics, application in case of free electrons in metals, energy distribution, Fermi energy.

Lasers: Spontaneous and stimulated emission of radiations, Einstein's theory of matter-radiation interaction, Einstein's coefficients and relation between them, Population inversion, components of a laser, different kinds of lasers, Ruby laser, He-Ne laser, solid state lasers, properties of laser beams, mono- chromaticity, coherence, directionality and brightness, applications of lasers in various technological applications.

UNIT- 5

Materials of Technological Importance:

Dielectric Materials: Electric field in presence of dielectric medium, concept of electric polarization,different types of polarizations, behaviour of dielectric in a.c. field, concept of dielectric loss and loss energyand their importance.

Semiconducting Materials: Concept of energy bands in solids, carrier concentration and conductivity in intrinsic semiconductors and their temperature dependence, carrier concentration and conductivity in extrinsic semiconductors and their temperature dependence, Hall effect in semiconductors, compound semiconductors, amorphous semiconductors.

Nano Materials: Basic principles of nanoscience and technology, preparation, structure and propertiesof fullerene and carbon nanotubes, applications of nanotechnology.

Superconducting Materials: Resistivity and susceptibility of Superconductors, Type – I and Type – II superconductors, Meissner effect, Low temperature Superconductors, Organic Superconductors, Oxide Superconductors, High temperature Superconductors, BCS theory (Qualitative).

Text Books:

1. Engineering Physics, R. K. Shukla, Pearson Education, Vol.-II, 2014
2. Electrical Engineering Materials, R.K. Shukla, McGraw Hill, 1st Edition, 2012
3. Principles of Engineering Physics, R.K. Shukla, Ira Books, 1st Edition, 2011
4. Engineering Physics –I & II, S.K. Gupta, Krishna Prakashan Media (P) Ltd., 2014

References Books:

1. Fundamental university physics, Vol. - I: Mechanics, Marcelo Alonso, J. Finn Edwards, Addison-Wesley, 1st Edition, 1967
2. Concepts of Modern Physics, Arthur Beiser, McGraw Hill, 6th Edition, 2003
3. Introduction to Electrodynamics, David Griffiths, Cambridge University Press, 4th Edition, 2017
4. Introduction to Solid State Physics, Charles Kittel, Willey, 8th Edition, 2005
5. Introduction to Nanotechnology, Charles P. Poole Jr., Frank J. Owens, Wiley-Interscience, 1st Edition, 2003

Web Links:

1. https://nptel.ac.in/courses/122101002 [IIT Bombay, Prof. D.K. Ghosh]
2. https://nptel.ac.in/courses/122103011 [IIT Guwahati, Prof. Alika Khare , Prof. Pratima Agarwal, Prof. S. Ravi]
3. https://nptel.ac.in/courses/115105099 [IIT Kharagpur, Prof. Amal Kumar Das]
4. https://nptel.ac.in/courses/115101005 [IIT Bombay, Prof. D.K. Ghosh]
5. https://nptel.ac.in/courses/115106066 [IIT Madras, Prof. S. Lakshmi Bala]

NMA-101 ENGINEERING MATHEMATICS –I

L	T	P	C
3	1	0	4

OBJECTIVE: The objective of this course is to educate the students about

- The convergence of infinite series, improper integrals, and differential calculus.
- Partial differentiation, multiple integrals and Beta, Gamma functions.
- Vector calculus, matrices, linear algebra, and optimization techniques.

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

CO1	find nth derivative, determine the expansion of functions, and findconvergence of series and improper integrals.	K1, K2
CO2	find partial differentiation and evaluate area and volume usingmultiple integrals.	K2, K5
CO3	convert line integrals to surface integrals and volume integrals,determine potential functions for irrotational force fields.	K3, K5
CO4	solve linear system of equations and determine the eigen vectorsof the matrix.	K3, K4, K5
CO5	learn concept of optimization and optimization techniques.	K1, K2

CO-PO Mapping:

CO	PO1	PO 2	P O3	PO 4	P O5	P O6	P O7	P O8	P O9	PO 10	PO 11	PO 12
CO1	3	3	2	1	2	-	-	1	-	1	-	3
CO2	3	3	2	1	2	-	-	1	-	1	-	3
CO3	3	3	2	1	2	-	-	1	-	1	-	3
CO4	3	3	2	1	2	-	-	1	-	1	-	3
CO5	3	3	2	1	2	-	-	1	-	1	-	3
Average	3	3	2	1	2	-	-	1	-	1	-	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is nocorrelation, put* "- "

SYLLABUS

Unit I- Functions of One Real Variable: 6 hours

Successive differentiation, Leibnitz theorem, Mean value theorems, sequences and series,expansion of functions, improper integrals, and their convergence.

Unit II- Functions of Several Real Variables: 10 hours Limit, Continuity, Partial differentiation, Total differential and approximations, Jacobian, Euler'stheorem for expansion of functions, Beta and Gamma Functions, Multiple integrals, change oforder, Change of variables, Applications to area, volume, mass, surface area etc. Dirichlet'sIntegral & applications.

Unit III- Vector Calculus: 8 hours

Point functions, differentiation, Differential operators: Gradient, Laplacian, Hessian, Directional derivative; Divergence and Curl of a vector and their physical interpretations, Solenoidal & irrotational fields, Integration: Line, Surface and Volume integrals, Green's, Stoke's and Gauss Divergence theorems (without proof) and applications

Unit IV- Matrices and Linear Algebra: 10 hours Vector space and subspace, linear dependence, basis and dimensions, Linear transformation andits matrix representation, Elementary transformations, Echelon form, rank & nullity, consistencyof linear system of equations and their

solutions, characteristic equation, Cayley Hamiltontheorem, real and complex eigenvalues and eigenvectors, diagonalization, SVD, quadratic forms,complex, orthogonal, and unitary matrices, Application to Cryptography, discrete,Compartmental models, and system stability.

Unit V- Optimization: 6 hours

Engineering applications of optimization, statement and classification of optimization problems, Optimization techniques, single and multi-variable optimizations with no constraint, with equality and inequality constraints, Linear Programming Problems, Graphical method, and Simplex method.

Textbooks:

1. R.K. Jain & S. R. K. lyengar; Advanced Engineering Mathematics, Narosa Publishing House2002.
2. Erwin Kreyszig: Advanced Engineering Mathematics. John Wiley & Sons 8th Edition.
3. Dennis G. Zill & Michael R Cullen; Advanced Engineering Mathematics, Jones & BartlettPublishers, 2nd Edition.
4. S.S. Rao; Optimization: Theory & application Wiley Eastern Limited.

Reference Books:

1. T.M. Apostol, calculus, Vol. I, 2nd ed., Wiley 1967.

2. T.M. Apostol, Calculus, Vol. II, 2nd ed., Wiley 1969.

3. Gilbert Strang, Linear Algebra & its applications, Nelson Engineering 2007.

Calculus & Analytic Geometry, Thomas and Finny.

NEE-101 : Introduction to Electrical Engineering

L	T	P	C
3	0	2	4

OBJECTIVES

The goal of the course is to make the students understand the basic principles of electrical engineering.

Course Outcomes

At the end of the course the students will be able to:

CO1. apply Mesh and Nodal Methods of Analysis and Network Theorem in DC Network.

CO2. understand and analyze the ac circuit and calculate the various parameters.

CO3. understand and analyze the 3-phase connections of source and load, and, measurement of 3-phase power.

CO4. understand the magnetic circuit with working & applications and to calculate the various parameters of magnetic circuits and transformer efficiency.

CO5. understand the basic principles of AC & DC Machines

Course Articulation Matrix (CO-PO Matrix)

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

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

SYLLABUS

UNIT 1 - DC Circuit Analysis and Network Theorems

Circuit Concepts: Concepts of Network, Active and Passive elements, voltage and current sources, concept of linearity and linear network, unilateral and bilateral elements. R L and C as linear elements. Source Transformation. Kirchhoff's Law, loop and nodal methods of analysis; star – delta transformation; Network Theorems: Superposition Theorem, Thevenin's Theorem, Norton's Theorem, Maximum Power Transfer Theorem. (Simple Numerical Problems)

UNIT 2 - Steady State Analysis of Single Phase AC Circuits

Sinusoidal, Square and Triangular waveforms – average and effective values, form and peak factors, concept of phasors, phasor representation of sinusoidally varying voltage and current. Analysis of series, parallel, and series – parallel RLC Circuits: Apparent, Active & Reactive Powers, Power factor, causes and problems of low power factor, power factor improvement. Resonance in Series and Parallel Circuits. (Simple Numerical Problems)

UNIT 3 - Three Phase AC Circuits

Three Phase System – its necessity and advantages, meaning of phase sequence and star and delta connections, balanced supply and balanced load, line and phase voltage / current relations, three phase power and its measurement. (Simple Numerical Problems)

UNIT 4 - Magnetic Circuits and Transformer

Magnetic Circuit: Magnetic circuit concepts, analogy between Electric & Magnetic circuits, Magnetic circuits with DC and AC excitations, Magnetic leakage. B-H curve, Hysteresis and Eddy Current losses, Magnetic circuit calculations.

Single Phase Transformer: Principle of Operation, Construction, e.m.f. equation, Power losses, efficiency. (Simple Numerical Problems)

UNIT 5 - Electro Mechanical Energy Conversion

Basic Principles of electro mechanical energy conversion.

DC Machines: Types of DC machines, e.m.f. equation of generator and torque equation of motor, Speed-Torque characteristics of DC Series and Shunt Motors, Applications of dc motors. (Simple Numerical Problems).

Three Phase Induction Motor: Types, Principle of Operation, Slip – torque Characteristics, applications. (Simple Numerical Problems).

Single Phase Induction Motor: Basic Principles of 1-phase Induction Motor and its applications

Three Phase Synchronous Machines: Principle of Operation of alternator and synchronous motor and their applications.

List of Experiments

1. Verification of Kirchhoff's laws.
2. Verification of Superposition Theorem.
3. Verification of Thevenin's Theorem.
4. Verification of Maximum Power Transfer Theorem.
5. Measurement of power and power factor in a $1-Ø$ ac series inductive circuit and study improvement of power factor using capacitor.
6. Study of phenomenon of resonance in RLC series circuit and obtain the resonant frequency.
7. Measurement of power in $3-Ø$ circuit by Two Wattmeter method and determination of its power factor.
8. Determination of parameter of ac $1-Ø$ series RLC Circuit.
9. Determination of Efficiency by load test of a $1-Ø$ Transformer.
10. To study running and speed reversal of a $3-Ø$ induction motor and record its speed in both direction.

Note:

a. Department may add any three experiments in the above list.
b. Minimum eight experiments are to be performed out of the above list.

Text books:

1. V. Del Toro, "Principles of Electrical Engineering" Prentice Hall International
2. I. J. Nagarath, "Basic Electrical Engineering" Tata Mc - Graw Hill
3. D. E. Fitzgerald & A. Grabel Higginbotham, "Basic Electrical Engineering" Mc - Graw Hill
4. B. L. Theraja and A. K. Theraja, "Basic Electrical Engineering: July 1999.

Reference books:

1. Edward Hughes, "Electrical Technology" Longman
2. T. K. Nagsarkar & M. S. Sukhija, "Basic Electrical Engineering" Oxford University Press
3. H. Cotton, "Advanced Electrical Technology" Wheeler Publishing
4. W. H. Hayt & J. E. Kennely, "Engineering Circuit Analysis" Mc - Graw Hill

NME-101: Introduction to Mechanical Engineering

L	T	P	C
3	1	0	4

OBJECTIVES

To explain the basic fundamentals of forces, moments, stresses, strains, fundamental of fluid and fluid flow application, fundamentals of thermodynamics and mode of heat transfers.

Course Outcomes (CO):

At the end of this course students should be able to:

CO1	Understand the basic laws concepts of mechanical systems.	K2, K1
CO2	Determine resultants and apply conditions of static equilibrium to plane force systems.	K3, K1
CO3	Analyze beam for shear force and bending moment along the span and analyze trusses for axial forces.	K4, K1
CO4	Evaluate the structural properties centroid and moment of inertia	K5, K1
CO5	Stress analysis for one- and two-dimensional stress systems.	K3, K1

K1- Remember, K2- Understand, K3-Apply, K4-Analyse, K5- Evaluate, K6- Create

Course Articulation Matrix (CO-PO Matrix)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3			1	1	1	1	1		1
CO2	3	3	3									1
CO3	3	3	3									1
CO4		3	2	2								1
CO5		3	2	2								1

1: Slight (Low) 2: Moderate (Medium) 3: Subsantial (High) If there is no correlation put "-".

SYLLABUS

UNIT-1: Fundamental Concepts and Definitions:

Mechanical Engineering: Scope and expanse

Concept of machines and mechanisms, classification of machines.

Thermodynamic systems, Laws of thermodynamics. Introduction to modes of heat transfer, applications.

Materials, classification, selection of materials in design of components.

Manufacturing processes, mechanical working of metals.

UNIT-2:

Two-Dimensional Force Systems: Basic concepts, laws of motion, Principle of transmissibility of forces, transfer of a force to parallel position, resultant of a force system, simplest resultant of two dimensional concurrent and non-concurrent force systems, distributed force system, free body diagrams, equilibrium and equations of equilibrium, applications.

Friction: Introduction, Laws of Coulomb friction, Equilibrium of bodies involving dry-friction, belt friction, applications.

UNIT-3:
Beam: Introduction, Shear force and bending moment, differential equations for equilibrium, shear force and bending moment diagrams for statically determinate beams.
Trusses: Introduction, simple truss and solution of simple truss, Method of joints and method of sections.

UNIT-4: Centroid and Moment of Inertia: Centroid of plane, curve, area, volume and composite bodies, Moment of inertia of plane area, Parallel Axes theorem, Perpendicular axes theorems, Principal moment of inertia, mass moment of inertia of circular ring, disc, cylinder, sphere and cone about their axis of symmetry.

UNIT-5: Introduction to Strength of Materials: Introduction, normal and shear stresses, stress- strain diagrams for ductile and brittle material, elastic constants, One Dimensional loading of members of varying cross- sections, strain energy, 2D state of plane stress, Principal stresses and strains.

Text books:

1. Engineering Mechanics by Abhijit Chanda and Debabrata Nag, Wiley India Pvt. Ltd, 2018, Kindle -Edition, ISBN: 9788126570935.
2. Engineering Mechanics: Statics by J L Meriam. L G Kraige. Virginia Polytechnic Institute and State University, John Wiley & Sons, 2017.ISBN-978-8126564033.
3. Engineering Mechanics of Solids, Egor P. Popov, PHI Publications, 1990.
4. Theory of Machines and Mechanisms by J.E. Shigley, Oxford University Press, 5th Edition, 2017.
5. Engineering Thermodynamics by P K Nag, TMH Publication, 4th Edition, 2008.

Reference Books:

1. Theory of Machines and Mechanisms by Amitabha Ghosh and Asok Kumar Mallick, Affiliated East-West Press, 3rd Edition, ISBN: 9788185938936.
2. Engineering Mechanics by Timoshenko S., McGraw-Hill Education – Europe, 5th Edition, 2013.
3. Engineering Mechanics by Nelson A, McGraw Hill Education India, 1st Edition, ISBN-978-0070146143, 2017
4. Materials and Manufacturing: An Introduction to How they Work and Why it Matters by Mark A Atwater McGraw-Hill Education, 1st Edition, ISBN: 9781260122312, 2018
5. Engineering Thermodynamics: Work and Heat Transfer by Rogers, Pearson Education India, 4th Edition, 2002.

Web Links:

1- https://nptel.ac.in/courses/112106286 [IIT Madras, Prof. K. Ramesh]
2- https://nptel.ac.in/courses/112103108 [IIT Guwahati, Prof. US Dixit]
3- https://nptel.ac.in/courses/112103109 [IIT Guwahati, Prof. US Dixit]
4- https://eng.utq.edu.iq/wp-content/uploads/sites/4/2019/09/engineering-mechanics-lectures.pdf[Thi-Qar University, Prof. Haider]
5- https://www.youtube.com/watch?v=tisNUzd_f1M&t=96s [Dr. V. P. Singh, HBTU, Kanpur]
6- https://www.youtube.com/watch?v=a6RNss9kBuI&t=11s [Dr. V. P. Singh, HBTU, Kanpur]
7- https://www.youtube.com/watch?v=LE1Lc6_640U[Dr. V. P. Singh, HBTU, Kanpur]

NHS 101: Professional Communication

L	T	P	C
3	0	2	4

OBJECTIVES

- Critically think about communication processes and messages.
- Write effectively for a variety of contexts and audiences.
- Interact skillfully and ethically.
- Develop and deliver professional presentations

Course Outcomes (CO)

At the end of this course students should be able to:

CO1	Effectively communicate their ideas in the contemporary global competitive environment.	K2, K1
CO2	Convey their messages through constructive writing.	K3, K1
CO3	Draft potent E-Mails, letters, proposals and reports.	K4, K1
CO4	Present their presentations along with using all nuances of delivery with clarity and thoroughness.	K5, K1
CO5	Solve problems based on real time situations and articulate them eventually.	K3, K1

K1- Remember, K2- Understand, K3-Apply, K4-Analyse, K5- Evaluate, K6- Create

Course Articulation Matrix (CO-PO Matrix of selected Course): NHS 103

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	0	0	0	0	0	0	0	0	2	3	0	1
CO2	0	0	0	0	0	0	0	0	2	3	0	1
CO3	0	0	0	0	0	0	0	0	2	3	0	1
CO4	0	0	0	0	0	0	0	0	2	3	0	1
CO5	0	0	0	0	0	0	0	0	2	3	0	1

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

SYLLABUS

UNIT I

Fundamentals of Technical Communication

Process of communication, language as a tool of communication, levels of communication , flow of communication, barriers to communication, communication across cultures; Technical Communication: meaning, significance, characteristics, difference between technical and general communication.

UNIT II

Elements of Written Communication

Words and phrases, word formation, synonyms and antonyms, homophones, one word substitution, sentence construction, paragraph construction,

UNIT III

Forms of Technical Communication

(A) business letters, job application letter and resume, 7C's of letter writing, business letters: sales & credit letters, letters of enquiry, letters of quotation, order, claim and adjustment letters, official letters: D.O. letters, government letters, letters to authorities, etc. ,

(B) Technical Reports: general format of a report, formal and informal reports, memo report, progress report, status report, survey report, trip report, complaint report, , Joining Report ,laboratory report, research papers, dissertations and theses. E-mail writing

Technical Proposals: purpose, characteristics, types, structure

UNIT IV

Presentation Strategies

Defining the subject, scope and purpose, analysing audience & locale, collecting materials, preparing outlines, organising the contents, Pre-presentation strategies, during presentation strategies, nuances of delivery, verbal and non-verbal communication, Body language, paralinguistic features of voice, visual aids.

UNIT V

Value-based Text Reading

(A) Study of the following essays from the text book with emphasis on writing skills:

1. Man and Nature	by J. Bronowski
2. The Language of Literature and Science	by Aldous Huxley
3. The Aims of Science &The Humanities	by Moody E Prior
4. Gods in this Godless Universe	by Bertrand Russell
5. Science and Survival	by Barry Commoner

(B) Readings of selected short stories:

1. The Renunciation	by Rabindranath Tagore
2. The Lament	by Anton P. Chekhov
3. The Barber's Trade Union	by Mulk Raj Anand
4. The Eyes Are Not Here	by Ruskin Bond

Professional Communication Laboratory

Interactive practical sessions with emphasis on oral presentations / spoken communication:

Practical Sessions on:

1. Group Discussions: selected topical issues to be discussed in groups.
2. Mock interviews
3. Communication skills for seminars/conferences/workshops with emphasis on non-verbal skills.
4. Presentation skills for technical papers/project reports/professional reports.
5. Theme presentation/ key note presentation based on correct argumentation methodologies.
6. Argumentative skills
7. Role play
8. Comprehension skills based on reading and listening practice, asking questions.
9. Introduction to International Phonetics Alphabets
10. Audio Visual demonstration of effective communicative strategies & TED Talks

Text Books

1. Improve Your Writing Edited By V N Arora and Laxmi Chandra, Oxford University Press, First Edition, New Delhi, 2013.
2. An Anthology of English Short Stories, Edited by R P Singh, First Edition, 2015, Oxford University Press.
3. Technical Communication- Principles and Practices by Meenakshi Raman & Sangeeta Sharma, Third Edition, 2015, Oxford University Press, New Delhi.
4. Sethi and Dhamija, 'A Course in Phonetics and Spoken English', Second Edition, 2004, Prentice Hall of India, New Delhi.
5. Joans Daniel, 'English Pronouncing Dictionary', 18th Edition, 2011, Cambridge University Press.

Reference Books

1. Effective Technical Communication, by Barun K Mitra, First Edition, 2008, Oxford University Press.
2. Business Correspondence & Report Writing by R.C. Sharma & Krishna Mohan, Fifth Edition, 2017, Tata McGraw Hill, N.D.
3. Developing Communication Skills by Krishna Mohan & Meera Banerjee, Second Edition, 2000, Macmillan India
4. Technical Communication- Principles and Practices by M R S Sharma, Third Edition, 2015, Oxford University Press, New Delhi
5. R. K. Bansal & J.B. Harrison, Spoken English for India, Orient Longman, Fourth Edition, 2013, Orient Blackswan, Hyderabad.
6. Excellence in Business Communication, 13th Edition, 2020 Publisher-Pearson Education.

Web Links:

1. https://nptel.ac.in/courses/109104030 [Dr. T Ravichandran, IIT Kanpur]

NCE-103: ENGINEERING GRAPHICS

L	T	P	C
0	0	4	2

Course Outcomes

At the end of this course, students should be able:

CO1	To understand and apply the concepts of lettering, dimensioning, scales and geometric construction
CO2	To visualize the position and location of any point, line, plane, or surface and draw their orthographic projections
CO3	To visualize and draw/develop the true shape, size, and sections of solid objects the true shape, size, and specifications of physical objects
CO4	To apply the visualization skill, to draw a simple isometric and perspective projections
CO5	To understand and draw basic civil Engineering building components using AutoCAD

Course Articulation Matrix (CO-PO Matrix)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	-	-	-	-	-	-	-	1	2	-	-
CO2	2	-	-	-	-	-	-	-	1	2	-	-
CO3	2	-	-	-	-	-	-	-	1	2	-	-
CO4	2	-	-	-	-	-	-	-	1	2	-	-
CO5	2	-	-	-	3	-	-	-	1	2	-	-

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

SYLLABUS

Unit –I

Lettering and Dimensioning: Introduction, lettering practices, Rules of dimensioning – systems of dimensioning.
Geometric Constructions: Freehand sketching, Conic Sections, Special Curves.
Engineering Scales

Unit –II

Orthographic Projection
Projection of Points: First and Third Angle Projections; Projection of Points
Projection of Lines: Projection of straight lines (First angle projection only); Projection of lines inclined to one plane and both planes, true length and true inclinations.
Projection of solids: Classification of solids, Projection of solids in simple position, Projection of solids inclined to one plane.

Unit –III

Sections of Solids: Right regular solids and auxiliary views for the true shape of the sections.
Development of Surfaces: Development of surfaces for various regular solids.

Unit –IV

Isometric Projection: Isometric scales, Isometric projections of simple and combination of solids;
Perspective Projection: Orthographic representation of perspective views – Plane figures and simple solids – Visual Ray Method.
Conversion of pictorial view into orthographic Projection.

Unit –V

Introduction to Auto CAD, Drawings of Buildings and their components – front view, top view, and sectional views of a typical residential building using Auto CAD.

Detailed Drawing of RCC Design- Slab, beam, column, footings.

Textbooks

1. D.A. Jolhe (2008). '*Engineering Drawing- With an Introduction to AutoCAD.',* Tata Mcgraw, Delhi.
2. N D Bhatt and V M Panchal (2001). '*Engineering Drawing.'*, 43rd Ed., Charotar Publishing House, Anand, 2001.
3. M B Shah and B C Rana (2009). '*Engineering Drawing.',* 2nd Ed., Pearson Education, Delhi.

Reference Books

1. A Textbook of Engineering Graphics by K.V. Natarajan.
2. T E French, C J Vierck and R J Foster, *Graphic Science and Design*, 4th Ed., McGraw Hill, 1984.
3. W J Luzadder and J M Duff, *Fundamentals of Engineering Drawing*, 11th Ed., PHI, 1995.
4. K Venugopal, *Engineering Drawing and Graphics*, 3rd Ed., New Age International, 1998

Web Resources

https://nptel.ac.in/courses/112103019

https://nptel.ac.in/courses/112102304

https://nptel.ac.in/courses/112105294

https://archive.nptel.ac.in/courses/112/102/112102304/

NCY-102: Engineering Chemistry

L	T	P	C
3	0	2	4

OBJECTIVE:

The objective of this course is to make students learn the laboratory skills needed to design safe conduction of reactions and experiments in Chemistry. The student will acquire a foundation of Chemistry to enable them to understand and critically interpret the primary research in Chemistry.

Course outcome

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

CO 1	Interpret UV-Visible and IR-Spectra	K2, K4
CO 2	Describe reaction rates for reactions of various orders	K2, K3, K4
CO 3	Understand different aspects of corrosion and thermodynamic view of electrochemical processes, reversible, irreversible cells and nanochemistry	K2, K3
CO 4	Understand the stereochemistry of molecules and identify organic reactions on the basis of their mechanism	K1, K3, K4
CO 5	Distinguish between different polymeric structures, classify polymers, and analyze the polymerization mechanism and use of polymers in different walks of life. Knowledge of conductivity of polymer, biodegradable polymers and fibre reinforced plastics. Acquire knowledge about water and treatment of municipal water and solid waste management	K2, K3, K5, K6
CO 6	To develop experimental skills to perform, monitor and manipulate the reactions.	K2, K4, K5

K1-Remember, K2-Understand, K3-Apply, K4-Analyse, K5- Evaluate, K6-Create

Course Articulation Matrix (CO-PO Matrix)

PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO12
3	3	1	3	2	-	2	-	-	-	-	3
3	3	1	3	2	-	2	-	-	-	-	3
3	3	1	3	2	-	2	-	-	-	-	3
3	3	1	3	2	-	2	-	-	-	-	3
3	3	1	3	2	-	2	-	-	-	-	3
3	3	3	3	2	2	2	2	1	2	-	3

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

SYLLABUS

UNIT- 1

Bonding VSEPR Theory, Valence Bond Theory, Crystal-field theory, Electronic Spectra and Ligands (strong and weak field), Phosphorescence and Fluorescence, Jablonski diagram, hydrogen bonding and their effect on physical properties, Metallic bonds, Classification and Applications of Liquid crystals, Band Theory of Solids and superconductors.

Spectroscopy Basic Principles, Instrumentation and Applications of UV-Vis and IR Spectroscopy.

UNIT- 2

Chemical Kinetics Second order reactions. Determination of order, Fast and slow reaction, steady state approximation, Temperature effect, Concept of Activated Complex / Transition State: Energy of activation, Potential energy surface, Theories of reaction rate: Collision and Transition State theories interms of enzyme catalysis.
Surface Chemistry Introduction, Types of adsorption, Adsorption isotherms, BET, Applications of adsorption.

UNIT- 3
Electrochemistry Dry and fuel cells, electrochemical cell, Solar cells, Disensitized cell, Photovoltaic cell.
Nanochemistry Introduction, general methods of synthesis, classification and applications of nano materials.
Environmental Chemistry Air and Water Pollution, analysis of gaseous effluents oxides of Nitrogen, oxides of Sulphur and H_2S, chemical analysis of effluents liquid streams, BOD, COD, control of pollution, Depletion of ozone layer.

UNIT- 4
Stereochemistry Stereoisomerism of organic compounds containing one & two chiral centers. Enantiomers & Diastereomers, E-Z nomenclature, R-S configuration, Atropisomerism, and Optical isomerism in Allenes, biphenyl and Spiranes, Circular Dichroism.
Reaction Mechanism Inductive, Electromeric and Mesomeric effects. Study of reaction intermediates (Carbanion, carbocation, carbene, nitrene and benzyne). Mechanism of nucleophilic and electrophilic substitution reactions. Mechanism and application of following reactions:

a) Suzuki-Miyaura Cross coupling reaction
b) Fries and Photo-Fries Rearrangement
c) Wagner-Meerwein Rearrangement
d) Umpolung Reactions
e) Favorskii Rearrangement

UNIT- 5
Polymers: Introduction, types of polymers, Molecular mass-number and mass average molecular weight, determination of molecular mass by Osmometry, viscosity, light scattering and size exclusion chromatography, Rheological properties and uses of some common polymers. Synthetic Polymers (carbon framework, silicon framework, fluorinated polymer), Conducting and Biodegradable polymers.

Water Analysis: Introduction; Hardness of Water- cause, types, units, Disadvantages of using hard water for domestic and industrial purposes, Softening of hard water, Chemical analysis of Water- estimation of free chlorine, total alkalinity, hardness, Numerical based on determination of hardness.
Solid Waste Management: Classification, waste treatment & Disposal methods (Composting, sanitary landfilling, thermal processes, recycling and reuse).

List of Experiments:

1. Determination of alkalinity in given water sample.
   i. Sodium Carbonate & Sodium Bicarbonate
   ii. Sodium Carbonate & Sodium Hydroxide
2. Determination of temporary and permanent hardness in water sample using EDTA as standard solution.
3. Determination of Chloride content of water by Mohr's Method.
4. Determination of Chlorine content in Bleaching powder.
5. Determination of strength of supplied Ferrous Ammonium Sulphate (FAS) solution in using external, internal indicators.
6. Determination of viscosity of a given liquid by Ostwald's viscometer.
7. Determination of surface tension of a given liquid by Stalagmometer.

8. pH metric titration.
9. Determination of Dissociation constant of weak acids by conductometric Titration.
10. To prepare aspirin (acetyl salicylic acid) from salicylic acid.
11. Synthesis of polyurethanes
12. Find the concentration of the given samples using UV-visible spectroscopy.

Textbooks

1. A Text Book of Engineering Chemistry by Shashi Chawla, Dhanpat Rai & Co., Fifth Edition, 2017.

Reference Books:

1. Organic Chemistry by I. L. Finer, Vol-1, Ninth Edition, 2015, Pearson Publisher.
2. Physical Chemistry by Puri, Sharma & Pathania, Vishal Publishing Co., 48th Edition, 2021, ISBN: 978-93-87015-81-4
3. Polymer Science by V. R. Gowarikar, N. V. Vishwanathan and J. Shridhar, Wiley Eastern Ltd.,New Delhi, 1987, ISBN: 978-0470203224.
4. Elementary Organic Spectroscopy by Y.R. Sharma, S. Chand, Fifth Edition, 2013, ISBN: 9788121928847.

Web links

1. https://nptel.ac.in/courses/104101121 [Prof. Debabrata Maiti, IIT Bombay]
2. https://nptel.ac.in/courses/104106119 [Prof. Harinath Chakrapani & Prof. Neeraja Dashaputre, IIT Madras]
3. https://nptel.ac.in/courses/104105084 [Prof. Debashis Ray, IIT Kharagpur]
4. https://nptel.ac.in/courses/104106129 [Prof. M. V. Sangaranarayanan, IIT Madras]

NCS-102: Introduction to Computer Science and Engineering

L	T	P	C
3	1	0	4

Course Outcomes (COs):

To explain the fundamentals of the computer system in terms of hardware components and basics of an operating system, understanding of programming, database management systems, and working with Internet and web applications.

At the end of this course students should be able to:

CO1	Understand hardware components of computer systems such as memory system organization, and input/output devices, and be aware of software components of computer system	Understand	K1
CO2	Understand Operating systems and be able to develop basic shell scripts.	Understand, Apply	K1, K2
CO3	Develop a basic understanding of programming and get a concept of algorithmic thinking.	Apply, Analyze	K2, K3
CO4	Understand Databases, Use SQL to write queries.	Understand, Evaluate	K1, K4
CO5	Explain how the Internet works and be able to make basic static Web applications.	Understand, Create	K1, K5

K1-Understand, K2-Apply, K3-Analyse, K4-Evaluate, K5-Create

Course Articulation Matrix (CO-PO Matrix)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	-	-	-	-	-	-	-	-	-	-	-
CO2	2	1	1	-	-	-	-	-	-	-	-	-
CO3	3	3	2	3	1	-	-	1	1	1	1	1
CO4	3	2	2	3	1	-	-	-	1	-	2	1
CO5	3	2	3	1	2	1	1	2	2	2	1	2

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

SYLLABUS

Unit - 1

Fundamentals of Computers: Introduction to Computers - Computer Definition, Characteristics of Computers, Evolution, and History of Computers, Types of Computers, Basic Organization of a Digital Computer; Classification of Digital Computer Systems: Microcomputers, Minicomputers, Mainframes, Supercomputers. Number Systems, Computer Codes – BCD, Gray Code, ASCII, and Unicode; Boolean Algebra – Boolean Operators with Truth Tables; Types of Software – System Software and Utility Software; Computer Languages - Machine Level, Assembly Level & High-Level Languages, Translator Programs – Assembler, Interpreter and Compiler; Planning a Computer Program – Data Structures, Algorithm, Flowchart and Pseudo code with Examples.

Unit-2

Operating System Fundamentals: Operating Systems: Introduction, Functions of an Operating System, Classification of Operating Systems, System programs, Application programs, Utilities, The Unix Operating System, Basic Unix commands, Microkernel Based Operating System, Booting.

Unit-3

Fundamentals of C Programming Language: Introduction to C Programming Languages, Structure of C programs, compilation and execution of C programs, Debugging Techniques, Data Types and Sizes, Declaration of variables, Modifiers, Identifiers and keywords, Symbolic constants, Storage classes (automatic, external, register and static), Enumerations, command line parameters, Macros, The C Preprocessor.

Operators: Unary operators, Arithmetic & logical operators, Bitwise operators, Assignment operators and expressions, Conditional expressions, Precedence, and order of evaluation.

Control statements: if-else, switch, break, and continue the comma operator, goto statement. Loops: for, while, do-while. Functions: built-in and user-defined, function declaration, definition and function call, and parameter passing: call by value, call by reference, recursive functions. Arrays: linear arrays, multidimensional arrays, passing arrays to functions, Arrays, and strings.

Unit-4

Introduction to Database Management Systems: Database, DBMS, Why Database -File system vs DBMS, Database applications, Database users, Introduction to SQL, Data types, Classification of SQL-DDL with constraints, DML, DCL, TCL

Unit-5

Internet Basics: Introduction, Features of the Internet, Internet application, Services of the Internet, Logical and physical addresses, Internet Service Providers, Domain Name System.

Web Basics: Introduction to web, web browsers, http/https, URL, HTML5, CSS

Text Books:

1. Kernighan B.W., Ritchie D.M., "The C Programming Language", 2nd Edition, Prentice Hall Software, 2015
2. V. Rajaraman, "Fundamentals of Computers", 6th Edition, PHI Learning Pvt. Ltd., 2015
3. Peter Norton's, "Introduction to Computers", 7th Edition, Tata McGraw Hill, 2017
4. David Riley and Kenny Hunt, "Computational Thinking for Modern Solver", Chapman & Hall/CRC, 1st Edition, 2014

Reference:

1. J. Glenn Brook shear," Computer Science: An Overview", Addision-Wesley, Twelfth Edition, 2017
2. R.G. Dromey, "How to Solve it by Computer", PHI, 1982
3. Balagurusamy E., "Fundamentals of Computers", Second ed. 2009, McGraw Hill
4. Thareja R., "Fundamentals of Computers", 2014, Oxford University Press.

Web link:

1. https://onlinecourses.swayam2.ac.in/cec19_cs06/preview

NET-102 : Introduction to Electronics Engineering

L	T	P	C
3	1	0	4

Course Objective

To understand the fundamentals of analog & digital electronic devices like diode, transistor, logic gates, flip-flop and to understand the working principles of common Instruments used in electronic measurement.

Course Outcomes (CO):

At the end of this course students should be able to:

CO1	To understand the basic concept of diodes, and use the diode as a circuit element for different applications.	K2,K3
CO2	To understand the working of BJT, FET and OP-amp and their application.	K2, K3, K6
CO3	To design the simple digital circuits using different logic gates.	K4, K6
CO4	To identify the errors while making electronic measurements and to understand the working of different types of transducers.	K1, K4, K5
CO5	To understand the working principle of electronic instruments and displaying it on electronic devices.	K1, K2, K4

K1- Remember, K2- Understand, K3-Apply, K4-Analyse, K5- Evaluate, K6- Create

Course Articulation Matrix (CO-PO Matrix)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	1	1	-	-	-	-	-	-	-
CO2	2	3	3	3	2	2	-	-	-	-	-	-
CO3	3	2	1	3	2	1	-	-	-	-	-	-
CO4	3	2	1	1	1	-	-	-	-	-	-	-
CO5	3	1	3	2	1	-	-	-	-	-	-	-

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

Course Content

Unit-I:

P-N Junction Diode, Depletion layer, Barrier potential, forward and reverse bias, Knee voltage, V-I Characteristics and its Equivalent Models, Avalanche and Zener Break Down, Diode Applications as Half Wave, Full Wave & Bridge Rectifier and their comparative analysis, Clippers, Clampers, Voltage Multiplier Circuit, Zener Diode and its Applications as a voltage regulator, Varactor diode.

Unit-II:

Basic theory and operation of PNP and NPN transistors, Characteristics of Common Base, Common Emitter and Common Collector configuration, DC Biasing : Fixed Bias, Emitter Bias, voltage divider bias, Field effect transistor: JFET, Drain and Transfer characteristic, MOSFET, Introduction to Operational Amplifier and its Applications as Adder, Subtractor, Integrator, Differentiator, log antilog.

Unit-III:

Number System, Base Conversion, BCD code, Excess-3 code, Gray Code, Review of Logic Gates, Concept of Universal Gates &, Boolean laws and theorems, SOP and POS representation of Boolean functions, Minimization of Boolean functions using K map, Basic Combinational Circuits: Half Adder, Full Adder, Subtractor, Sequential Circuits: Latch, Flip-Flops, Characteristic and Excitation Table of SR, JK, D and T Flip-flop. Concept of Master Slave Flip- Flop, Shift Registers.

Unit-IV:
Functional Elements of Instruments, Classification & Characteristics, Types of Errors, Sources of Error, Dynamic Characteristics, Active and Passive Transducers: Resistive Transducers, Thermistor, Strain Gauge, Thermocouple, Differential Output Transducers, LVDT and their Characteristics.

Unit-V:
Display Devices: LCD, LED, Seven Segment Display, Alphanumeric Display, Electronic Ammeter and Voltmeter, Digital Multi-meter, Cathode Ray Oscilloscope (CRO), Digital Storage Oscilloscope (DSO)

Text Books:

1. Electronics Principles by Albert Malvino, & David Bates, 2016, Tata McGraw-Hill, Eigth Edition, ISBN-978-0-07-337388-1
2. Electronic Devices & Circuit Theory by Boylestad, Robert & Nashelsky, 2015, Louis, Prentice Hall of India. Eleventh Edition, ISBN- 10-9332542600
3. Electronic Instrumentation and Measurements by H.S. Kalsi, 2019, Tata McGraw-Hill, Fourth Edition, ISBN-10- 9353162513
4. Digital Principles and Applications by Leach, Malvino, & Saha, 2014, Tata McGraw-Hill, 8th Edition, ISBN-10- 9789339203405

Reference Books:

1. Microelectronic Circuits by Adel Sedra, Kenneth C.(KC) Smith, Tony Chan Carusone, Vincent Gaudet, 2020, Oxford University Press, 8th Edition, ISBN-10-0190853468
2. A Course in Electrical and Electronic Measurements and Instrumentation by A K Sawhney 2021, Dhanpat Rai & sons, ISBN-10- 8177001000
3. Fundamentals of Microelectronics by Behzad Razavi, Wiley, Second Edition, ISBN-13:9781118156322

Web Links:

1. **https://nptel.ac.in/courses/108101091**
2. **https://nptel.ac.in/courses/122106025**

NCE-102 : Introduction to Civil Engineering

L	T	P	C
3	1	0	4

Course Outcomes

At the end of this course students should be able to:

CO1	To understand the overview and scope of Civil Engineering and apply the fundamentals of Surveying
CO2	To understand the various types of Civil Engineeringmaterials
CO3	To understand the basic concepts of water and wastewater quality, infrastructure, and also the basics of different pollution
CO4	To understand the basics of Highways, Railways and Airport Engineering
CO5	To understand the basics of various Civil Engineering structures

Course Articulation Matrix (CO-PO Matrix)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	-	-	-	-	2	-	-	-	-	-	1
CO1	2	-	-	-	-	2	-	-	-	-	-	1
CO2	2	-	-	-	-	2	3	-	-	-	-	1
CO3	2	-	-	-	-	2	3	-	-	-	-	1
CO4	2	-	-	-	-	2	3	-	-	-	-	1
CO5	2	1	1	-	-	2	1	-	-	-	-	1

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

SYLLABUS

Unit-1: Introduction

Civil Engineering: Overview and scope of Civil Engineering, Civil Engineering landmarks, Job opportunities in Civil Engineering

Fundamentals of Surveying: Introduction, Types of Surveying - Chain, Compass, levelling and contouring, Total Station, Introduction to Remote Sensing/ GIS/ GPS

Unit-2: Civil Engineering materials

Building materials : Bricks, Stones, Cement, Aggregate, Concrete, RCC, Steel, Timber, Tiles, lime, paint.

Highway materials: bitumen, concrete, Surkhi, sand, stone dust

Soil: Types of soil, classification of soil.

Unit-3: Environmental Engineering

Water and Wastewater Quality, Drinking Water Standards, Water infrastructure- Intake, Treatment plants, distribution system, and household plumbing.

Waste waterinfrastructure- household drainage system, sewerage system, Treatment Plant, and, disposal, effluent standards.

Introduction to Air Pollution, Air Quality Index, Air quality standards, Solid Waste Management- collection and segregation, Noise Pollution- standards

Unit-4: Transportation Engineering

Highway Engineering: Introduction, Model, elemental and functional classification of Transportation System, IRC classification of roads, Typical cross-section of pavements, Control system.

Railway Engineering: Types of rails, Components of permanent way, stations

Airport- Components of the airport
Introduction to Docks,Harbour, and Inland waterways

Unit-5: Civil Engineering Structures
Introduction to buildings: Elements- slab, beam, column, footing

Introduction to various Civil Engineering Structures- Bridges,Retaining Wall, Tanks and Reservoirs, Hydraulic Structures-Dams, Canals, Weirs, Barrage,Industrial Structures

Textbooks

1. S.S. Bhavikatti (2010). 'Basic Civil Engineering.', 1st edition, New Age International Publishers, New Delhi
2. Sateesh Gopi (2009). 'Basic Civil Engineering.', Pearson Publishers, Delhi, India
3. Punmia, B.C., Jain, A.K. and Jain, A.K. (2003). 'Basic Civil Engineering.', Laxmi Publications, New Delhi.

Reference Books

1. An Introduction to Civil Engineering by V. Okumu, CreateSpace Independent Publishing Platform.
2. Penn M. R. and Parker P. J. "Introduction to Infrastructure: An Introduction to Civil and Environmental Engineering" John Wiley & Sons 2011.

Web Resources

https://nptel.ac.in/courses/105106201

NCT 102: Introduction to Chemical Engineering and Technology

L	T	P	C
3	1	0	4

Objective:

The objective of the course is to impart

- Knowledge of basics concepts of microbiology and Food processing
- General introduction to Oils, fats, oleochemicals, essential oils, their sources, composition and structures. Basic concepts about paints, ingredients, functions, formulation and application of paints
- Knowledge of basic concepts of Polymer and Plastics
- Knowledge of basic concepts of chemical engineering
- Knowledge of basics of leather processing

Course Outcome

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

CO1	Understanding the basic concepts of microbiology and food processing	Understand
CO2	Understand the basic concepts about oils & paints, their ingredients and functions	Understand
CO3	Understand the basics and applications of Polymers and Plastics	Understand
CO4	Understand basics and application of chemical engineering	Understand
CO5	Understanding basics of leather processing	Understand

PO/ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1				1	2	1	1	2		2
CO2	3	1				1	2	1	1	2		2
CO3	3	1				1	2	1	1	2		2
CO4	3	1				1	2	1	1	2		2
CO5	3	1				1	2	1	1	2		2
Average	3.0	1.8	1.8	1.4	1.0	1.4	1.0	1.4	1.4	0.0	0.6	1.4

Syllabus

Module 1: Introduction to Biochemical Engineering and Food Technology

Introduction to biochemical engineering. Microorganisms: Characteristics, classification, morphology, and reproduction in brief, Introduction to Food Technology: Scope of Food Technology, Overview of Food Constituents, Food Quality & Safety, Regulatory framework in India.

Module 2: Introduction to Oil and Paint

General introduction to Oils; their sources, composition, physiochemical characteristics. Fatty acids; structures nomenclature, classification and principal sources. Production and consumption pattern of various oils.

Basics concepts of paints, general ingredients & their functions. Introduction of drying oils, natural & synthetic resins, extenders & prime pigments, solvents, driers and plasticizers. General formulation of paint and basic machineries used in its manufacture. Testing and application of paint.

Module 3: Introduction to Polymer Science and Technology

Concept and definition of monomers, polymers, plastics and related chemicals, Basic properties, and types of plastic materials, Utility of plastic materials in variety of fields and their advantages over other material of construction, Global and Indian scenario of Plastic and allied industries.

Module 4: Introduction to Chemical Engineering

Introduction to Chemical Engineering, Unit Operations and Processes, Thermodynamics and Kinetics, Material and Energy Balances, Reactor Design, Piping and Instrumentation, Automation and Control, Energy Resources and Environmental Engineering, Process Safety, Operations and Troubleshooting, Career Opportunities and Challenges.

Module 5: Introduction to Leather Technology

History of Leather; Overview of Leather Sector; By-Product of Meat Industry; Biodegradable products; Hides and Skins Protein; Curing of Hide & Skins; Introduction to Leather Processing; Leather Machinery.

Suggested Readings

Module 1:

Text Books:

1. Biochemical Engineering Fundamentals by J. E. Bailey & D. F. Ollis (1987) 2nd Ed. McGraw Hill International Edition.
2. Pelczar M J, Chan E C S and Krieg N R "Microbiology, 5th Edition, " Mc Graw Hill, New York (1995)
3. Food Science By Norman N. Potter, 2012

Reference Books:

1. Food Microbiology By William C. Frazier, Dennis C. Westhoff · 2004
2. The Food Safety and Standards Act,2006
3. Food Facts and Principles By N. Shakuntala Manay & M. Shadaksharaswamy

Web Links:

1. www.fssai.gov.in
2. https://egyankosh.ac.in

Module 2:

Text Books

1. Baileys Industrial oil and fat products by Daniel Swern, Wiley Interscience publication (1979)
2. Chemistry and Technology of Oils and Fats by Prof. M. M. Chakrabarti, Allied publishers (2003)
3. Nontraditional oilseeds and oils by N. V. Bringi, Oxford and IBH Co. Pvt. Ltd. (1989)

Reference Books:

1. Fatty Acid by K. S. Markely, Inter Science publishers (1968)
2. Organic Coating Technology, Vol. I& II; byHF Payne.
3. Outlines of Paint Technology; byWMMorgan.
4. Basics of Paint Technology(Part I& II);by Malshe & Sikchi.

Web Links:

1. https://www.youtube.com/watch?v=34IADhdkvKQ
2. https://www.youtube.com/watch?v=6j8HnaZLVL8
3. https://www.youtube.com/watch?v=KTyQ-T21XgM

Module 3:

Text Books:

1. F. W. Billmeyer; Text Book of Polymer Science; Wiley; Third edition; January 2007.
2. Vasant R. Gowariker; Polymer Science; New Age International; January 2019

Reference Books:

1. Premamoy Ghosh; Polymer Science and Technology; Tata McGraw-Hill Education, New Delhi;1990.
2. R.J. Young and P.A. Lovel; Introduction to Polymers; CRC Press; London, 2011.

Web Links:

1. Introduction to Polymer Science - https://nptel.ac.in/courses/104/105/104105124/
2. Science & Technology of Polymers - https://nptel.ac.in/courses/113/105/113105028/
3. Polymer Chemistry - https://nptel.ac.in/courses/104/105/104105039/

Module 4:

Text Books:

1. Salil K Ghosal, Siddhartha Datta, "Introduction to Chemical Engineering" Tata McGraw Hill Education Private Limited, 1993.
2. Warren Lee MacCabe Smith, Peter Harriott, "Unit Operations of Chemical Engineering", 7th Edition, McGraw Hill 2005

Reference Books:

1. Maloney, James O. Perry Chemical Engineers Handbook. The McGraw-Hill Companies, Inc, 2008

Web Links:

1. https://youtu.be/WgWNQVdhE9A
2. https://www.pmu.edu/department-of-chemical-engineering/pdf/IntroductionChemicalEngineering.pdf
3. https://en.wikipedia.org/wiki/Chemical_engineering

Module 5:

Text Books:

1. Dutta. S.S., “An Introduction to the Principles of Leather Manufacture”.

Reference Books:

1. Covington T., “Tanning Chemistry: The Science of Leather”.
2. Sarkar K.T., “Theory & Practice of Leather Manufacture”.

Web Links:

1. https://youtu.be/z6QnUCc7ZCg
2. https://youtu.be/4PBRW-g01Ag
3. https://www.neratanning.com/knowledge/the-leather-making-process-step-by-step/

NWS 102 : Workshop Practice

L	T	P	C
0	0	4	2

Course Objective: The objective of this course is to educate and impart basic knowledge of various hand tools and equipments and their use in different shops, day to day industrial work and domestic life. Students able to understand safety precautions in the workshop. Student acquires skills of application oriented task.

Course Outcome

At the end of the course the student should be able to :

CO 1	Study and practice on machine tools and their operations	K2
CO 2	Practice on manufacturing of components using workshop trades including fitting, carpentry, foundry, black - smithy and welding work	K3
CO 3	Identify and apply suitable tools for machining processes including plain turning, step turning, taper turning, facing, thread cutting operations	K4
CO 4	Understand and practice welding and forging operations	K3
CO 5	Select the appropriate tools required for specific operation and the proper safety measure required to be taken while using different tools.	K2 , K3

K1 - Remember, K2 - Understand, K3 - Apply, K4 - Analyze, K5 - Evaluate, K6 – Create

Course Articulation Matrix (CO-PO Matrix)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO(	PO10	PO11	PO12
CO1	2	-	-	1	1	1	-	-	-	-	-	1
CO2	2	-	-	1	1	1	-	-	-	-	-	1
CO3	2	-	-	1	1	1	-	-	-	-	-	1
CO4	2	-	-	1	1	1	-	-	-	-	-	1
CO5	2	-	-	1	1	1	-	-	-	-	-	1

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

CO1

1. Working principle of lathe machine
2. Parts and operations on lathe machine
3. Tool geometry of single point cutting tool

CO2

1. Study and practice of different tools used in Fitting shop, Carpentry shop and Foundry shop.
2. Study and practice of different tools used in Black-smithy shop, Sheet metal shop and Welding shop.

CO3

1. Explanation and demonstration of various processes like plain turning and step turning.

2. Explanation and demonstration of various processes like taper turning and facing.
3. Explanation and demonstration of various processes like thread cutting, knurling and chamfering.

CO4

1. Classification of different welding processes with the help of flow chart.
2. Explanation and demonstration forging operations.
3. Safety precautions during actual forging and welding.

CO5

1. Selection of proper drilling tool for drilling operation.
2. Selection of proper tap for internal thread cutting operation.
3. Selection of power hacksaw blade, wood cutting cutter , snips, chisels etc.

CO6

1. Proper demonstration of safety precautions to be taken for example leather apron, leather hand gloves, welding shield etc.
2. Description of different safety tools and precautions in workshop.

Course Content

1. Carpentry Shop

Practice (I) : To prepare half lap corner joint from given pieces of mango wood.
Practice (II) : To prepare mortise and tenon joint from given pieces of mango wood.
Instructions : Description and demonstration of different tools, joints along with advanced carpentry joints, classification and definition of timber, wood seasoning, demonstration of wood working lathe and advanced power tools used in carpentry work, safety precaution during actual working.

2. Fitting and Bench working Shop

Practice (I) : To prepare male-female joint from given pieces of mild steel.
Practice (II) : To prepare practice work piece involving marking , measuring , sawing, drilling and tapping operations.
Instructions : Classification and description of different tools used in fitting shop e.g. marking and measuring tools , holding and supporting tools, striking tools and cutting tools etc , safety precaution during actual working.

3. Black Smithy Shop

Practice (I) : To prepare ‘ L ’ shape job from given piece of mild steel rod by hand forging.
Practice (II) : To prepare a ‘ Ring ’ from given piece of mild steel rod by hand forging.
Instructions : Description of various forging processes done in black-smithy work e.g. upsetting, drawing down, punching, bending, fullering etc, classification and description of different tools, equipments used in black smithy shop, safety precaution during actual working.

4. Welding Shop

Practice (I) : To prepare simple butt joint and lap joint by electric arc welding from given pieces of mild steel.
Practice (II) : To prepare simple lap joint by oxy-acetylene gas welding and gas flame cutting practice.
Instructions : Concept of welding, classification and explanation of various types of welding with the help of flow chart, description of different tools. Equipments required for arc welding and gas welding, demonstration of various types of flames in Oxy-

acetylene gas welding, setting of current and selection of electrodes along with different welding joints, safety precaution during actual working.

5. Sheet Metal Shop

Practice (I)	:	To prepare a funnel complete with soldering from given G.I. sheet.
Practice (II)	:	To fabricate tray / tool box or electric panel box from given G.I. sheet.
Instructions	:	Classification and description of different types of tools, equipments used in sheet metal work, different types of metals used in sheet metal shop e.g. Galvanized iron, lack iron, copper, aluminum etc, concept of development of surfaces along with different types of joints in sheet metal work, safety precaution during actual working.

6. Machine Shop

Practice (I)	:	To prepare a job by plain turning, facing, step turning and chamfering operation from given mild steel rod.
Practice (II)	:	To prepare a job by taper turning, threading, knurling operations from given mild steel rod.
Instructions	:	Classification of lathe machines, different parts of lathe machine, tools and equipments used, explanation and demonstration of various operations on lathe machine, tool geometry of single point cutting tool, cutting speed, feed and depth of cut in turning, safety precaution during actual working.

7. Foundry Shop

Practice (I)	:	To prepare a mould of given pattern in Green Sand
Practice (II)	:	To prepare a mould with two step pulley with runner and riser
Instructions	:	Description and use of various foundry tools, showel, flat rammer, hand rammer, strike off bars, vent wire, trowels, hand riddle etc. Types of various moulding sands, types of patterns, pattern materials, pattern allowances, safety precautions during actual working.

Text Books

1. Elements Of Workshop Technology Vol-1, by Choudhury H S K, MPP Pvt. Ltd., 2008
2. A Course in Workshop Technology Vol I by Raghuwanshi, Dhanpat Rai & sons, 2011.
3. Workshop Practice Manual by V Kapoor, Dhanpat Rai & sons, 1998
4. Workshop Technology: Manufacturing Processes by Khurmi & Gupta, S. Chand Publications, 2008

Reference books

1-Mechanical Workshop Practice, 2/E 2nd edition, Kindle Edition, K.C.John, PHI, 2010.
2-Workshop Practice , Singh Swarn, Katson Books, 2003.
3- Workshop Practice, R.K.Rajput, 2016.
4- Workshop Practice, B.L.Juneja, Cengage Learning Publishers, 2015.

Link:

1- https://sjce.ac.in/wp-content/uploads/2018/04/Workshop-Laboratory-Manual.pdf
2- https://nptel.ac.in/courses/112107219

NMA-201 Engineering Mathematics–II

L	T	P	C
3	1	0	4

OBJECTIVE: The objective of this course is to educate the students about

- ordinary differential equations and their applications as mathematical models.
- series solutions of ordinary differential equations and special functions.
- Laplace transform, Fourier series, differential equations, and boundary value problems.

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

CO1	solve first and higher order ordinary differential equations.	K3, K5
CO2	find series solutions of ordinary differential equations and learnBessel's and Legendre's function and its applications.	K1, K3
CO3	solve IVPS and BVPS using Laplace Transform.	K3, K5
CO4	find Fourier series expansion of given function and solvepartial differential equations.	K3, K5
CO5	solve boundary value problems using variable separablemethod etc.	K2, K3

CO-PO Mapping:

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

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is nocorrelation, put "- "*

SYLLABUS

Unit- I: Ordinary Differential Equations: **10 hours** First order ordinary differential equations, Existence and uniqueness of solutions of initial valueproblems, Solution of higher order linear differential equation with constant coefficients,Solution of second order differential equations by changing dependent and independentvariables, Cauchy- Euler equations, Methods of diagonalization, undetermined coefficients and

variation of parameters: Nonlinear equations, Linear and nonlinear models, Initial value andboundary value problems, Systems of equations. Application of differential equations as mathematical models, Models from population dynamics, Newton's Law of cooling, electriccircuit, Oscillation of spring.

Unit-II: Series Solutions of Ordinary Differential Equations & Special Functions: 8 hours Ordinary and singular points of a differential equation, Power series solutions, Frobenius method, Bessel's and Legendre's equations and their series solutions, Properties of Legendre's polynomials and Bessel's functions, Generating

functions, Fourier- Bessel series and Fourier- Legendre series expansions, Sturm- Liouville Problem and related theorems.

Unit-III: Laplace Transform: 8 hours

Laplace transform, Existence conditions and ROC, Inverse Laplace transform, Operational properties, Convolution, Unit step function, Dirac-Delta function, Periodic functions, Applications to solve IVPs and BVPs: Linear ordinary differential equations, Transfer function and control system analysis.

Unit-IV: Fourier Series and Partial Differential Equations: 8 hours

Orthogonal functions, Fourier series, existence conditions, Fourier series of even and odd functions, convergence of Fourier series, Fourier half range series, Harmonic analysis, Complex Fourier series and frequency spectrum. Development of partial differential equations and solutions, Solution of first order partial differential equations, Solutions of linear higher order partial differential equations with constant coefficients.

Unit-V: Boundary-Value Problems: 6 hours

Classification of second order partial differential equations, Derivation of heat and wave equations, solutions in rectangular coordinates by separation of variable method, solution of Laplace equation, D'Alembert's solution of wave equation, non-homogeneous equations and boundary conditions, Orthogonal series expansions, Fourier series in two dimensions, Boundaryvalue problems in polar, cylindrical, and spherical coordinate systems and their solutions.

Books Recommended:

1. E.A. Coddington, An Introduction to Ordinary Differential Equations, Practice Hall, 1995.
2. I.N. Sneddon, Elements of Partial Differential equations, McGraw-Hill 1957.
3. Dennis G, Zill & Michael R. Cullen; Advanced Engineering Mathematics, Jones & BartlettPublishers. 2nd Edition.
4. B. S. Grewal," Higher Engineering Mathematics", Khanna publishers, 42nd edition, 2013.

Reference Books:

1. R.K. Jain & S.R.K. Iyengar; Advanced Engineering Mathematics, Narosa Publishing House,2002.
2. Erwin Kreyszig; Advanced Engineering Mathematics, John Wiley & Sons 8th Edition.
3. H. K Das and Er. Rajnish Verma, "Higher Engineering Mathematics", S. Chand publishing,1st edition, 2011.
4. **B.V.** Ramana "Higher Engineering Mathematics" Tata Mc Graw-Hill, 200

NCT-201 Fluid Mechanics & Mechanical Operations

L	T	P	C
3	0	2	4

Course Objectives: The objective of this course is to impart

- Knowledge of various fluid properties and their measurement devices.
- Knowledge of different types flow and flow behavior during flow of fluid through pipes.
- Knowledge of mass, energy and momentum balance in the system for interdisciplinary applications
- Knowledge of mechanical operations used in understanding fluid mechanics.

CO1	Understand the concept of viscosity and other fluid properties and their measurement.	Understand
CO2	Design the fluid flow systems by applying integral balances.	Design, Apply
CO3	Apply differential balance on fluid flow to formulate and solve the problems related to fluid flow.	Analyze, Apply, Evaluate
CO4	Apply the concept of agitation and mixing of liquids to solve problems related to particulate flow	Apply, Evaluate
CO5	Understand the principle involved in various mechanical operations.	Understand, Apply
CO6	Conduct various experiments to apply the concepts of fluid mechanics and mechanical operations.	Analyze, Understand, Apply, Evaluate

CO-PO Mapping

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	**3**	**2**	**-**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**2**		
CO2	**3**	**2**	**3**	**2**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**2**		
CO3	**3**	**3**	**3**	**2**	**1**	**-**		**-**	**-**	**-**	**-**	**2**		
CO4	**3**	**3**	**3**	**1**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**2**		
CO5	**3**	**3**	**3**	**1**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**2**		
CO6	**3**	**3**	**2**	**2**	**1**	**-**	**-**	**1**	**3**	**3**	**3**	**3**		
Average	3	2.7	2.8	1.6	1	0	0	1	3	3	3	2.2		

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

SYLLABUS

Module I (6 hours)
Definition of a fluid; Continuum hypothesis; Newtonian and non-Newtonian fluids, Fluid statics: pressure variation in a static fluid, hydrostatic forces on submerged surfaces, buoyancy, Manometers. Dimensional analysis and similitude: Buckingham Pi theorem and applications

Module II (6 hours)
Macroscopic Balances: derivation of integral balances for mass, energy and momentum; Derivation of engineering Bernoulli equation with losses, Application of macroscopic balances. Flow measurement: Orifice meter, venturimeter, Pitot tube, and Rota meter, Hydrodyanmics in environmental systems.

Module III (6 hours)
Differential balances of fluid flow: derivation of continuity and momentum (Navier-Stokes) equations for a Newtonian fluid, Boundary layer theory, Pipe flows and fittings: laminar and turbulent flows; friction factor charts, losses in fittings, Fluid transportation: Valves and Pumps.

Module IV (6 hours)

Flow through packed and fluidized beds: Flow through beds of solids, motion of particles through the fluid, Particle settling, Fluidization, minimum fluidization velocity, Mixing and Agitation- power consumption, mixing times, scale up. Application of fluidized systems for environmental remediation.

Module V (6 hours)

Properties and handling of Particulate solids. Classification of size reduction equipment: Crushers, Grinders, Ultra-fine grinders, Cutting machines and related Problems. Size reduction – Rittingers Law, Kicks law, Bonds crushing law, Work index, Problems. Different types of screening equipment in industries, Screen efficiency. Filtration: Governing equations, constant pressure operation, constant flow operation, cycle time, types of filters. Centrifuges and Cyclones: Gravity settling, centrifugal separation, cyclone separations, separation efficiency, pressure loss. Basic idea of transportation equipment's.

List of experiments

1. To determine coefficient of discharge of an venturimeter
2. To determine coefficient of discharge of an orifice meter.
3. To determine the minor losses in pipe fittings
4. To verify the Bernoulli's Theorem
5. To find critical Reynolds number for a Pipe flow,
6. To calculate reduction ratio in Jaw crusher
7. To calculate reduction ratio in crushing roll
8. To calculate critical speed of Ball mill
9. To perform differential and cumulative screen analysis

Text book:

1. Dr. R. K. Bansal, Fluid mechanics and hydraulic machines, Lakshmi Publication, Tenth edition, 2019
2. McCabe, Smith and Harriott, Unit Operations of Chemical Engineering: McGraw Hill, 7th Edition 2017
3. K. Swain, H. Patra, G. K. Roy, Mechanical operations, Mc Graw Hill, 2017

Reference:

1. Chhabra, R. P., and V. Shankar, eds. Coulson and Richardson's Chemical Engineering: Volume 1A: Fluid Flow: Fundamentals and Applications. Butterworth-Heinemann, 2017.
2. Gupta, Vijay and S. K. Gupta, "Fluid Mechanics and its Applications", Wiley Eastern, New Delhi, 2015

Web Links:

https://nptel.ac.in/courses/103102211
https://archive.nptel.ac.in/courses/103/104/103104043/

NPT 201: Introduction to Surface Coatings and Their Components

L	T	P	C
3	1	0	4

OBJECTIVE: The objective of this course is to enable the students understand and apply.
The composition of paints and their classifications.
The chemical modifications of fixed oils to enhance their properties.
The composition and properties of driers.
Various volatile solvents and their properties.

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

CO1	Understand the composition and functions of Paints & Coatings.	Understand
CO2	Understand the composition and properties of various vegetable oils.	Understand
CO3	Understand the deficiencies of vegetable oils and to apply to improve them upon, by chemical modifications.	Apply
CO4	Understand the compositions and properties of various driers and apply in coatings	Apply
CO5	Understand the composition and properties of various volatile solvents, and design thinners having the targeted properties.	Apply

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	2	2	1	2	2	3	2	-	-	2
CO2	3	2	2	2	2	1	1	2	3	-	1	3
CO3	3	2	3	3	2	2	2	1	2	-	2	2
CO4	3	2	-	-	-	1	-	-	-	-	-	-
CO5	3	2	2	-	-	1	-	1	-	-	-	-
Average	3.0	1.8	1.8	1.4	1.0	1.4	1.0	1.4	1.4	0.0	0.6	1.4

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

SYLLABUS

Module-I: Surface Coatings

Definitions and general classifications; paints, varnishes and lacquers; their components and functions; coating binders, media/vehicles, pigmentations, paint manufacture; dispersion, soaking, flocculation, emulsion, stabilization, coating applications; mechanism of film formation; eco-friendly surface coatings; properties of surface coatings and their films; film ageing; Indian and global picture of paint industry; career in paint technology.

Module-II: Fixed Oils

Essential, mineral and fixed oils; sources and composition of glyceride oils (Such as Linseed, soya, Castor Oil); molecular structure of tri-glyceride oils; non-glyceride components of oils; constitution and molecular structure of fatty acids; distribution of fatty acids in oil molecules; extraction of oils; processing of oils; evaluation & characterization of oils – physical and chemical; fatty acid composition, characteristics and classification of individual oils-drying, semi drying and non-drying; properties and uses of glyceride oils; yellowing and non-yellowing oils; chemical properties of oils – oxidation, iodination and hydrogenation, hydrolysis, acidolysis, alocoholysis, saponification, sulphation, sulphonation, epoxidation; fatty alcohols and fatty amines; foreign matter, breaks and foots in oils.

Module-III: Modifications of Oils

Deficiencies in oil films; chemical modifications of triglyceride oils- heat bodied/thermally polymerized (stand) oils, blown oils, boiled & double boiled oils; solvent segregation; isomerized oils; dehydrated castor oil; Vinylation, Acrylation, Epoxidation, Styration of Oils. maleinized oils & water soluble oils; co-polymerized oils; reconstituted (semi-synthetic) oils; limed oils; catalyzed oils; methyl esters and biodiesel, refining of oils, contamination: sources, causes and effects.

Module-IV: Drying Control addtives

Constitution; active & auxiliary, primary and secondary; surface & through driers; metal part and organic acid part of driers; properties and uses of individual driers; mechanism of drier action; manufacture of driers; evaluation of driers; combination of driers; drier dosage; drier substitutes; drier related paint film defects; driers for water based coatings; future trends; Antiskining agents, Antioxidats

Module--V : Volatile Solvents

General classes of solvents, Aliphatic, Aromatic, Paraphinic, Nepthanic, Ester, Alcohol, Green solvents, solvents from renewable sources such as molasses etc; properties of solvents e.g. solvent (cutting) power, rate of evaporation, boiling point & vapor pressure, distillation range, flash point, auto ignition temperature, toxicity, aromatic content etc.; chromatographic techniques for solvent analysis; criteria of solubility; thermodynamics of solubility; solubility parameters; solvent mixture (thinners) – true solvents, latent solvents and diluents; evaporation properties of solvent mixtures; azeotropes; activity coefficients; evaporation from polymer films; sources and properties of individual solvents. Water as coating solvent; effect of volatile solvents on film properties; use of supercritical fluids as solvents; uses of solvents with different binder systems; safety, health & environmental aspects such as legislation related to VOC

References and suggested readings :

1. Organic Coating Technology, Volume I, by Henry Fleming Payne, John Wiley & Sons.
2. Basics of Paint Technology, Part I & II, by V.C. Malshe&MeenalSikchi
3. Surface Coatings, Volume I, by OCCA Australia (Prepd.), Chapman and Hall
4. Outlines of Paint Technology, III Ed. By W.M. Morgans,
5. Surface coatings: Science and Technology, by Swaraj Paul, John Wiley and Sons
6. Organic Coatings: Science and Technology, Volume I, by Z.W. Wicks, F.N. Jones and S.P. Pappas, Wiley-Interscience
7. Fatty Acid vol. I –V, by Markley
8. Websites of PRA, Wikipedia etc.
9. BIS Specifications; IS74.1979

NPT 203: Technology of Organic, Functional and Effect Pigments

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

CO1	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, "-"*

SYLLABUS

Module -I: Colour Phenomena

Comparison of organic and inorganic pigments, 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. Definition of dyes, pigment-dyestuffs, toners and lakes.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.

Module -II: Industrial Organic Pigments

Raw materials: coal-tar 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.

Module -III: 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.

Industrial- Organic pigments:- B-Naphthol pigments, Naphthol AS pigments (Naphthol reds). Benzimidazolone pigments, Diazo condensation pigments, Metal complex pigments, Isoindolinone pigments, polycyclic pigments, phthalocynine pigments, Anthraquinone pigments, perylene and perinone pigments, Thioindigo pigments ,Antha pyrimidine pigments Dioxazine, Pyzanthrone pigments, Anthanthrone pigments, Triarycarbonium pigment. +quinopatholane pigments

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, calciumplumbate 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, quinocridones, perylene, perinone, dioxazine-carbazole, phthalocynines, diketopyrrolopyrrol (DPP), quinophathalones, anthraquinone, and vat pigments. Composite and mixed pigments. Testing and identification of organic pigments. Introduction to colour index name and number. Colour coding systems.

References and suggested readings

1. The Chemistry and Physics of Organic Pigments by L.S.Pratt.
2. Pigment Hand book Vol. I, II and III by T.C.Patton.
3. Basics of Paint Technology, Part I & II, by V.C.Malshe&MeenalSikchi
4. Pigments, dyestuffs and lakes, part six, Paint Technology Manuals.
5. Organic Coating Technology Vol. I & II by H.F.Payne.
6. Industrial Organic Pigments by Dr. Willy Hurbst

TPT-205 Chemical Process Calculation

L	T	P	C
3	0	0	3

Course Objective:

To understand and apply the basics of calculations related to material and energy flow in the processes.

Course Outcome

CO1	Demonstrate comprehensive understanding of material and energy balance equations for open and closed systems.	Remember, Understand, Apply
CO2	Select appropriate basis and conduct degree of freedom analysis for solving material and energy balance problems.	Apply, Evaluate
CO3	Make elementary flow-sheets and perform material and energy balance calculations without and with chemical reactions, and involving concepts like recycle, bypass and purge.	Analyze, Evaluate
CO4	Perform process calculations utilizing psychometric charts and steam tables.	Understand, Apply, Evaluate
CO5	Design of steady statecontinuous flow systems and unsteady state systems by applying simultaneous material and energy balance calculations	Design, Apply, Evaluate

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	**PSOs**	
CO1	3	3	2	1	-	-	-	-	-	-	-	2		
CO2	3	3	3	2	-	-	-	-	-	-	-	2		
CO3	3	3	3	3	2	2	-	-	-	-	-	2		
CO4	3	3	2	2	1	-	-	-	-	-	-	2		
CO5	3	3	2	1	-	-	-	-	-	-	-	2		
Avg	3	3	2.4	1.8	1.5	2	0	0	0	0	0	2		

Syllabus

Module 1 (6 hours)

Dimensions, system of units and their conversions, Mass and volume relations, Basic stoichiometric principles, limiting and excess reactants, Degree of completion, Conversion, Ideal gas law, Dalton's Law,

Module 2 (6 hours)

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 (6 hours)

Material balance without chemical reactions and its application to unit operations like distillation, absorption etc.

Module 4 (6 hours)

Materialbalance with chemical reaction Recycle, bypass and purging. Yield and selectivity.

Module 5 (6 hours)

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.

Text books

1. Hougen, O.A., Watson, K.M and Ragatz, R.A., "Chemical Process Principles Part-I", John Wiley and Asia Publishing, 2nd edition 2005.
2. Himmelblau, D.M., "Basic Principles and Calculations in Chemical Engineering", Prentice Hall Inc., seventh edition, 2003
3. Felder, R.M. & Rousseau, R.W. "Elementary Principles of Chemical Processes ", JohnWiley, 4th edition, 2016.

Reference Books

1. Venkataramani, V., Anantharaman, N., Begum, K. M. MeeraSheriffa, "Process Calculations", Prentice Hall of India, Second Edition, 2011.
2. Sikdar, D. C., "Chemical Process Calculations", Prentice Hall of India, 2013.

Web Links:

https://archive.nptel.ac.in/courses/102/106/102106069/

NHS 201: Economics and Management

Course Outcome (COs)

L	T	P	C
3	0	0	3

1. Understand essential economic principles for solving economic problems with suitable policy alternatives.
2. Apply the knowledge of production, cost and market functions
3. Understand and apply basic functions of management
4. Develop and apply the understanding of people and marketing
5. Develop and apply the understanding of finance and operations

CO-PO Mapping

Co/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	0	0	0	0	0	0	2	1	0	0	0	2
CO2	0	0	0	0	0	0	2	1	0	0	0	2
CO3	0	0	0	0	0	0	2	1	2	2	1	2
CO4	0	0	0	0	0	0	2	1	2	2	2	2
CO5	0	0	0	0	0	0	2	1	2	2	3	2

UNIT I: Introduction to Economics:
Overview: production possibility curve, choices-what, how and for whom, micro- and macroeconomics, inflation, unemployment, GDP and business cycle; demand and supply, elasticity of demand, consumer surplus and its applications,

UNIT II: Production, Cost and Market:
Production function, Cost Function, Types of Market: Perfect Competition, Monopoly, Oligopoly

UNIT III: Fundamentals of Management:
Development of Management Thoughts, Objectives, Functions of Management

UNIT IV: Functional Areas of Management-I
Human Resource Management: HRP, Recruitment and Selection, Performance Appraisal; Marketing Management: Functions, Strategies

UNIT V: Functional Areas of Management-II
Finance Management: Objectives, Functions; Operations Management: Concepts, Functions, Inventory Management

Text Books:

1. **Koutsoyiannis, A**., 'Modern Microeconomics', English Language Book Society, Macmillan.
2. **Joseph, L Massod,** "Essential of Management", Prentice Hall, India.
3. **S. P. Robbins,** "Management"**,** Prentice Hall, India

Additional Reference Books:

1. **Armstrong, Michel**, "A Handbook of Management Techniques", Kogan Page Limited
2. **Samuelson, Paul A** , 'Economics', 5th edition, McGraw Hill New York.
3. **Henderson, J M and Quadnt, R E** , 'Microeconomic Theory: A Mathematical Approach.', Tata MacGraw Hill, New Delhi,2003

NPT 207: Introduction to Surface Coatings and their Components Lab

L	T	P	C
0	0	4	2

OBJECTIVE: The objective of this course is to enable the students apply -
Physical Examination of Glyceride Oils.
Chemical Examination/ Characterization of glyceride oils.
Preparation and testing of modified oils.
Preparation and Analysis of Driers.
Evaluation of Volatile Solvents.
Preparation and Testing of different Types of Oil-based Coating Media

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

CO1	Physical Examination of Glyceride Oils	Apply
CO2	Chemical Examination/ Characterization of glyceride oils	Apply
CO3	Preparation and testing of modified oils	Apply
CO4	Preparation and Analysis of Driers	Apply
CO5	Evaluation of Volatile Solvents	Apply
CO6	Preparation and Testing of different Types of Oil-based Coating Media	Apply

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	2	2	1	2	2	3	2			2
CO2	3	2	2	2	2	1	1	2	3		1	3
CO3	3	2	3	3	2	2	2	1	2		2	2
CO4	3	2				1						
CO5	3	2	2			1		1				
CO6	3	2	3	2		2	1		2			1
Average	3.0	1.83	2.0	1.5	0.83	1.5	1.0	1.16	1.5	0.0	0.5	1.33

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

SYLLABUS

I. Physical examination of drying oils: Colour, Specific Gravity, Refractive index, Viscosity, Solubility, Drying Time
II. Chemical Examination/ Characterization of drying oils: Acid Value, Iodine Value, Saponification Value, Hydroxyl Value

III. Preparation and testing of modified oils:
Heat-bodied (stand) oils, Boiled oils, De-hydrated castor oil, Oil-Splitting and Reconstituted oils, Co-polymerized oils, Maleinized oils, Water-soluble oils

IV. (A) Preparation of Driers: Salts of Lead/ Cobalt/ Manganese, as Naphthenates and Octoates
(B) Analysis of driers: Non-volatile Content, Metal content

V. Evaluation of Volatile Solvents: Colour, Acidity, Moisture Content (K&F), Solvent (Cutting) Power, Distillation Range, Relative Evaporation Rate, Flash Point, Aniline Point, Aromatic Content, Refractive Index, Copper Corrosion Test, Density, Surface Tension, Electrical Conductivity, Purity by Gas Chromatography.

VI.(A) Preparation of different Types of Oil-based Coating Media: By using various Drying Oils/ Natural resins combinations

(B) Testing of Oil-based Coating Media: Colour, Specific Gravity, Refractive index, Viscosity, Drying Time (with Various Driers), Non- volatile (Solid) Content

NOTE: Evaluation / Testing/ Analysis/ Characterization is to be done by using MODERN INSTRUMENTS.

References and suggested readings:

1. BIS Specifications, IS 74.1979, IS 548 Part (I).1964
2. AOCS Specifications
3.Paint & Coating Testing Manual, Gardener-Sward Handbook),15th Edition, ASTM International.

NCY-202: Modern Analytical Techniques

L	T	P	C
3	0	3	4

OBJECTIVE:

The objective of this course is to make the students aware of the modern instrumental techniques, the principles underlying them and their applications in the characterization of materials.

Course outcome

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

CO1	Interpret Raman and IR–Spectra for characterization of materials.	Understand,Apply,Analyze
CO2	Interpret NMR, Mass and ESR–Spectra for characterization of materials.	Understand,Apply,Analyze
CO3	To analyze the conductivity to determine the concentration of Solution and i-E characteristics of the samples.	Understand,Apply
CO4	Analytical separation carried out by Chromatography in A multi-component system.	Remember,Apply,Analyze
CO5	Elucidation of the Thermal Stability of different molecules and their Characterization on the basis of their thermal stability and Glass Transition Temperature of Polymers. Determine the specific heat, heat of reaction, Melting point & boiling point. Check the purity of drugs, crystallization and fusion of polymeric Materials.	Understand,Apply,Evaluate,Create
CO6	To develop experimental skills to perform, monitor and manipulate the reactions.	Understand,Evaluate,Analyze

Chemistry												
BCY252	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	3	2	-	1	-	-	-	-	3
CO2	3	3	2	3	2	-	1	-	-	-	-	3
CO3	3	3	2	3	2	-	1	-	-	-	-	3
CO4	3	3	2	3	2	-	1	-	-	-	-	3
CO5	3	3	2	3	2	-	1	-	-	-	-	3
CO6	3	3	3	3	2	2	2	2	1	2	-	3
Average	3	3	2.17	3	2	0.33	1.17	0.33	0.17	0.33	-	3

1:Slight(Low) 2:Moderate(Medium) 3:Substantial(High) If thereisnocorrelationput"-".

SYLLABUS

Module I

(i) ***Infrared Spectroscopy*****:** Principle, mechanics of measurements, Selection rules, fundamental vibration modes, Factors influencing the band position and intensities, some characteristic frequencies and co-relation of IR spectra with molecular structures (applications), effect of Hydrogen Bonding on vibrational frequencies.(Lectures: 5-6)

(ii) ***Raman Spectroscopy*****:** Introduction theory of Raman Spectroscopy, Mechanism of Raman and Rayleigh scattering, Rule of Mutual Exclusion, correlation with the molecular structure, difference between Raman and IR spectra, Resonance Raman effect, Application of Raman Spectroscopy.
(Lecture 2-3)

(iii) ***Inductively coupled plasma-*** Introduction, Principle and applications of ICP-AES or OES.

(Lectures:2-3)

Module II

(i) ***Nuclear Magnetic Resonance Spectroscopy*****:** Introduction, basic principles, mechanics of measurements, chemical shift, band multiplets, spin-spin splitting, shielding and deshielding effect, spin-spin coupling and coupling constant(J), some characteristics of NMR positions, Application in elucidation of molecular structure,,Elementary idea of NOE, DEPTNMR, C^{13}NMR, P^{31}NMR, F^{19}NMR.

(Lectures:4-5)

(ii) ***Mass Spectroscopy*****:** Introduction, basic principles, instrumentation, fragmentation patterns, nitrogen rule, McLafferty Rearrangement, interpretation of mass spectra and applications.

(Lectures:3-4)

(iii) ***ESR*****(*****Electron Spin Resonance*****)-**Basic Principles, Instrumentation and Applications.

(Lectures:2-3)

Module III

(i)***Potentiometry and Conductometry*****:** General principles, reference and indicator electrodes, potentiometric and conductometric titrations.

(Lectures: 3-4)***Polarography*****:** Basic principle, dropping mercury electrode (DME), half wave potential ,polarographic currents and applications.

(Lectures:3-4)

Module IV

(i) ***Chromatographic methods***: Introduction to chromatographic methods: Paper, TLC, Column and Gas chromatography, Principles, Instrumentation, GC column, Detectors and stationary phases and applications Hyphenated techniques(GC-MS). (Lectures: 4-5)

Liquid Chromatography LC/HPLC, Column efficiency in LC, Detectors, Instrumentation, Partition/Adsorption/Ion Exchange Chromatography and applications.

(Lectures: 4-5)

ModuleV

(i) ***Thermal Methods of Analysis*****:** Thermo gravimetric analysis, differential thermal analysis and differential scanning calorimetry and applications.(Lectures:4-5)

(ii)***Electron Microscopy:*** Introduction and Applications of Transmission Electron Microscopy (TEM) and Scanning Electron Microscopy (SEM). (Lectures: 2-3)

(iii) ***X-ray methods:*** Introduction and applications of XRD.(Lectures: 2-3)

CHEMISTRYLAB

List of Experiments:

1. Estimation of vitamin C in commercial soft drink/GluconD.
2. Determine the strength of oxalic acid conductometrically using sodiumhydroxide solution.
3. Separation of amino acids by thin layer chromatography.
4. Determination of R_f value of Methyl Orange and Phenolphthalein using paper/thin layer chromatography.
5. Separation of metal ions by paper chromatography.
6. Determine the adsorption isotherm of oxalic acid/acetic acid on activated charcoal and verify the Freundlich adsorption isotherm.
7. Determine the rate constant(K)of hydrolysis of ethyl acetate catalyzed by HCl.
8. Synthesis of p-nitro acetanilide from acetanilide and find its percentage yield.

9. Determine the viscosity and percentage composition of the given liquid using Ostwald's viscometer.
10. Determine the strength of given glucose solution by titration against Fehling's solution.
11. Determination of dissociation constant k for a weak acid using conductometry.
12. Separation of mixtures using column chromatography.
13. Estimation of Phosphoricacid from cocacola.
14. Preparation of picric acid (2,4,6-trinitrophenol) from phenol.

ReferenceBooks:

1. Instrumental Analysis by Douglas A. Skoog, F. James Holler & Stanley R. Crouch, Publisher: Thomson Brooks/Cole.
2. Instrumental Methods Analysis, by B. K. Sharma, Publisher: Krishna Prakashan Media.
3. Textbook of Quantitative Inorganic Analysis, A. I. Vogel, Publisher: Longman
4. Elementary Organic SpectroscopybyY.R. Sharma, Publisher: S. Chand .
5. Engineering Chemistry by Shashi Chawla, Publisher: Dhanpat Rai& Co.

NMA-204 Computer Oriented Numerical Methods

L	T	P	C
3	0	2	4

OBJECTIVE: The objective of this course is to provide conceptual understanding of:

- various numerical methods for solving linear and nonlinear equations.
- various numerical techniques of interpolation, integration, and differentiation with their applications.
- various numerical methods to solve IVP_S and BVP_S.

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

CO1	find roots of nonlinear equations and solve systems of algebraic equations.	K1, K5
CO2	use interpolation techniques and to find numerical differentiation/ integration of data, function.	K3, K5
CO3	use numerical methods for finding solutions of ordinary differential equations, simultaneous and higher order equations.	K3, K5
CO4	learn numerical methods for finding solution of initial and boundaryvalue problems, partial differential equations.	K1, K2
CO5	learn basic concepts of some Finite element methods.	K1, K2

CO-PO Mapping:

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

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

SYLLABUS:

UNIT I: Nonlinear Equations and Simultaneous Linear Equations: 12 hours Roots of nonlinear equation: Methods of solution, Order of convergence of iterative methods, Simple roots: Bisection, False position, Secant, Newton-Raphson, Chebyshev, Iteration and multi point iteration methods, Multiple roots: Newton-Raphson and Chebyshev, Complex roots: Newton-Raphson and Muller's method, System of nonlinear equations: Newton-Raphson and Iteration methods, Polynomial equations: Bairstow's method, convergence analysis of abovemethods.

Linear systems: Introduction, Direct methods, Operation count, Pivoting, Ill conditioned linear systems & condition number, Iteration methods: Jacobi, Gauss-Seidel, SOR methods, convergence conditions. Special system of equations: Thomas algorithm, Eigen value problems: Given's and Power methods.

UNIT II: Interpolation, Differentiation and Integration: 10 hours Curve fitting: Polynomial interpolation, error, existence and uniqueness, truncation errorbounds, difference operators,

Newton forward and backward difference interpolations,Lagrange, Newton divided difference and iterated interpolations, Stirling and Bessel'sinterpolations, Spline interpolation, Least squares and Chebyshev approximations, Numericaldifferentiation: Methods based on interpolation, error analysis, Numerical integration: methodsbased on interpolations (Trapezoidal, Simpson's 1/3, Simpson's 3/8 rule), Gauss quadraturemethods, Romberg integration, error bounds and estimates.

UNIT III: Numerical Solution of Ordinary Differential Equations: 6 hours Initial-value problems, Single step methods: Taylor's, Picard's, Euler's, Modified Euler'smethod and Runge-Kutta method (fourth order), error estimates, multi-step methods: Adam's-Bashforth and Milne's methods, convergence and stability analysis, Simultaneous and Higherorder equations: RK Fourth order method.

UNIT IV: Initial & Boundary Value Problems and Iterative Solvers: 6 hours BVP: Shooting method and finite difference methods for ordinary differential equations,Solution of partial differential equations: Laplace, Poisson equations: standard 5- point anddiagonal 5- point formulae, Jacobi method, Gauss Seidel method (Liebmann's iterative method),Relaxation method. Solution of heat equation: Crank – Nicolson method, Solution of waveequation.

UNIT V: Finite Element Method: 6 hours
Basic concepts, variational formulation and functional, base functions, approximations weighted residual methods: Ritz method, Galerkin method, least squares method, collocation method, Finite element and solution of simple problems and time dependent problems.

NT Lab:
Develop Programs of the following techniques in C/C++ Language:

1. To implement iterative methods to solve a nonlinear equation.
2. To implement iterative methods to solve a system of linear equations.
3. To implement Forward, Backward and Central difference interpolation formulae.
4. To implement Newton's divided difference and Lagrange's interpolation formulae.
5. To implement Numerical differentiation.
6. To implement Numerical integration using Trapezoidal, Simpson 1/3 and Simpson3/8 rules.
7. To implement single step methods to solve initial value problems.
8. To implement multi step methods to solve initial value problems.
9. Solution of Heat equations (Parabolic equations) by finite difference method.
10. Solution of Laplace equations (elliptic equations) by finite difference method.
11. Solution of wave equations (Hyperbolic equations) by finite difference method.

Books Recommended:

1. M.K. Jain, S.R.K. Iyengar & R.K. Jain, Numerical methods for Scientific and Engineering Computation, N age International Publication.

2. S.S Sastry, Introductory Methods of Numerical Analysis, Eastern Economy Edition.

3. S. Rajsekaran, Numerical Method in Science and Engineering, Wheeler Publishing House.

4. B.S. Grewal, Numerical Method in Engineering & Science, Khanna Publisher.

Reference Books:

1. Chapra, S.C. and Canale, R.P., "Numerical Methods for Engineers", Tata McGraw –Hill.

2. Balagurusamy, E., "Numerical Methods", Tata McGraw –Hill.

3. Bradie, Brian (2006). A Friendly Introduction to Numerical Analysis. Pearson EducationIndia. Dorling Kindersley (India) Pvt. Ltd. Third Impression, 2011.

4. K. W. Morton and D. F. Mayers, Numerical Solution of Partial Differential Equations,Cambridge University Press.

NPT 202: Technology of Natural Resins, Alkyds and Polyesters

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 rosin and shellac and modify them for use in surface coatings	Understand, Apply
CO2	Study natural high polymers and plasticizers and their application in surface coatings	Apply
CO3	Study the functionality, degree of polymerization and molecular weight and their determination. Properties and applications of polyester resins	Apply
CO4	Formulate and evaluate Alkyd resins and carry out calculations for making tailor made alkyds	Apply, Evaluate
CO5	Study Hydrocarbon resins, Bitumen, CNSL and BNSL resins	Understand
CO6	Physical and chemical examination of natural resins and their modifications	Apply

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

Module- I: Natural Resins and Their Modifications
(a) Resins and polymers, resinous state and degree of polymerization, Resinous polymers/Polymeric resins, classification of resins, Natural, Semi-synthetic & Synthetic Resins/Polymers, classification of natural resins, sources, availability and properties of fossil & semi-fossil resins, processing of natural resins- congo, copal, kauri etc.
(b) Rosin/ colophony : sources and recovery of rosin, grades of rosin, composition of oleoresin, composition of rosin, abietic type acids & pimaric type acids, types of rosins (gum rosin, wood rosin, tall oil rosin), properties of rosins, structure-property relationship, deficiencies of rosin films, dis-proportionated rosin, modification of rosins ; polymerized (dimerized) rosin, hydrogenated rosin, limed rosin, rosin esters, maleinized rosin, maleopimaric acid, maleic resins (regular and spirit soluble), water soluble maleic resins, identification of presence of rosin. Application of rosin in surface coating
(c) Shellac: origin and extraction, different kinds of lacs and their properties, composition of lac(shellac), properties and testing of shellac, chemical modifications of shellac, French polish, uses of shellac in surface coatings.
(d) Introduction to Terpene resin:
Module-II: Natural Polymers and Their Modifications
(a) Cellulosic polymers : sources, constitution and properties of natural cellulose, deficiencies of natural cellulose as coating binder, chemical modifications of cellulose, ethers , esters and mixed esters, nitro cellulose (NC) , degree of substitution(DS) and degree of polymerization (DP), grades of NC based on solution viscosity, grades of NC based on Nitrogen content & solubility, structure-property relationship, Thinner composition for NC, handling & storage of NC, water soluble cellulose derivatives; preparation, properties, testing and uses of individual cellulose derivatives (CA, CAB, EC, HEC, EHEC, MC, CMC, SCMC).

(b) Plasticizers : definitions, role of plasticizers, internal and external plasticizers- primary and secondary plasticizers, mechanism of plasticization, types of plasticizers – oils, resin type and simple chemicals such as phthalates, sebacates, phosphates, camphor, polymeric and non-phthalate plasticizers etc. , molecular structure, properties and uses of individual plasticizers, efficiencies of plasticizers, evaluation of plasticizers based on tensile strength, percent elongation, low temperature flexibility, exudation etc.
(c) Rubber and their modifications: sources & recovery of natural rubber from latex, properties of natural rubber,deficiencies of natural rubbers as coating binder, modifications of natural rubber-chlorinated rubber resins, cyclized (isomerized) rubber resins, grades of modified rubbers resins, properties of chlorinated rubber resins vs cyclized rubber resins and their evaluation, merits and demerits of chlorinated and cyclized rubber resins, specific uses of modified rubber resins., butadiene- acrylonitrile co-polymers, chloroprene rubber, high SBR co-polymer, chlorinated paraffins & chloro waxes, biphenyls &polyphenyls, rubber resin latexes/ lattices for use in water-based coatings.

Module-III: Alkyd Resins, Formulation and Manufacture
Raw materials & their properties, oils & fatty acids for alkyds, chemistry and formulation of various alkyds, oil length & molecular structure and their effect on alkyds film properties, excess hydroxyls, Carother's equation and its applications, alkyd constant, tailor-made alkyds, formula calculation, manufacturing processes, oil/monoglyceride process, fatty acid process; fusion & solvent methods, Commercial plant (batch & continuous) for alkyd manufacture, gelation tendency & safe processing, classification, properties and application of various types of alkyds, modification of alkyds such as acrylation, styrenation, silicone modification, vinylation urethane modification, epoxy modification, co-polymerized alkyds, natural & synthetic resin modified alkyds, water soluble alkyds. Alkyd emulsions (O/W, W/O), secondary inverted emulsion,
.
Module-IV: Introduction to Synthetic Polymers and Polyesters
(a) Polymerisable monomers vs. Monomeric chemicals, functionality of molecules and its determination; degree of polymerization and molecular weight; non-convertible and convertible film-formers, Thermoplasts & Thermosets

(b) Polyester resins : saturated polyesters (oil-free alkyds), unsaturated polyesters, components and formulations of polyester resins, curing mechanism, air inhibition, properties, applications of polyester resins, hydrolytic stability, recent trends, hyper-branched polyesters, high solids and radiation curable compositions, water soluble polyesters

Module-V: Hydrocarbon and Other Resins
Bitumens and asphalts , petroleum bitumens, natural bitumens, gilsonite, albino bitumens (petroleum resins), pitches, gums , glues, proteins (casein), waxes.
Hydrocarbon resins :coumerone and indene resins, resins from petroleum products, terpene resins, dicyclopentadiene resins (DCPD), hydrogenated DCPD resins. Miscellaneous resins : Gum damar, fluoro polymers, PVDF resins, PVDC Emulsions, PTFE, ketonic resins, polycarbonates, CNSL & BSNL resins etc.

References and other readings:
1. Organic Coating Technology, Volume I; by Henry Fleming Payne, John Wiley & Sons.
2. Surface Coatings, Volume I; by OCCA Australia (Prepd.), Chapman and Hall
3. Basics of Paint Technology, Part I & II, by V.C.Malshe nht & MeenalSikchi.
4. Modern Surface Coatings, by P.Nylen and E. Sunderland.
5. Outlines of Paint Technology, III Ed.; by W.M.Morgans, Edward Arnold
6. Organic Coatings: Science and Technology, Volume I; by Z.W.Wicks, F.N.Jones and S.P.Pappas, Wiley-Interscience
7. Handbook of coatings additives, by L.J. Calbo (Ed.), Marcel Dekker Inc.
8. Protective and decorative coatings; by J.J. Mattiello.
9. Technology of Paints, Varnishes and Lacquers by C.R.Martin.

NPT 204 Chemical Engineering Thermodynamics

L	T	P	C
3	1	0	4

OBJECTIVE:

To understand the theory and applications of classical thermodynamics, thermodynamic properties, equations of state, methods used to describe and predict phase equilibria.

Course outcomes:

CO1	Understand the basic laws of thermodynamics and the terminology associated with engineering thermodynamics.	Understand, Analysis
CO2	Apply the laws of thermodynamics to evaluate the work and energy required/produced in different thermodynamic processes	Apply, Evaluate
CO3	Apply the knowledge of phase equilibria in two-component and multi-component systems.	Apply, Evaluate
CO4	Analyze the thermodynamic properties of substances in gas or liquid state of ideal and real mixture	Understand, Analysis
CO5	Understand intermolecular potential and excess property behaviour of multi-component systems	Understand, Analysis

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	-	-	1	-	-	1	-	1
CO2	3	1	1	1	-	-	3	-	-	1	-	1
CO3	3	3	2	2	-	-	-	-	-	1	-	1
CO4	3	3	3	2	-	-	1	-	-	1	-	1
CO5	3	2	2	3	-	-	1	-	-	1	-	1
Avg.	3	2.2	1.8	1.8	-	-	1.5	0	0	1	0	1

Syllabus

Module 1 (8 hours)

Basic Concepts: Scope of thermodynamics, System & Surroundings, Properties, phase, zeroth law of thermodynamics, Temperature, Equilibrium, Reversible & Irreversible process, Work, Heat, Energy;

First Law of Thermodynamics: Joule's Experiment, Internal energy, Enthalpy, Heat capacities, Application of first law to closed & open systems; Volumetric properties of pure fluids: PVT behaviour of pure substances, Phase rule; Virial equation of state and its application: ideal gas and cubic equation of state.

Module 2 (6 hours)

Second Law of Thermodynamics: Limitations of First law of thermodynamics, second law of Thermodynamics, Kelvin–Planck statement & Clausius Statement, Heat engine and thermal efficiency, Heat pump, Refrigerator, COP, Carnot's cycle, Carnot theorems; Entropy: Clausius theorem & Clausius inequality, Principle of entropy, Entropy changes of an ideal gases, Entropy generation, Entropy balance for open systems, ideal work, and lost work, Sustainability in chemical process industry.

Module 3 (6 hours)

Thermodynamic Properties of Fluids: Residual properties, Two phase systems: Clapeyron equation, Estimation of thermodynamic properties by using graphs and tables;

Vapor-Liquid Equilibria: Nature of equilibrium, phase rule, VLE qualitative behaviour, Simple Models for VLE, VLE by Modified Raoult's law

Module 4 (6 hours)

Solution thermodynamics Theory: Fundamental property relation, Chemical potential and phase equilibria, Partial properties, Ideal gas mixture model, Fugacity, and fugacity coefficient for pure species and in solution, Ideal solution model and excess properties.

Module 5 (4 hours)

Solution thermodynamics Application: Liquid phase properties from VLE data, Models for the excess Gibbs energy, Property changes of mixing.

Text Books

1. J.M. Smith and H.C. Van Ness, Introduction to Chemical Engineering Thermodynamics, McGraw Hill International Ltd,7th Edition, 2009.
2. Y.V.C. Rao, Chemical Engineering Thermodynamics, Universities Press (India) Ltd. Hyderabad.
3. K.V. Narayanan, Chemical Engineering Thermodynamics, Prentice Hall. 2007

Reference Books

B.G. Kyle, Chemical and Process Thermodynamics, Prentice Hall. 1999 Çengel, Y.A., Boles, M.A., Kanoğlu, M., Thermodynamics: An Engineering Approach, McGraw-Hill Education, New York.

Web Links:

https://archive.nptel.ac.in/courses/103/106/103106070/

https://archive.nptel.ac.in/courses/103/101/103101004/

NPT-206 Heat Transfer Operations

L	T	P	C
3	0	0	3

OBJECTIVE: To understand the fundamentals of heat transfer mechanisms in solids and fluids through different modes and their applications in various heat transfer equipment such as heat exchangers and evaporators etc in process industries.

Course outcomes:

CO 1.	Understand different modes of heat transfer and solving steady and unsteady heat conduction problems	Understand Analyze, Evaluate
CO 2.	Apply calculation of heat transfer by free and force convection	Apply, Analyze, Evaluate
CO 3.	Apply mechanism of radiation of heat transfer in systems used in different processing operations including solar radiation	Apply, Evaluate
CO 4.	Understand phase-change phenomena of boiling and condensation	Understand, Analyze, Evaluate
CO 5.	Design of heat exchangers and its various types and applications	Design

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	**PSOs**	
CO1	3	3	2	1	-	-	-	-	-	-	-	2		
CO2	3	3	3	2	-	-	-	-	-	-	-	2		
CO3	3	3	3	3	2			-	-	-	-	2		
CO4	3	3	2	2	1	-	-	-	-	-	-	2		
CO5	3	3	2	2	-	-	-	-	-	-	-	2		
Avg	3	3	2.4	2	1.5	0	0	0	0	0	0	2		

Syllabus:

Module 1 (6 hours)
Introduction to heat transfer and general concepts of heat transfer by conduction, convection and radiation, Types of Insulating materials ,Conduction: Basic concepts of conduction in solids, liquids, gases, steady state temperature fields and one dimensional conduction without heat generation e. g. through plain walls, cylindrical and spherical surfaces, composite layers, insulation thickness, Extended surfaces, fins and their applications. Introduction to unsteady state heat transfer.

MODULE 2 (6 hours)

Convection: Fundamentals of convection, Basic concepts and definitions, natural and forced convection, hydrodynamic and thermal boundary layers, laminar and turbulent heat transfer inside tubes, Dimensional analysis, determination of individual and overall heat transfer coefficients.

MODULE 3 (6 hours)
Radiation: Basic laws of heat transfer by radiation, black body and gray body concepts, view factors, Kirchoff's law, solar radiations, combined heat transfer coefficients by convection and radiation.

MODULE 4 (6 hours)
Heat Transfer by phase change: Condensation of pure vapors, film wise and drop wise condensation, heat transfer in boiling liquids, boiling heat transfer coefficients, Evaporation: Elementary principles, types of evaporators, Single and multiple effect evaporators.

MODULE 5 (6 hours)

Heat exchangers: Types of heat exchangers, Principal components of a concentric tube & shell-and- tube heat exchangers, baffles, heat exchanger with multiple shell and tube passes, log-mean temperature difference, overall heat transfer coefficient, fouling factors, design of double pipe and shell and tube heat exchangers.

Text Books:

1. B. K. Dutta, Heat transfer: principles and applications. PHI Learning Pvt. Ltd., 2000.
2. C.P. Gupta, R. Prakash, Engineering Heat Transfer, Nem Chand & Bros., 2012.
3. D. Q. Kern. Process heat transfer, New York: McGraw-Hill, 1950

Reference books

1. J.P. Holman, Heat transfer. McGraw Hill Higher Education; 2010.
2. Y. A., Cengel and A. J. Ghajar, Heat and Mass Transfer Fundamentals and Applications, McGraw Hill, 5th edition, 2016.

Web Links

https://archive.nptel.ac.in/courses/103/105/103105140/

https://archive.nptel.ac.in/courses/103/101/103101137/

NPT 208: Technology of Inorganic Pigments and Extenders

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 various properties of pigments and extenders and determine them by analytical methods	Understand, Apply
CO2	Study the manufacturing processes of inorganic prime pigments	Understand,
CO3	Prepare extender pigments and study their properties and applications	Apply, Create
CO4	Study the manufacturing processes and determine various properties of white and black pigments	Understand, Apply
CO5	Prepare coloured various inorganic 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: Pigmentary properties

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,

Module-II: Inorganic prime pigments

Definition and classification of pigments. General methods of manufacturing of natural and synthetic inorganic: Mechanical process,precipitation process, calcination process, other methods; pigments size reduction; micronisation, air classification mill, airjet mill and surface treatment of pigments. Manufacturing, applications and merits and demerits of nano pigments,

Module-III: 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.

Module-IV: 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.

Module-V: Colour pigments

Source, manufacture, properties and uses of natural and synthetic iron oxides, lead chromates, silico-chromates and molybdate, chromegreen, chromium oxide, mixed metal pigments, cadmium pigments, prussian and ultramarine blue, mercuric sulphide, cobalt blue, cadmium pigments, synthetic inorganic complexes and mixed pigments e.g. Sprinel pigments etc.

Text Book:

1. Gerhard Pfaf, Inorganic Pigments, ISBN 978-3-11-048450-2, CPI books GmbH, 2017
2. Gunter Buxbaum, Industrial Inorganic Pigments, ISBN 3527288783, 2nd edition, 1998

Reference Book:

1. T.C.Patton, Pigment Hand book Vol. I, II and III.
2. Basics of Paint Technology, Part I & II, by V.C.Malshe&MeenalSikchi.
3. Pigments, dyestuffs and Lakes, part six, Paint Technology Manuals.
4. H.F.Payne, Organic Coating Technology Vol. II.
5. Outlines of Paint Technology by W.M.Morgan.
6. Paints and Surface Coatings byLambourne
7. Technology of Pigments by A.B. Karnik

NPT 210: Pigments and Extenders Lab

L	T	P	C
0	0	4	2

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	Analyze and evaluate various pigments and extenders	Analyze, Evaluate
CO2	Prepare various inorganic prime pigments	Apply, Create
CO3	Prepare extender pigments and study their properties and applications	Apply, Create

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
Avg	3.0	1.67	1.0	1.67	1.33	1.0	1.0	0.67	1.33	0.33	1.67	2.0

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

I.Testing and Evaluation of general properties of pigments and extenders

Texture, colour, Tinting strength, Reducing power, Oil absorption, Daniel flow point, Residue on sieve, Bulking value / Bulking density, Specific gravity, Moisture content, Water-soluble matter, Bleeding.

II.Preparation of pigments

Lemon chrome, Middle chrome, Scarlet chrome, Zinc chrome, Prussian blue, Yellow oxide of Iron, Red oxide of Iron, Chrome green.

III.Preparation of Extenders

Calcium carbonate, Barium sulphate, Silica.

References:

1. B.S. Specification No. 33, 44.
2. AOCS Specifications
3. ASTM Specifications

NPT 301: Technology of Formulation & Manufacture of Coatings

L	T	P	C
3	0	2	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 additives and their application in surface coatings. Formulate coatings for various application	Apply
CO2	Study the principles of coating manufacture and their applications	Apply
CO3	Study various equipment and machinery used in paint manufacture, their selection, calculations involved in efficient operation, economic considerations, etc.	Apply
CO4	Production planning and Factory layout. Safety, health and environment	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

Module-I: Principles of Coating Formulation

Prerequisites, Mathematics & Steps; Pigment Packing Factor, Oil Absorption Value, mechanism, Methods for Determining Oil Absorption, Spatula Rub-Out Method, Gardner–Coleman Method, Useful Equations Based upon CPVC Calculated from Oil Absorption Data PVC, CPVC, LCPVC, RCPC, % Volume solids, Relationship between PVC and physical, permeability and optical film properties, Theoretical Covering Capacity, P/B ratio; Porosity, Typical formulations of dry distempers, cement Paints and skim coats. Typical formulations of solvent base Primers, Undercoats, Intermediate coats and Finish coats (Decorative and Industrial). Typical formulations of water base Primers, Acrylic washable distempers, Plastic emulsion Paints, Texture and Effect- Interiors & Exteriors, Durability of Exterior Paints, Formulation Principles of Industrial coatings

Module-II: Principles of Coating Manufacture

Steps in Paint manufacturing, Phenomenon of Mixing, Soaking, wetting, grinding, dispersion and stabilization. Dispersion processes, Daniel wet & flow point, Composition of grinding vehicle, Classification of grinding equipment, important considerations in pigment dispersion and stabilization. Dispersion for aqueous media, high solids coatings. Mill Base Composition, Rheology of Mill base, Concept of F(PVC), MBC (Mill base concentration), RTM (Ratio of Total Paint volume to Mill base volume), let down vehicle, Let down troubles, Optimum let down conditions, Stabilization of Mill base. Shearing, Smearing, Kneading and Smashing phenomena Dispersion Equipment

Module-III: Heavy Duty Machines and Ball Mills, Attritors, and High-Speed Machines

Heavy duty mixtures, double blade mixers, sigma mixture, Warner & P'flauder 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. Ball and Pebble mills: 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, 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 a& disadvantages of sand mill, Dyno Mill. High speed disc disperser: description; size, positioning & speed of disperser blades, mill base rheology, power input, advantages & limitations of HSSD; Basket Mill, 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.

Module-IV: Production planning, Factory Layout and Safety, Health & Environment

Environment, Safety and Human Health Act (ESHA), Human resource Planning: Importance and processes, Job analysis and Engagements, Training need analysis and Training of staff, Factory lay out: Principles, general considerations, typical flow diagrams, single & multi storied buildings, different sections of a paint factory and their locations, Instrumentation and automation. Safety considerations in storage of hazardous and inflammable raw materials. Fire Protection and safety: Sources, types, Fire & explosion index, safety measures for protection. Health and Hazards: Resources, competence & regulations, systems & tools, HAZOP guidelines, Environment: Eco-friendly, waste minimization & waste disposal, system efficiency, respiratory protective equipments, Toxicity, Mutagenicity and carcinogenic, Heavy metal restriction (Legislation EN 71.3) and compliances. Introduction to Sustainable development goal (SDG), Compliances to Local and International related to plastic, biocides

Module-V: Computers and modeling in paint resin formulating

Introduction to artificial intelligence (AI) and regenerative ChatGPT and its application in Paint Technology, Software algorithems, Information technology and knowledge-based system, Modelling and mathematical techniques, Molecular modeling, Resin formulation and processes, Resin scale-up and manufacture, Polymer properties, curing, and network properties, Solvents and solubility properties, Paint formulation and manufacture, and coating performance, Experimental analysis, design, and quality control

Module-VI : Laboratory Experiments

Preparation of a sample of Dry distemper, Cement Paint, Oxide floor colour. Skim coat (Wall Putty), White Primer (Solvent base), Red oxide Primer, Synthetic Enamel, Air drying cum stoving Enamel, Road Marking Paint, Zinc Rich Primer, N.C. Lacquer, chlorinated rubber paint, Oil bound distempers, Acrylic washable distemper, Interior plastic emulsion paint, Exterior plastic emulsion paint, various types of coatings by vibroshaker, Preparation of surface of wood, glass, concrete, plastic, ferrous metal, non-ferrous metal, previously painted surface, for application of coatings. Application of a sample of coating by brush, spray application.Application of a sample of coating by powder coating plant, electro-deposition method. Characterize the converted coating structure on treated surface by imaging microscope. Spectrophotometeric colour measurement and its sample preparation.

References and suggested readings:

1. Organic Coating Technology, Vol. I & II, By: H.F.Payne
2. Outlines of Paint Technology, By: W.M.Morgan
3. Basics of Paint Technology, Part I & II, by V.C.Malshe&MeenalSikchi
4. Surface Coatings, Volume I & II; by OCCA Australia
5. The chemistry of organic film-formers, by D.H.Solomon, R.E. Krieger Pub.
6. Introduction to paint chemistry; by G.P.A. Turner, Chapman and Hall
7. Paint and surface coating theory and practical II edition R.LamBournee and TA Striven

NPT 303: Technology of Synthetic Resins and Polymers

L	T	P	C
3	1	0	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: Formaldehyde Resins
(a) Phenolic resins : classification, pure & reduced phenolics, types of phenols used, reaction of phenols and formaldehyde, P/ F ratio, phenolic condensate, novolacs and resoles, oil soluble and oil reactive phenolics, heat reactivity of phenolics, resin production, properties and applications of various phenolics, water soluble phenolics.
(b) Amino resins: urea-formaldehyde and melamine-formaldehyde resins, various amines, formulation of methylol products, HMMM, alkylation, curing reaction, manufacture, properties, applications in surface coatings, water soluble and other amino resins

Module-II: Epoxy and Polyamide Resins
(a) Epoxy resins : Chemistry, raw materials, BPA, hydrogenated BPA(Bisphenol A free) epoxies, diepoxide resins, polyepoxide resins (novolac epoxies), manufacture of epoxy resins, epoxy value/epoxide equivalent, hydroxyl value/ equivalent, various curing agents for epoxies, Phr, formulation of two pack systems like solvent based coatings, solventless, high solids coatings, single pack epoxies like epoxy esters, degree of esterification, epoxy phenol novolacs, high functionality poly phenols for high solid coatings, low viscosity resins, UV stable epoxy resins (hydrogenated BPA and hydrogenated di amino di phenyl methane resins), Di cyan di amide (Dicy) curing agents, thermoplastic epoxies, modified epoxy resins and their applications, water borne epoxies, epoxy-amine adducts for use in CED coatings
(b) Polyamide resins: polyamines and acids used, dimerized fatty acids, properties and applications of various polyamides, reactive and non-reactive polyamides

Module-III: Polyurethane Resins
Isocyanate reactions, various isocyanates (Aromatic, Cycloaliphatic & Aliphatic), blocked isocyanates, Isocyanate adducts & polymeric isocyanates (Isocyanurates), polyols, castor oils, catalysts. NCO/ OH ratio, reactions of isocyanate groups, isocyanate hazards, classification of polyurethanes, 1K PUs (Oxygen curable, Water curable, Heat Curable) & 2K PUs (Catalyst curable, Polyol curable), urathane oils and uralkyds, properties and applications of various single and two-pack systems, aqueous PU systems, PUDs, film forming and non-film forming PU resins for flexible packaging, non-isocyanate PU (NIPU) manufacture.

Module-IV: Silicone Resins
Silicate binders (alkali & alkyl silicates), synthesis of silicone resins, silicone oils and greases, structure-property relationship, pure silicones, modified silicones, properties and applications of silicone resins, phenyl, vinyl

silicones for high temperature coatings, RTV silicones for sealants and coatings, reactive silicone intermediates and their modifications.

Module-V: Ethylenic Resins

(a) Vinyl resins: vinyl monomers, types of vinyl resins used in surface coatings, PVC, PVC- PVAc copolymers, vinylidene chloride copolymers, PE-PVAc copolymers, polyvinyl esters, PVA, vinyl acetal resins, properties and uses of individual vinyl resins/ copolymers.

(b) Acrylic resins: acrylic monomers, effect of monomers on polymer & film properties,thermoplastic and thermosetting acrylics, Tg & MFFT , commercial plant for emulsion polymerization, water-borne acrylics, emulsions/ latices, water-reducible TSAs

References and suggested readings

1. Organic Coating Technology, Volume I & II; by Henry Fleming Payne
2. Surface Coatings, Volume I & II; by OCCA Australia
3.Basics of Paint Technology, Part I & II; by V.C.Malshe&MeenalSikchi
4. Outlines of Paint Technology; by W.M.Morgans
5. The chemistry of organic film-formers, by D.H.Solomon, R.E. Krieger Pub.
6. Introduction to paint chemistry; by G.P.A. Turner, Chapman and Hall
7. A Manual for resins for surface coatings; by P.K.T. Oldring
8. AOCS Specification
9. ASTM Specification
10. B.S.Specification

NPT 305: Technology of Paint and Coating Additives

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: General Description of Chemically active additives : Thickeners, Levelling Agents and Coalescing Agents

Definition, Classification According to Function, quantities used., Chemical Composition, Effectiveness; Inorganic Thickeners- Organo-clays, Their production, Influence on various coating properties and Incorporation techniques; Organic Thickeners- Cellulose derivatives, Their chemistry, Addition, Influence, New developments, Toxicology; Thickeners for Solvent Based and Water-Borne Coatings; Levelling Additives- Definition & Measurement of Levelling, Improvement of Levelling, Polymers, Silicones, Fluoro-surfactants, Solvents, Application of Levelling Additives; Coalescing Agents-Polymer Dispersions, Mode of Action, Performance Aspects, Ecology. Economic Significance of Coating Additives, pH Buffers

Unit-2: Surface active additives: Wetting & Dispersing Agents, Defoamers& Antifoams, Adhesion Promoters

Surface Active Agents- Wetting and Dispersing Agents, Chemical Composition, Dispersion Process, Pigment wetting, Stabilization in polar & non-polar media, Polymeric Dispersing Agents, Degree of Dispersion & Flocculation; Defoamers& Antifoams- Theory of Foam Formation, Causes of Foam Stabilization, Factors Affecting Foam in Coatings, Foam Inhibiting Agents, Antifoam Selection, Empirical selection, Test Methods for the Evaluation of Defoamers; Adhesion Promoters- Definition, Organo-functional Silanes, Organometallic Compounds, Chlorinated Polyolefins, Special Condensates, Phosphates, Silicones & Silicone Modified Polymers; Additives to improve substrate wetting, Measurement of Surface Tension, Chemistry & Usage of Silicone Additives, Anti-Float Agents; Mar and Slip Aids; Waxes and Surfactants, Wet-Edge Additives; Base-Tintercompatiblizers

Unit-3: Special active additives: Biocides: antialgaecides, fungicides, antifouling, antiviral, antibacterial, antiseptic

Biocides- Retrospective of Biocide Development, Plant Hygiene, Factors influencing Microbial growth, Microbiology of Coating Compositions, Characteristics of Bacteria & Fungi, Enzyme production and effect of biocidal effect, In-can Preservation, In-film Preservatives, Selection of a Biocide; Solubility, leaching, Compatibility, Volatility. Various national and international statutory compliances related to use of biocide. Freeze-Thaw Stabilizers, Sequestering agents

Unit-4: Catalytic active additives: Heat &Light Stabilizers, corrosion Inhibitors, Driers, and Additives for Special Function

Heat & Light Stabilizers- Photo-oxidation of polymers, Stabilization possibilities, UV Absorbers, Hindered Amine Light Stabilizers (HALS), Corrosion Inhibitors-Corrosion Mechanism, Electrical studies, Inhibition mechanism, Types & Properties of Inhibitors

Driers- Composition, metal carboxylates, Manufacturing (Precipitation, Fusion, Direct Metal reaction, double decomposition), Drier metals, Active, Auxiliary and Combination of driers

Unit-5: Surfactants- Theory, Properties & Types

Surfactants- Theory of surface action, effect and behavior of surface active agents on different interfaces, Bulk properties of surfactant solutions, micelle properties, foaming, wetting, emulsification, dispersion, and detergency; measurement of critical micelle concentration; Anionic Surfactants- Soaps and other Carboxylates, Sulfonation and Sulfation, Sulfates, Sulfonates, Nonionic Surfactants- Types, Ethoxylated Alcohols and Alkylphenols, Cationic Surfactants- Linear Alkyl-amines and Alkyl-ammoniums, Amphoteric Surfactants, Silicon Surfactants, Fluorinated Surfactants, Polymeric Surfactants.

Reference books:

1. Handbook of Coating Additives by Leonard J Calbo
2. Additives for Coatings by Johan Bieleman
3. Chemistry and Technology of Polymer Additives by Al-Malaika
4. Additives in Water-borne Coatings by Gerry Davison and Bruce Lane
5. Surfactants: Types and Uses by Jean-Louis Salager
6. Surfactant Science and Technology by Drew Myers

NPT-307 Mass Transfer Operations

L	T	P	C
3	0	0	3

Course Objectives: The Mass Transfer Operations course aims to provide students with an understanding of the principles, processes, and equipment involved in mass transfer operations. Upon completion of the course, students should be able to:

1. Understand the fundamental principles of mass transfer, including diffusion, convection, and mass transfer coefficients.
2. Analyze mass transfer processes in various unit operations such as distillation, absorption, extraction, and drying.
3. Design and optimize mass transfer equipment such as packed and trayed columns, liquid-liquid extraction units, and drying equipment.
4. Apply mathematical models and simulations to predict and optimize mass transfer processes, including heat and mass transfer coefficients, mass transfer rates, and system performance.

Course outcomes:

CO 1	Understand the basic principles and laws of mass transfer, Calculation of rate of mass transfer	Understand & Evaluate
CO 2	Analyze the mass transfer concepts and apply them for Absorption and Distillation processes to evaluate different process parameters	Analyze, Apply & Evaluate
CO 3	Analyze the mass transfer concepts and apply them for LLE and SLE processes to evaluate different process parameters	Analyze, Apply & Evaluate
CO 4	Analyze the mass transfer concepts and apply them for Humidification and Drying processes to evaluate different process parameters	Analyze, Apply & Evaluate
CO 5	Analyze the mass transfer concepts and apply them for Adsoption, Membrane separation and Crystallization processes to evaluate different process parameters	Analyze, Apply & Evaluate

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	**PSOs**	
CO1	3	2	2	1	-	-	-	-	-	1		1		
CO2	3	2	1	1	-	-	-	-	-	1		1		
CO3	3	2	3	2	3	-	-	-	-	1		1		
CO4	3	3	2	2	3	-	-	-	-	1		1		
CO5	3	3	3	3	2	-	-	-	-	1		1		
Avg	3	2.4	2.2	1.8	2.7	0	0	0	0	1	0	1		

SYLLABUS

Module I (6 hours)

Concept of Mass Transfer, Diffusion: Steady-state molecular diffusion: Fick's law of diffusion; Equimolar counter diffusion; Stagnant film diffusion, Diffusion coefficients: Film theory; Penetration theory; surface-renewal theory; film-penetration theory, Two-film theory. Concept of interphase /mass transfer, Analogies in mass transfer.

Module II (6 hours)

Absorption and Stripping: Gas-liquid equilibrium, Henry's law, Selection of solvent,calculation of number of stages and Equipments used in Absorption and Stripping

Distillation: Equilibrium diagrams for ideal and non-ideal solutions; Relative volatility, Flash Distillation-

Differential distillation, McCabe Thiele method, for determining number of stages & Equipments for Distillation

Module III (6 hours)

Liquid-Liquid Extraction(LLE): Applications; Ternary liquid-liquid equilibria; Triangular graphical representation; solution of single and multistage operation. Solid-Liquid Extraction: Applications; Solid-liquid equilibrium; Equipments used for single stage and multistage continuous operations in LLE & Leaching

Module IV (6 hours)

Humidification and Dehumidification: Vapor pressure temperature curve and Fundamental concepts Drying: Solid-gas equilibrium, Definitions of moisture contents, Different modes of drying operations, Rate and mechanism of batch drying, Time of drying, Classification of Cooling Towers and Dryers

Module V (6 hours)

Adsorption: Concept and application of adsorption, Nature of adsorbents; Adsorption isotherms and adsorption hysteresis; Number of Stages and Equipment used in adsorption. Introduction to membrane separation processes, Introduction to Carbon Capture Technology, Crystallization: Concept and laws; Supersaturation, Nucleation & Crystal growth; Types of crystallization; Equipments used for crystallization.

Text Books

1. R.E. Treybal, "Mass Transfer Operations", 3rd ed. New York: McGraw-Hill, 2017.

2. B. K. Dutta, "Principles of Mass Transfer and Separation Processes", 8th Printing, PHI Learning Private Limited, 2015

3. W. L. McCabe, J. C. Smith, P. Harriott, "Unit Operations of Chemical Engineering", McGraw-Hill, VII International edition, 2005.

Reference Books

1. T. K., Sherwood, R. L. Pigford, and C.R. Wilke, "Mass Transfer" McGraw Hill, 1975.
2. C.J. Geankoplis, "Transport Processes and Separation Process Principles", 4th ed., PHI Learning Private Limited, New Delhi, 2012.
3. J.D. Seader, and E.J., Henley, "Separation Process Principles", 2nd ed., Wiley India Pvt. Ltd., New Delhi, 2013.
4. S. Foust, "Principles of Unit Operations", 2nd Ed., Wiley, 1980.
5. P.C., Wankat "Separation Process Engineering", Prentice Hall, III edition, 2011.

Web-Links

https://archive.nptel.ac.in/courses/103/103/103103145/

https://archive.nptel.ac.in/courses/103/103/103103154/

NPT-309 Chemical Reaction Engineering

L	T	P	C
3	0	0	3

Course Objective: To apply knowledge from calculus, differential equations, thermodynamics, general chemistry, and material and energy balances to solve reactor design problems, To examine reaction rate data to determine rate laws, andto use them to design chemical reactors, To simulate several types of reactors in order to choose the most appropriate reactor for a given need, To design chemical reactors with associated cooling/heating equipment.

Course Outcomes:

CO 1	To develop an understanding of the basic concepts involved in using reaction rate equations and kinetic constants	Understand, Apply
CO 2	To Perform derivations of rate equations for non-elementary reactions both in homogenous and in heterogeneous reacting systems	Apply
CO 3	To understand the role of temperature and concentration in the rate equation	Understand
CO 4	To Perform constant volume batch reactor calculations	Apply
CO 5	To Develop calculations using the integral method and applying differential method of analysis using reactions with different orders	Understand, Apply

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	**PSOs**	
CO1	3	2	3	-	-	-	-	-	-	1	-	1		
CO2	3	3	3	1	-	-	-	-	-	1	-	1		
CO3	3	3	3	2	-	-	-	-	-	1	-	2		
CO4	3	3	1	-	2	-	-	-	-	1	-	2		
CO5	3	3	2	2	2	-	-	-	-	1	-	2		
Avg.	3	2.8	2.4	1.7	2	0	0	0	0	1	0	1.6		

SYLLABUS

Module I (6 hours)

Rate of Reaction, Elementary and non-elementary homogeneous reactions, Molecularity and order of reaction, Introduction of Arrhenius, collision, and transition theories. Integral and differential methods for analyzing kinetic data, interpretation of constant volume reactor, zero, first, and second, half-life period, irreversible reaction in series, auto catalytic reaction, reversible reactions.

Module II (6 hours)

Interpretation of variable volume batch reactions for zero, first and second order reactions, Space-time and state-velocity, design equation for ideal batch, steady-state continuous stirred tank, steady-state plug flow reactors for isothermal reaction.

Module III (6 hours)

Design for single reactions, Size comparison of single reactors, Multiple reactor systems, plug flow/mixed flow reactors inseries and parallel, reactors of different types in series, recycle reactor, autocatalytic reactions.

Module IV (6 hours)

Introduction to multiple reactions, yield, selectivity, qualitative discussion about product distribution, optimum temperature progression. Introduction of heterogeneous catalyst preparation and kinetics. kinetics of enzyme

reactions (Michaelis-Menten and Monod models).

Module V (6 hours)

Residence time distribution of fluids in vessels, State of aggregation of the flowing systems, Earliness of mixing, Role of RTD, State of Aggregation and earliness of mixing in determining reactor behavior, E, F and C curves, Conversion in Non-ideal flow reactors.

Text Book:

1. Levenspiel, O., "Chemical Reaction Engineering", 3rd edition, John Wiley 2006.

Reference Books

1. H. Scott Folger, "Elements of Chemical Reaction Engineering" 6th Edition, Prentice Hall, 2021.
2. J. M. Smith., "Chemical Engineering Kinetics", 3rd Edition, McGraw-Hill chemical engineering series, 1981.

Web Links

https://archive.nptel.ac.in/courses/103/103/103103153/

https://archive.nptel.ac.in/courses/103/101/103101141/

NPT 311: Technology of Synthetic Resins and Polymers Lab

L	T	P	C
0	0	6	3

OBJECTIVE: The objective of this course is to enable the students understand:
The concept of resin and polymer manufacturing technique and enable to synthesise the same in laboratory.

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

CO1	Preparation of polyester, alkyd and water soluble alkyd	Create, Analyze
CO2	Preparation of Phenolic, MF and UF resins	Create, Analyze
CO3	Preparation of Epoxy, epoxy ester and water soluble epoxy	Create, Analyze
CO4	Preparation of acrylics and its emulsion, PU and PUD	Create, Analyze
CO5	Preparation of homopolymer and copolymers.	Create, Analyze

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	-	1	-	2	2	2	3
CO1	3	3	2	2	2	-	1	-	2	2	2	3
CO1	3	3	2	2	2	-	1	-	2	2	2	3
CO1	3	3	2	2	2	-	1	-	2	2	2	3
CO1	3	3	2	2	2	-	1	-	2	2	2	3
Avg	3.0	3.0	2.0	2.0	2.0	0.00	1.0	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 "-"*

Experiments

1. Preparation of alkyds (solvent and water based) and testing them for their acid value, colour, drying time and film properties.
2. Preparation of alcohol and oil soluble phenolic resins and their testing.
3. Preparation of butylated and Methylated UF and MF resins and their testing
4. Preparation of epoxy resins and epoxy esters and their characterization.
5. Preparation of saturated and unsaturated Polyester resins
6. Preparation of acrylic resins (TPA, TSA)
7. Preparation of polyurethane resins – Urethane oils & Uralkyds
8. Preparation and Testing of Water Soluble Alkyds
9. Preparation and Testing of Water Soluble Epoxies
10. Preparation of Oil-in-Water & Water-in-Oil Type Emulsions
11. Preparation of Water Reducible & water Dispersible Media
12. Preparation and Testing of Emulsions from Acrylics/ Vinyl resins
13. Preparation and Testing of Homopolymers and Copolymers by Emulsion Polymerisation

References:

1. BIS Specifications
2. AOCS Specification
3. ASTM Specification
4. B.S.Specification

NHS 351: Entrepreneurship

Course Outcomes (COs)

L	T	P	C
2	0	0	2

1. Develop understanding of basics of entrepreneurship.
2. Apply the beginner's concept, ownership and various forms
3. Identify opportunities using identification; project conceptualisation, formulation & evaluation.
4. Learn , apply and evaluate the project financing and working capital management
5. Evaluate the role of Institution support and policy framework of Government for entrepreneurship development in India.

CO-PO Mapping

Co/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	0	0	0	0	0	0	1	1	0	0	1	2
CO2	0	0	0	0	0	0	1	1	0	0	2	2
CO3	0	0	0	0	0	0	1	1	0	0	3	2
CO4	0	0	0	0	0	0	1	1	0	0	3	2
CO5	0	0	0	0	0	0	1	1	0	0	3	2

UNIT I Entrepreneurship:
Entrepreneur and manager, Growth of entrepreneurship in India, Government's policy actions towards entrepreneurial motivation, entrepreneurship development programmes.

UNIT II Business Enterprises and Ownership Structure:
Small scale, medium scale and large scale enterprises, role of small enterprises in economic development; proprietorship, partnership, companies and co-operatives firms: their formation,

UNIT III Project Management:
Identification and selection of projects; project report: contents and formulation, project evaluation,method

UNIT IV Project Financing and Working Capital Management:
Cost of Project, Capital Structure Planning, Sources of long term financing, Working Capital Management

UNIT V Institutional Support and Policies:
Institutional support towards the development of entrepreneurship in India: technical consultancy organizations (TCOs), government policies for small scale enterprises.

Text Books:

1. **Khanka, S S**. 'Entrepreneurial Development', S Chand & Company Ltd. New Delhi
2. **Desai, Vasant**, ' Project Management and Entrepreneurship', Himalayan Publishing House, Mumbai, 2002.

Additional Reference Books

1. **Gupta and Srinivasan**, 'Entrepreneurial Development', S Chand & Sons, New Delhi.
2. **Ram Chandran**, 'Entrepreneurial Development', Tata McGraw Hill, New Delhi
3. **Saini, J. S**. 'Entrepreneurial Development Programmes and Practices', Deep & Deep Publications (P), Ltd
4. **Holt, Davis, '**Entrepreneurship : New Venture Creations, PHI

NPT -302 Instrumentation & Process Control

L	T	P	C
3	0	2	4

OBJECTIVE: Objective is to introduce the fundamentals of process control, controllers, stability and frequency response along with different process instruments used in chemical industries. The course will teach the students, how to obtain dynamic response of closed loop systems, stability analysis in transient and frequency domains. The course will also introduce about the instruments used for measurement of temperature, pressure, flow, level, viscosity.

CO1	Introduction to process control and controllers along with open and closed loop systems	Understand, Apply
CO2	Transient response of simple control systems	Apply, Evaluate, analyze
CO3	Concept of stability and frequency response, control system design by frequency response	Analyze, Evaluate, Design
CO4	Understand the principles involved in measurements. knowledge on different measurement methods employed in industrial process units	Understand, Apply, Evaluate, analyze
CO5	Application of different measurement devices in Chemical allied industries	Apply, evaluate , analyze
CO6	Conduct various experiments to apply the concepts of fluid mechanics and unit operations.	Apply, Evaluate , analyze

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

SYLLABUS

Module 1 (6 hours)

Introduction to Process control systems, Use of Laplace & Inverse Laplace Transformation in study of Process Dynamics & Control. Dynamic Modeling of a Process, Dynamic behavior of First order system. First order systems in series, Second and higher order systems for various kind of inputs, Linearization of nonlinear systems, Transportation & Transfer Lag.

Module 2 (6 hours)

Classification of control systems, Regulator & Servo control, Feed Forward & Feed backward control, Negative & Positive Feedback Control, Controllers & Final control Elements, Reduction of Block & Signal Flow Diagrams, P, PI, PD and PID controller, Response of control system with these controllers

Module 3 (6 hours)

Concept of stability, Stability Criterion, Routh test for stability, Introduction to frequency response, Introduction to control system design by frequency response (Bode Plot, Zeigler Nichols controller settings), Introduction to Controller Tuning.

Module 4 (6 hours)

Principles of measurements and classification of process control instruments, Functional elements of an instrument, Static & Dynamic Characteristics of instruments, Transducers, Error analysis, Measurement of temperature: expansion thermometers, Resistance Thermometers, thermocouples, Thermistors, Pyrometers.

Module 5 (6 hours)

Flow measurement instruments, Concentration Measuring Instruments, Level measurement; float types-hydrostatic types, thermal effect types, electrical methods and solid level measurement. Pressure Measurement: Manometers, measurement of vacuum.

List of Experiment

1. To calibrate and study the response of bimetallic thermometer.

2. To study the response of a liquid level tank system.

3. To calibrate the P/I converter.

4. To calibrate the given manometer for level measurement.

5. To study and calibrate diaphragm control valve.

7. To study the response of first order system in series using two tank liquid level system (Non-interacting system) to step input.

8. To study the response of first order system in series using two tank liquid level system (interacting system).

9. To calibrate a thermocouple using a glass bulb thermometer.

10. To assess the accuracy of a pressure gauge with a dead weight gauge tester.

Text Books

1. Coughnour and Koppel, "Process Systems Analysis and Control", McGraw-Hill, New York, 3rd Edition, 2017.

2. George Stephanopolous, "Chemical Process Control ", Prentice-Hall of India Pvt-Ltd., New Delhi, 2015.

3 Eckman, D.P., “Industrial Instrumentation”, Wiley Eastern Ltd., New York, 1990

Reference Books:

1. Singh, S. K. , “Industrial Instrumentation and Control” , Prentice Hall of India, 2016

Web Links:

https://archive.nptel.ac.in/courses/103/105/103105064/

https://archive.nptel.ac.in/courses/103/105/103105130/

NPT 304: Technology of Surface Preparation, Treatments and Coating Applications

L	T	P	C
3	0	2	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 ofpreparingsurfaces for painting	Understand
CO2	Apply the knowledge of pretreatment methods to ferrous and non-ferrous substrates	Apply
CO3	Learn aboutvariousmethods 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

Module-I : Objective , methods and equipments of surface preparation

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

Module-II : 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, tricationic treatment, Nano technology in surface treatment, eco-friendly in-situ phosphating, chromate conversion coating: classification, coating process; rinsing, accelerator, and passivation.

Module-III : Coating application and electro-deposition

Coating application: brush, roller, curtain, dip, flow, silk screen, knife coating, calendar coating, powder coating application, coil coating application ,spray application: conventional air spray, airless spray, hvlp spray, dual-feed spray, electrostatic spray, bell application, robot painting, transfer efficiency, overspray disposals. electro-deposition: 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. Diamond like coating (DLC).
Paint circulation systems (need, flow diagram, air velocity & balance, dust level, filter pressure drop) spray booth management

Module-IV : Curing of film, effluent treatment, waste management

a) Curing of wet film. Spray booth (preparation zone, spray zone, flash-off zone), paint circulation systems(need, flow diagram, construction of paint containers, filters, pressure gauges & regulators, pumps, pipelines & insulations, CCV, flushing line, air supply & exhaust systems), promix (definition, need,

construction & working principle, paint-hardener ratio, promix calibration), air handling units (definition, importance, construction & working principle, flow diagram., humidifier, filtration system, eliminator, plennum, dampers), ovens (types, zones & temperature curves), conveyors (need, types, I beam type, enclosed tack, floor conveyor, selection of conveyor, elements of conveyor, lubrication unit, drive unit, safety mechanism, tension take up unit, anti-back mechanism, drive synchronization, point load conveyor pitch), jigs & trollys (guidelines for jig designing & its construction, importance of jig maintenance jig utilization) water in pretreatment shop: control of quality, economy, (DM/ RO plants)

b) Effluent treatment & waste disposal, ETP – Primary , secondary and tertiary treatments

Module-V : Paintshop services, paint defect and paint remover

Paint shop troubles inspection and services. Paint and coating defects: Stages of defects: During manufacturing, during storage, during application, during service life. Paint classification, causes & remedies, paint and varnish removers: solvent & chemical paint removers, mechanism, methods.

Module-VI: Laboratory experiments

Preparation of surfaces of wood, glass, concrete, plastic (adhesion promoter), ferrous , non- ferrous for application of coatings. Preparation of previously painted surfaces for the application of coatings. Application of coating by brush, spray application. Application of coating by powder coating plant and by electro-deposition apparatus. Characterization of converted coating structure on treated surface by imaging microscope.

References :

1. Good painting practices vol. 1 by Joseph Bigos
2. Surface Coatings, Vol. I & II; by: OCCA, Australia
3. Outlines of Paint Technology; by: W.M.Morgan
4. Surface Coating Technology,; by: Swaraj Paul
5. Basics of Paint Technology (Part II); by: Malshe&Sikchi
6. Phosphating of metals by Warner Rausch
7. Paint Film defects by Hess's
8. Blasting Technology by Momber

NPT 306: Characterizations, Analysis and Evaluation of Coatings

L	T	P	C
3	0	0	3

OBJECTIVE: The objective of this course is to enable the students
To understand various coating properties and their evaluation
To understand to analyze the paints.
To understand the mechanical properties of a coating
To test the ageing properties of a coating

Course Outcome

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

CO1	Analyze the surface coatings and evaluate the raw materials used	Apply
CO2	Determine optical properties of surface coatings by various methods of analysis	Apply
CO3	Apply the quality assurance procedures. Test the liquid paints for various characteristics	Apply
CO4	Test various physical, chemical and mechanical properties of surface coatings	Apply
CO5	Test weathering and ageing properties of surface coatings	Apply

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

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

SYLLABUS

Module-I: Classification of coating properties and their analysis

Classification of coating properties: Properties and evaluation of raw materials used in coating formulations. Pigment content, binder or solid vehicle content (% NV), volume solid %, water content, ash content, pigment, binder and solvent analysis.Description of Adhesion and cohesion properties, factors affecting wetting power and adhesion.

Module-II: Optical Properties of paint films and complete application in colour development

a) Optical properties; colour, gloss, haze and clarity, orange peel, DOI (Distinctiveness of Image), transparency, hiding power, opacity

b) Algorithm of Kubelka-munk equation etc, Shade matching, spectrophotometry,

Module-III: Quality control

a) Quality control and quality assurance procedures, standard specifications and test methods (BIS, ASTM, ISO, BS, DIN etc.) concept of quality circle, six sigma methodology. Test of liquid paints, density, fineness of grind, viscosity, consistency, application of films, spreading capacity, wet opacity, dry hiding, spreading time, drying time, wet and dry film thickness, etc.

b) Characterization of polymer for molecular weight and molecular weight distribution. (Mw, Mn, Mz, definitions and significance with coating performance properties, flow properties of solutions)

c) in-can preservation and dry film preservation assessment

Module-IV: Physical, Chemical and Mechanical Properties of paint films

Newtonian and non-Newtonian flow behaviours, factors affecting viscosity and influence on rheological behavior. Testing methods for adhesion, flexibility, impact resistance, hardness, mar resistance, abrasion resistance, tensile strength, slip resistance and stress phenomenon in organic coatings. water and moisture resistance; water vapour transmission, PAC and salt spray test, chemical resistance of coatings, resistance to heat and fire, air permeability etc. Electrical resistance properties-conductivity, dielectric constant etc.

Specific product testing viz. traffic paints, can & coil coatings, automotive paints, pipeline coatings, marine coatings, aircraft coatings, radiation resistant coatings etc.

Module-V: Lightfastness and Weatherfastness of paint films

Lightfastness (1-8 scale bluewool scale), Weatherfastness (1-5 bluewool scale,)
Natural & accelerated outdoor weathering tests, weather-o-meter (QUV and Atlas weather-o-meter and their correlation with real life situation), defects observed in paint film on exposure & its evaluation, evaluation of water based paints, Exterior test protocol, hygiene surfaces, biological effects on water based paint films.

References and suggested readings:

1.Organic Coating Technology, Vol, I & II by H.F. Payne
2.Surface Coatings, Vol, I & II by OCCA, Australia
3.Outlines of Paint Technology by W. M. Morgan
4.Testing of Organic Coatings by Norman I. Gaynes
5.Paint& Coating Testing Manual, Gardener-Sward Handbook),15th Edition, ASTM International.
6.Organic Coatings Analysis by Konstandt
7. Organic Coatings, Science and Technology: By Frank N. Jones, Nichols & Pappas,4th Edition, Wiley
8.Specifications BIS, ISO, BS etc.
9.BIS Specifications IS:33-.1992, IS:74.1979, IS:101.1964

NPT 308: Technology of Printing Inks and Coatings

L	T	P	C
3	0	0	3

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
Nature of printing inks, nature of print, methods of drying of printing inks, classification of printing inks. Printing processes-impact type: offset lithographic process, flexographic process, gravure process, letterpress process, screen printing process, intaglio printing process. Printing processes non-impact type: inkjet printing, continuous and drop on demand type, toner printing systems. Pad printing process, flex and vinyl inks, digital inks. Special inks; UV curing inks (flexo, screen and offset), plastisol inks, sublimation inks, MICR inks, fugitive inks and security inks. Print recognition, substrate selection and need for communication.

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, pre-polymers, reactive diluents, photo-initiators, additives and inhibitors).

Module-III:Letterpress, Lithographic and Web offset inks
Letterpress inks: general characteristics, types of presses, letterpress ink formulation, inks for packaging, ink-related problems and their possible solution, lithographic inks: general characteristics, offset ink formulations, inks for packaging, ink-related problems and their possible solution, web-offset inks for paper and board. Metal decorating inks, dry offset inks, formulating principles of two-piece can decoration inks, multi-colour process printing and hexachrome inks.

Module-IV:Gravure, Flexographic, Screen, and Specialty 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, flexible packaging inks for different applications. Screen inks, general characteristics, screen inks for paper, plastics, textile, leather, wood, glass etc. Daylight fluorescent inks, specialty screen inks, inks for the electronics industry, ultra-violet and electron-beam curing inks

Module-V:Ink Manufacturing and Testing
Manufacture of inks, mixing and milling equipment, handling storage and manufacture of UV inks, modern production trends and innovations in printing inks, edible and soluble packaging inks, rheology of printing inks. Testing, quality control and analysis of printing inks. Health, safety and the environment,

References:

1. Printing Ink Manual, by R. H. Leach & R. J. Pierce
2. Ink Technology for Students & Printers; by E.A. Apps
3. Water based inks by Lad

NPT 310: Characterization, Analysis, and Evaluation of Coatings Lab

L	T	P	C
0	0	6	3

OBJECTIVE: The objective of this course is to enable the students
To understand testing methods and analysis of physical, optical, mechanical, chemical and electrical properties of surface coatings as per IS, BS and ASTM specifications

Course Outcome

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

CO1	Analyze the surface coatings and evaluate their physical properties as per IS, BS and ASTM specifications	Analyze, Evaluate
CO2	Analyze the surface coatings and evaluate their optical properties as per IS, BS and ASTM specifications	Analyze, Evaluate
CO3	Analyze the surface coatings and evaluate their mechanical properties as per IS, BS and ASTM specifications	Analyze, Evaluate
CO4	Analyze the surface coatings and evaluate their chemical properties as per IS, BS and ASTM specifications	Analyze, Evaluate
CO5	Analyze the surface coatings and evaluate their electrical properties as per IS, BS and ASTM specifications	Analyze, Evaluate

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

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

Experiments:

Evaluation of Physical Properties of Paints / Varnishes and Lacquers

1. Weight / litre of paint
2. Non-volatile matter
3. Fineness of grind by Hegman Gauge
4. Viscosity by Brookfield & Bubble Tube Viscometer
5. Application of films by Automatic Film Applicator and Bar Applicator
6. Determination of Wet Film and Dry Film Thickness
7. Drying Time

Evaluation of Optical Properties of Coating Films

8. Wet Opacity by Pfund Cryptometer
9. Gloss by Digital Gloss-o-meter
10. Color by Color Matching Cabinet

Evaluation of Mechanical Properties of Coating Films

11. Pencil Hardness by Pencil Hardness Tester
12. Adhesion by Pull off Adhesion Tester
13. Adhesion by Cross Cut Adhesion Tester
14. Flexibility by Conical & Cylindrical Mandrel Tester
15. Impact Resistance by Tubular Impact Tester
16. Abrasion Resistance by Wet Abrasion Tester & Taber Abrasion Tester

Evaluation of Chemical Resistance Properties of Coating Films

17. Salt Spray Test using Salt Spray Cabinet
18. Corrosion Resistance by Digital Corrosion Cabinet
19. Exterior Durability by Accelerated UV Weathering Cabinet

Evaluation of Electrical Properties of Coating Films

20. Electrical resistivity /conductivity of paint film

Paint Analysis Includes analysis of pigments content, binder content and volatile content.

References:

1. BIS Specifications IS 101.1964.
2. AOCS Specifications
3. Paint & Coating Testing Manual, Gardener-Sward Handbook),15th Edition, ASTM International.
4. B.S. Specifications

NPT-322 Process Equipment Design

L T P C
3 0 0 3

OBJECTIVE: The objective of this course is to acquire basic understanding of design parameters, complete knowledge of configuration and design procedures for commonly used process equipment in important operations.

Course Outcomes:

CO1	Understand the basics of process equipment design and important parameters of equipment design	Understand, Apply
CO2	Design internal pressure vessels and external pressure vessels.	Evaluate , Apply
CO3	Analyze, synthesize and design processes for process heat exchangers.	Understand, Apply, Evaluate
CO4	Integrate and apply techniques and knowledge acquired to design distillation	Analyze, Apply, Evaluate
CO5	Design of storage tanks, other important equipments : evaporator	Analyze, Apply, Evaluate

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	-	3	-	-	1	1	-	2
CO2	3	3	3	2	3	3	-	-	1	-	-	2
CO3	3	3	3	2	3	1	-	-	1	-	-	3
CO4	3	3	3	2	3	1	-	-	1	-	-	3
CO5	3	3	3	2	3	1	-	-	1	-	-	3
Avg	3	2.8	2.8	1.8	3	1.8	0	0	1	1	0	2.6

Syllabus

Module-I:

Introduction to Equipment Design Introduction: Classification of engineering materials, engineering properties of Ferrous metals, Non ferrous metals, alloys & Ceramic materials Structure-Property relationship in materials. Deformation of Materials Fracture: Elastic deformation, Plastic deformation, Creep. Corrosion And Prevention: Direct Corrosion, electro-chemical corrosion, Galvanic cells, High temperature corrosion, Passivity, factor influencing corrosion rate, Control and of corrosion-modification of corrosive environment, Inhibitors, Cathodic protection, protective coatings. Corrosion charts, Metal forming & Metal joining techniques – Different types

Module-II:

Type of pressure vessels, Thin cylinder theory for internal pressure. Code & standard for pressure vessels (IS:2825: 1969), Design considerations, classification of pressure vessels as per codes, design of cylindrical and spherical shells under internal and external pressure, selection and design of heads such for pressure vessel.

Module-III

Introduction, Basic design procedure and theory, Heat exchanger analysis: the effectiveness NTU method, Overall heat-transfer coefficient, Fouling factors (dirt factors), Shell and tube exchangers: construction details, Tubes, Shells, Tubesheet layout (tube count), Shell types (passes), Shell and tube designation, Baffles, Support

plates and tie rods, Tube sheets (plates), Shell and header nozzles (branches), Design methods, Kern's method, Bell's method, Shell and bundle geometry, Effect of fouling on pressure drop, Pressure-drop limitations.

Module-IV

Design methods for binary distillation systems, Basic equations, McCabe-Thiele method, The Smoker equations, Batch distillation, Steam distillation, Plate efficiency, Prediction of plate efficiency. Approximate column sizing, Plate contactors, Selection of plate type, Plate-design procedure.

Module-V

Storage Tanks: Introduction and Classification of storage tanks; Design of storage tanks and few other important equipments: Evaporator, Dryer, Centrifuge etc

Text Books

1. L. E. Brownell and E. H. Young, "Process Equipment Design", Wiley, 2004.
2. B. C., Bhattacharya "Introduction of Chemical Equipment Design", CBS Publishers, 2003.
3. D.Q., Kern, Process Heat Transfer, International Student Edition, McGraw Hill, 2002.
4. R.E. Treybal, "Mass Transfer Operations", 3rd ed. New York: McGraw-Hill, 2017.

Reference Books

1.M.V. Joshi "Process Equipment Design 2/e", Macmillan India, 1981(reprint 1985).
2. E. E. Ludwig, "Applied Process Design for Chemical and Petrochemical Plants", Vol. 2, 3rd Ed., Gulf Publishers. 1997

Web Links:

https://archive.nptel.ac.in/courses/103/107/103107207/
https://archive.nptel.ac.in/courses/103/105/103105210/

NPT-324 Process Modeling and Simulation

L	T	P	C
3	0	0	3

OBJECTIVE:

This course explores the basic concepts and steady state equations of simple systems in chemical process industries. It deals with the techniques for derivation of system model equations, data analysis and visualization. The course aims to present the basic idea and concept on process model with detailed analysis and solution of model equations for steady operation.

Course Outcomes:

CO1	Understand create and analyze the conservation principles, classification of models and numerical methods	Understand, & Analyze
CO2	Understand, analyze & evaluate the degree of freedom, system design variables, and flow of information in system	Understand, Analyze & evaluate
CO3	Apply the concepts to analyze and create models giving rise to nonlinear algebraic equation (NAE) systems based upon input and output data.	Apply, Analyze & Design
CO4	Apply the concepts to analyze and create models giving rise to Differential Algebraic Equations (DAEs) & Partial Differential Equations (PDEs) systems based upon input and output data.	Apply, Analyze,Evaluate, Design
CO5	Develop simulation approaches based on the concepts to solve the model equations (ANE, DAE & PDEs)	Apply, Analyze,Evaluate

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	**PSOs**	
CO1	3	3	3	3	2	-	-	1	-	1	1	2		
CO2	3	3	3	3	3	-	-	1	-	1	1	2		
CO3	3	3	3	2	3	-	-	1	-	1	1	2		
CO4	3	3	3	2	2	-	-	1	-	1	1	2		
CO5	3	3	3	3	3	-	-	1	-	1	2	3		
Avg	3	3	3	2.6	2.6	-	-	1	-	1	1.2	2.2		

Syllabus

Module I (6 hours)

Introduction to mathematical modeling; Advantages and limitations of models and applications of process models of stand-alone unit operations and unit processes; Classification of models: Linear vs. Non-linear, Lumped parameter vs. Distributed parameter; Static vs. Dynamic, Continuous vs. Discrete; Numerical Methods: Iterative convergence methods, Numerical integration of ODE- IVP and ODE-BVP.

Module II (6 hours)

Concept of degree of freedom analysis: System and its subsystem, System interaction, Degree of freedom in a system e.g. Heat exchanger, Equilibrium still, Reversal of information flow, Design variable selection algorithm, Information flow through subsystems, Structural effects of design variable selection, Persistent Recycle.

Module III (6 hours)

Simple examples of process models; Models giving rise to nonlinear algebraic equation (NAE) systems, steady state models of flash vessels, equilibrium staged processes distillation columns, absorbers, strippers, CSTR, heat exchangers, etc. Review of solution strategies for nonlinear algebraic equation (NAE).

Module IV (6 hours)

Steady state models giving rise to differential algebraic equation (DAE) systems; Rate based approaches for staged processes; Modeling of differential contactors-distributed parameter models of packed bed; Packed bed reactors; Modeling of reactive separation processes; Review of solution strategies for Differential Algebraic Equations (DAEs) & Partial Differential Equations (PDEs).

Module V (6 hours)

Simulation and their approaches, Modular, Sequential, Simultaneous and Equation solving approach, Simulation software and their applications. Review of available numerical software libraries.

Text Books

[1] A. K. Jana, "Chemical Process Modelling and Computer Simulation", PHI, 2011.

[2] Asghar Hussain, "Chemical Process Simulation", Wiley Eastern Ltd., New Delhi, 1986.

[3] M.M. Denn, "Process Modelling", Wiley, New York, 1990.

Reference Books

[1] C.D. Holland, "Fundamentals of Modelling Separation Processes", Prentice Hall, (1975)

[2] D. F. Rudd and C. C. Watson, "Strategy of Process Engineering", Wiley international, 1971

[3] W.L., Luyben "Process Modeling, Simulation, and Control for Chemical Engineering", Mc Graw Hill.

Web Links

https://archive.nptel.ac.in/courses/103/107/103107096/

NPT-326 Process Optimization

L	T	P	C
3	0	0	3

OBJECTIVE

The primary goal of this course is to provide an overview of state-of-the-art optimization algorithms, and the theoretical principles that underpin them, and to provide students with the modeling skills necessary to describe and formulate optimization problems and their use for solving several types of practically relevant optimization problems arising in process systems engineering.

Course Outcomes:

CO1	To identify different types of optimization problems	Understand, Apply
CO2	To explain different optimization techniques	Apply, Evaluate
CO3	To solve various multivariable optimization problems	Analyze, Evaluate
CO4	To solve problems by using Linear Programming	Apply, Evaluate
CO5	To solve optimization problems of staged and discrete processes, understand the concept of specialized & Non-traditional Algorithm	Understand, Apply, Evaluate

Table: Correlation of POs, PSOs v/s COs

PO/CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	3	1	2	2	1	-	-	1	3	-	-	2	
CO2	3	3	3	3	2	-	-	1	3	-	-	2	
CO3	3	3	3	3	3	-	-	1	3	-	-	2	
CO4	2	3	3	1	3	-	-	1	2	-	-	2	
CO5	2	3	3	1	2	-	-	1	1	-	-	3	
Average	2.6	2.6	2.8	2	2.2	-	-	1	2.4	-	-	2.2	

Syllabus

Module 1 (6 hours) Introduction to process optimization; formulation of various process optimization problems and their classification. Basic concepts of optimization-convex and concave functions, necessary and sufficient conditions for stationary points.

Module 2 (6 hours) Optimization of one- dimensional functions, unconstrained multivariable optimization-direct search methods. Bracketing methods: Exhaustive search method, Region elimination methods: Interval halving method, Fibonacci search method, Golden section search method.

Module 3 (5 hours) Linear Programming: Primal Simplex method, Artificial starting solution, Dual Simplex method, Primal-Dual relationship, Simplex method.

Module 4 (8 hours) Multivariable Optimization Algorithms: Optimality criteria, Unidirectional search, direct search methods, Powell's conjugate direction method. Gradient-based methods: Cauchy's (steepest descent) method, Newton's method. Constrained Optimization Algorithms: Kuhn-Tucker conditions, Transformation methods: Penalty function method, method of multipliers, Direct search for constraint minimization: Variable elimination method

Module 5 (5hours). Dynamic programming, Introduction to Specialized & Non-traditional Algorithms: Genetic Algorithm

Text Books

1 T.F. Edgar and D.M. Himmelblau, "Optimization of Chemical Processes", Mc Graw Hill, International editions, chemical engineering series, 2001

2. S. S. Rao, Engineering Optimization Theory and Practice, Fifth Edition, John Wiley & Sons, Inc., 2019

3. G.S. Beveridge and R.S. Schechter, "Optimization theory and practice", Mc Graw Hill, Newyork, 1970.

Reference book:

1. Hamdy A. Taha, " Operation Research", Pearson, 2008

Web Links

https://archive.nptel.ac.in/courses/103/105/103105139/

OPT 302: Basic Paint Technology

L	T	P	C
2	0	0	2

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 aspects and 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, lakes & toners, 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 & manufacture of coatings

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

Module-IV Testing of raw materials & paints

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

Module-V Surface preparation, application techniques and paint defects.

Various steps involved in preparation and chemical pre-treatment of surfaces, different application techniques viz. electrostatic spraying, electro-deposition.

Common paint defects and their prevention & cure, recent trends in paints & paint application, safety & health hazards in paint and coating industries.

References:

1. Organic Coating Technology, Vol. I & II; by HF Payne.
2. Outlines of Paint Technology; by W.M Morgan.
3. Surface Coatings, Vol. I & II; by OCCA, Australia.
4. Basics of Paint Technology (Part I & II); by Malshe&Sikchi.
5. BIS Specifications IS:33-.1992, IS:74.1979, IS:101.1964

NPT- 421: Technology of Architectural and Eco-Friendly 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

Module- I: Introduction To Eco-Systems - fundamental aspects of environmental protection related to coating industries (ozone layer, renewable resources, green coating, carbon neutral products, bio-degradability of materials). Eco-friendly coatings: aspects of environmental pollution (volatile organic compounds, VOC and hazardous air pollutants, HAP, Carbon foot print) with reference to conventional coatings & organic solvents, water as a substitute for organic solvents, merits & demerits of water as a solvent, water borne/based/thinnable/reducible coatings, aqueous dispersions vs. Non aqueous dispersions. Substrate type and aggressiveness of environment for architectural coatings

Module-II: Architectural Aspect of Eco-Friendly Coatings:-selection of raw materials for architectural and eco-friendly coatings, effect of solvent(s) on paints and coatings, drying mechanism of paint. Green building concept,GS 11- 2008, green engineering and green chemistry principles in paint formulation. VOC and its calculation, as per BIS and ASTM. International initiatives updates on green paints, APEO and AOX free, Heavy metal free EN 71.3 compliance, Mineral oil, Formaldehyde and PCB (Poly chloro Bisphenyl) free.

Module-III: Architectural Coating Systems:-Primer-surfacer/ surfacer, undercoats, putties, sound deadeners, under seal. Decorative/ Tradesale/ Architectural paints: sealers for wood, plasters, primers, surfacers, flat oil paints, synthetic enamels. Water based coatings: lime wash, lime colours, dry distempers, cement paint, oxide floor colours, skim coats, water thinnable primers, oil-bound distempers, acrylic washable distempers. Plastic emulsion paints: interior and exteriors; properties and uses, Tinters (Aqua and Universal).

Module-IV: Eco-Friendly Coatings:-

(a) High solids coatings: considerations, influence of solvents, temperature, pigments, additives, cross-linkers.

(b) Radiation curable coatings (UV and EB): types of radiations, UV curing, fundamental of photo-polymerisation, photo-initiators, photo sensitizers, oligomers, monomers, problems associated with Radiation curable (UV & EB) uses,

(c) Technologies for polymer in water- reducible coatings and water soluble Polymers. Aqueous emulsion coatings, Aqueous dispersion coatings, Latex film Formation—driving force for film formation, humidity and latex cure .Minimum film formation temperature, Wet MFFT and dry MFFT. Flash rusting.

(d) Powder Coatings, followed in module V

Module-V: Powder and Specialty Coatings:-Thermoplastic and Thermoset; manufacture of powders, powder classifications, types of powder coatings, application methods; electrostatic, fluidization

/electro-fluidisation, flame spraying, uses, performance affecting parameters. Miscellaneous coatings: wood coatings, melamine wood finish, floor paints, concrete paints, road marking paints

References and suggestive readings:

1.Surface Coatings, Vol. II, By: OCCA, Australia
2.Basics of Paint Technology (Part II), By: Malshe&Sikchi
3.Surface Coating Technology, By: Swaraj Paul
4.Outlines of Paint Technology, By: W.M.Morgan
5.Organic coating technology vol. II ByH.F.Payne
6.Powder coatings vo.-1 and vol. -2, by Heste

NPT-423: Advance in Resins and Polymers

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, Epoxy, Polyurethane, Silicone, Vinyl & Acrylic resins: preparation, properties and applications.

Course Outcome

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

CO1	Study Binders, Polymers & Resins, Natural Resins, Rosin, Cellulose, Rubber, Formaldehyde Resins	Understand, Apply
CO2	Develop and assess Alkyd resins while performing computations to create customized alkyds.	Apply, Evaluate
CO3	Conduct an examination on epoxy resins, including an analysis of their constituent materials, varieties, characteristics, and practical uses. Explore polyamide resins as potential curing agents for epoxy resins.	Apply
CO4	Conduct a comprehensive investigation into Polyurethane resins, encompassing an exploration of their various ASTM classifications and eco-friendly methodologies. Additionally, examine the utilization of Silicone resins in surface coatings.	Apply
CO5	Study of vinyl and acrylic resins, acrylic emulsions and adhesives	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	1	-	2	-	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	-	-	-	2	-	-	-	2	1
Avg	3.0	1.33	2.0	1.17	1.0	0.33	1.17	0.0	0.83	0.33	2.0	2.0

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 of desired solubility characteristics

Cellulose Derivatives (esters, ethers, water solubles), Degree of Substitution, Structure-property relationship.

Natural Rubber, Rubber Resins, Synthetic Rubbers, Resin Dispersions, Nitrile, Isoprene, SBR, NBR

Formaldehyde Resins (from Formalin, Paraformaldehyde, Hexamine) and (from Phenols, Amines, guanine, ketones) as Principal Binders, and as 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 coatings

(b) Alkyds- Chemistry, Classification, Formulation, Formula calculation for oi/Monoglyceride (Transesterification) &Acidolysis& Fatty Acid process, Gelation tendency, Carother's equation, Excess Hydroxyls, Non convertible oils, Tailor-making of alkyds, Non-phthalic alkyds Various modifiers for alkyd

resins; Vinylated, Silicone-modified, Polyamide-modified/Thixotropic alkyds, water reducible alkyds, hyperbranched alkyds, Acrylated alkyds, Styrenated alkyds, Vinylated, Styrenated, Rosinated, Urethane-modified alkyds, QD alkyds, Propargyl Chemistry, A3 B2 Resins, CLICK reaction; 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, polyepoxides/Novolac-epoxies (EPN, ECN) UV- resistant epoxies, Experimental determination of Epoxy value and Hydroxyl value, Various curing agents, Calculation of phr for curing agents as polyamines, ketimines& Reactive polyamides, Hydrogenated BPA bsed epoxies, Hyperbranched epoxies, Curing mechanisms, 1K & 2K Coating Systems, High Solids Coatings, Powder coatings

Water-based Coatings- Emulsions, Dispersions &CathodicallyElectrodepositable (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 (Isocyanurates), Castor oil as a polyol, Aliphatic, cycloaliphatic & Hybrid isocyanates, Activated prepolymers, Classification of PU coatings, 1K & 2K Coatings/Compositions, NCO/OH ratio, Polyurethane Dispersions (PUD) , Isocyanate hazards, Non-isocyanate Polyurethanes (NIPU)

(b) Silicones- Silicon, Silicone, Silane, Silanol, Polydimethylsiloxane resins, 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, Silicone Polyurethane (SPUR), Reactive Silicones, Silicone acrylate

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

(b) Acrylics- Acrylic monomers vs. Vinyl monomers, Reactive/functional acrylic monomers, Aqueous &Nonaqueous Solution & Dispersion acrylics, Thermoplastic & Thermosetting acrylics, Tg& MFFT, Acrylated epoxies, Water Soluble TSAs, Hyperbranched acrylates

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

Adhesives, Pressure Sensitive adhesives, Laminating adhesives, Flock adhesives, BOPP/PET Tape adhesives, Tamper evident BOPP Tape adhesives

References:

1. Introduction to Paint Chemistry and principles of paint technology, IV Ed; by J. Bentley and G.P.A. Turner, Champan& Hall, 1998

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 Dieter Stoye and Werner Frietag, Hanser Pub. 1996

NPT 425: Radiation Curable Coatings

L	T	P	C
3	1	0	4

OBJECTIVE: The objective of this course is to enable the students
To understand the concept of radiation curable coatings by various illuminates.
Study of photoinitiators and initiation mechanism.
Methods of radiation curing, mechanism and formulation.
Application of radiation curing coatings.

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

CO1	Understand the concept of radiation (UV and EB) curing and curing equipment	Understand
CO2	Study and analyze various photoinititors and its initiation mechanism	Understand, Analyze
CO3	Study radiation curing, mechanism of polymerization and formulation of such coatings	Understand, Apply
CO4	Study dual cure mechanism, additives and other miscellaneous components of radiation curable coatings	Understand
CO5	Study and apply end use of various radiation curable coatings	Understand, Apply

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	2	1	1	1	-	2	1	2
CO2	3	2	1	1	2	1	1	1	-	2	1	2
CO3	3	2	1	1	2	1	1	1	-	2	1	2
CO4	3	2	1	1	2	1	1	1	-	2	1	2
CO5	3	2	1	1	2	1	1	1	-	2	1	2
Avg	3.0	2.0	1.0	1.0	2.0	1.0	1.0	1.0	0.0	2.0	1.0	2.0

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

SYLLABUS

Module-1: Radiation (UV and EB) Curing and Curing Equipment

Radiation curing and its uses.Radiation and Radiation theory.Magnitude of UV and EB; and Visible radiation Energy.Photon production, Electrons.
Electron beams, UV radiation systems. Xenon lamps, Hybrid Xenon/ Mercury lamps, Excimer radiation, Visible radiation.

Module-2: Photoinitiators and Initiation Mechanisms

Free-radical Photoinitiators and Initiation Mechanisms
Photoinitiators, Free Radical Photoinitiators, Homolytic Fragmentation Type, Hydrogen Abstraction Type Photosensitizers, Oxygen Inhibition, Visible Radiation Photoinitiators.
Cationic Photoinitiators and Initiation Mechanisms
Onium Salts, Diazonium Salts, Lewis Acids, Iodonium and Sulfonium Salts, Bronsted Acids, Organometallic Compounds, Photosensitization.

Module-3: Radiation Curing Systems

Free Radical Systems, Unsaturated Polyester/Styrene Systems, Polyene/Thiol Compositions, Acrylate Compositions, Monofunctional. Acrylates, Polyfunctional Acrylates, Oligomeric Acrylates---Epoxy, Urethane, Oils, Acrylated Epoxides or Epoxy Acrylates, Urethane Acrylates, Esterified Polyol Acrylates, Acrylated Oils. Shrinkage.
Cationic Cycloaliphatic Epoxide Systems, Oils, Mechanism of Polymerization, Polyols. Water, Humidity, and Temperature Effects, Effect of Added Thermal Energy. Electron Beams and Epoxide Cure, Pigmentation. Formulation.

Vinyl Ethers: Free Radical Polymerization, Cationic Polymerization, Hybrid Polymerizations, Donor/Acceptor or Charge-Transfer Polymerizations, Oligomeric Vinyl Ethers, Urethane Vinyl Ethers, Ester Vinyl Ethers, Vinyl Ether-Silicone Blends, Vinyl Ether-Epoxide Blends.
UV Curable Powder Coatings: Polymer Systems, Wood Substrates, Metal Substrates, Fiberboard Substrates.

Module-4:
Dual Cure Mechanisms- Free Radical/Cationic Systems, Radiation/Thermal Cures, Radiation/Moisture-Cure Urethane Cures, Radiation/Epoxide Cure, Radiation/Radiation Cure, Radiation/Air-Drying Cures.
Additives and Miscellaneous- Antifoaming Agents, Expanding Monomers, Gloss Control, Inorganic Glasses for Pigmented and Thick Section Cures, Odor, Scratch, Slip, and Abrasion Resistance, Silane Coupling Agents, Surfactants, Textured Coatings, Thick Section Curing, Water-Based Systems, Weathering. Tackling the drawbacks of UV systems.

Module 5: End Uses
Automotive, Electrical/Electronics, Magnetic Media, Optical Components and Materials, Printing Inks and Graphic Arts, Stereolithography or Three-Dimensional Object Curing, Wood Coatings.The Future, Safety and Health considerations.Solventborne coatings, Water-based UV coatings, UV curable Powder Coatings, UV curing of pigmented coatings, UV Plasma curing.

References:
1. Radiation Curing of Coatings (ASTM Manual Series, 45.
2. UV coatings: basics, recent developments and new applications By Reinhold Schwalm
3.Surface Coatings Science and Technology by Swaraj Paul

NPT 443: Technology of Industrial and Automotive Painting

L	T	P	C
3	0	0	3

OBJECTIVE: The objective of this course is to enable the students
To get an overview of artificial intelligence in surface coating.
Deep learning techniques and computer vision for surface coating.
Natural language processing and fundamentals of machine learning
Industrial application of AI and ML in surface coating.

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

CO1	Understand the components of artificial Intelligence and its classification models for surface coating applications.	Understand
CO2	Understand neural networks, deep learning architectures and computer vision for surface coatings	Understand
CO3	Study natural language processing (NLP) techniques, AI in materials development, image analysis approach for smart surface and supply chain optimization for coating industry	Understand
CO4	Understand fundamentals of machine learning, statistical analysis and data visualization for quality control	Understand
CO5	Study AI-ML approach for the growth of global coating market and emerging trends and future directions in AI for surface coating	Understand

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	2	1	1	1	-	2	1	2
CO2	3	2	1	1	2	1	1	1	-	2	1	2
CO3	3	2	1	1	2	1	1	1	-	2	1	2
CO4	3	2	1	1	2	1	1	1	-	2	1	2
CO5	3	2	1	1	2	1	1	1	-	2	1	2
Avg	3.0	2.0	1.0	1.0	2.0	1.0	1.0	1.0	0.0	2.0	1.0	2.0

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

SYLLABUS

Unit-I: Selection of industrial paints for different end uses. Types of surfaces and paint application techniques for large surfaces. Surface Preparation (a) Mechanical - Hand cleaning, power tool cleaning, flame cleaning, Blast cleaning, SSPC and NACE standards (b) Chemical - Solvent wiping & degreasing alkali cleaning, emulsifiable solvent cleaning, steam cleaning, acid cleaning, picking, phosphating Zn & Fe. Paint removers

Unit-II: Shop Painting of steel in fabricating plants, Painting of Rail road bridges & structures, Painting of Highway bridges & structures, The Painting of steel vessels for fresh water service, Painting of steel tanks, Panting of Steel in Hydraulic Structures

Unit-III: Protection of Pipelines & other underground structures, Painting of industrial plants-(a) Water sewage works structures (b) Maintenance painting of steel coke oven plants (c) Petroleum refineries (d) Chemical plants Metallizing-Principles of Operation, Characteristics of sprayed metal, Nature of Protection

Unit-IV: Paint Shop Design and Quality Concepts: Coating Process Steps-General layout- Pretreatment, Electro-coating (EC), Sealing and Underbody Protection, Paint Application, Function Layer and Primer less Processes, Cavity Preservation; Coating Facilities-Process Technology, Automation in the Paint Application, Painting Robot, Application Technology, Atomizer, Paint Color Changer, Paint Dosing Technology for Liquid Paints and

Powder Paints, Paint-Material Supply system, Paint Mix Room, Container Group, Circulation Line System, Basic Principles for the Design of the Pipe Width for Circulation Lines, Paint Supply Systems for Small Consumption Quantities and Frequent Color Change, Voltage Block Systems, Voltage Block Systems with Color Change Possibility, Installations for the High Viscosity Material Supply, Conveyor Equipment.
Process Monitoring and Regulation, Automated Quality Assurance, Process Optimization in Automatic Painting Installations, Robot Interior Painting with High-Speed Rotation
Curing-Convection Curing, Duct Design, Oven Fuels, Materials of Construction, Infrared Curing, Oven Maintenance and Cleaning, Oven Exhaust, Oven Filtration, Oven Location, The Impact of Catalysts on Curing, Heat Recovery

Unit-V: Coatings for Plastic Parts, Exterior Plastic Substrates and Parts, Overview, Basic Physical Characteristics, Part Processing and Influence on Coating Performance, Pretreatment, Plastic-Coating Materials, Basic Technical Principles of Raw-Material Selection, Car-Body Color, Contrast Color and Clear Coat on Plastic Systems, Technical Demands and Testing, Basic Considerations, Key Characteristics and Test Methods, Trends, Challenges, and Limitations, Substrates and Parts
Interior Plastics-Introduction: the 'Interior' Concept, Surfaces and Effects, Laser Coatings, Substrate Requirements, Requirements to Be Fulfilled by the Paint Systems and Coating, Demands Expected by the Inscription Technique, Performances of Interior Coatings, Mechanical and Technological Demands, Substrates and Mechanical Adhesion, Equipment for the Application of Interior Paint Systems, Raw-Material Basis of Interior Paints

References:

1. Steel Structures Painting Manual Vol-1: Good Painting Practices, by Joseph Bigos
2. Steel Structures Painting Manual Vol-2: System & Specifications, by Joseph Bigos
3. Automotive Paints and Coatings by Streitberger and Dossel
4. Paint Technology Handbook by Rodger Talbert
5. Industrial Painting-Principles & Practices by Norman R Roobol
6. High-performance organic coatings Edited by Anand S. Khanna

NPT 445: Technology of Packaging

L	T	P	C
3	0	0	3

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: Elements of Packaging

Elements of packaging, concepts, function, entities, status, scope, biotic and abiotic, natural packaging, packaging values, Professional approach to development of package for food products, general consumables, cosmetics, pharmaceuticals, engineering materials and other utilities.

Module – II: Package Development & Design

Package Development Process, Package printing importance, Package Printing & Decorating; Color Perception, Introduction to Printing, Printing Methods, Electronic Product Coding, Coatings and lamination, paper films and foils for lamination, adhesives, labels and labeling, heat transfer labels, coding and holograms, Design & development of packaging laminates.

Conversion of substrates into print. Printing and converting method; Letter press, Offset, Flexo, Gravure, Metal deco, Screen, Pad printing, Intaglio, UV / EB, Aq Flexo, Digital technologies.

ModuleIII: **Packaging materials and their forms**

Types of substrates: Paper, plastic, metal, fabric, leather, foil.

Paper and paper board, folded cartons and setup boxes, corrugated board, box construction, interior packaging, moulded forms, paper composites, tetrapack, wood containers, glassware.

Plastics Packaging

Introduction to Polymers, Polymer Chemistry, Packaging Polymers, Polymer Property Comparisons, Plastics packaging material in different forms: Extruded Films, Flexible Packaging, Thermoforming, Injection Molding, Blow Molding Extrusion, and thermoforming, flexible polymeric films, metallic foils, orientation and metallization.

Module IV: **Containers & Closures**

Bottle Design Criteria, Metal containers, tin plate cans, tin free steel cansand tempers, coatings and linings, aluminium cans,collapsibletubes,fibertubes,Aerosols-principle,valves,spraypattern,meteringvalves.Closures, applicators, fasteners cushioning, straps, clips, nuts, nails. Ecology, safety, degradability and recyclability

Module V: Quality Control, Packaging Machinery, Package disposal

Distribution & Transportation Packaging; Distribution environment, Protective Packaging, Industrial Packaging.
Pre-shipment Testing, Test methods, quality control.
Packaging Machinery, Filling Systems and equipment.
Innovations in packaging: Active packaging, anti-microbial containers, RFID technologies.
Package disposal, Eco-Friendly packaging, Laws and regulations.

References :

1. Handbook of Package Engineering by Joseph F. Hanlon
2. Edible Coatings & Soluble Packaging by Roger Daniels
3. Protective Wrapping, by C.R.Oswin
4. Environmental effect on polymeric materials, by Dominick V. Rosato& Robert T. Schwart

NPT-447: Safety, Health and Environment (SHE) in Paint Industry

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 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: COMAH,

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

NPT 461: 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.

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-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: Corrosion Inhibitors, Introduction to liquid organic corrosion inhibitor to improve salt spray test

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-463: Instrumentation Technology for Characterization of Film Formers

L	T	P	C
3	0	0	3

OBJECTIVE: The objective of this course is to enable the students understand:
Instrumentation technique to characterize the film former
Thermal Properties evaluation by different instruments
Structural and morphological analysis of film formers
Electrical and mechanical properties of film
Chemical, Viscoelastic and weathering properties of film formers

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

CO1	Understand and analyze thermal properties of film formers	Apply and analyse
CO2	Analyse structural and morphological characterstics	Analyse
CO3	Evaluate electrical and mechanical properties of film	Evaluate
CO4	Analyze chemical and weathering properties of film formers	Analyze
CO5	Evaluate viscoelastic properties of film formers	Analyse and evaluate

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:

Thermal Properties: Glass transition temperature, melting temperature, crystallization temperature by Differential Scanning Calorimetry (DSC) heat distortion temperature, Thermogravimetric Analysis (TGA). Sample preparation, standardization, conditioning of sample, processability test, dynamic mechanical analysis, melt flow rate, Study of a dilatometer.Study of thermo-chemical analysis and differential scanning calorimeter.

Module II:

Structural and Morphological properties: Fourier transform infrared spectrometry, Ultraviolet - visible spectrometry, Nuclear magnetic resonance spectrometry, Mass spectrometry, X-ray diffraction spectrometry, Gas chromatography, Liquid Chromatography. Scanning electron microscopy, trasmission electron microscope Molecular weight determination Viscosity of polymer solutions and polymers: Their significance, application to polymers using different viscometers, Gel Permeation Chromatography (GPC)

Module III

Physical, Optical, Electrical and Mechanical properties: Surface volume resistivity, Breakdown voltage, Arc resistance, Tan Delta, Tensile strength, flexural strength, impact resistance, percentage elongation, tear test, fatigue and wear, hardness, compressive strength time dependant properties like creep, stress, relaxation, Refractive index, gloss, color matching, haze, limiting oxygen index, smoke density Tests for adhesives, Identification of polymers using chemical methods ESCR.

Module IV

Chemical and Weathering properties: Prediction of solubility parameter, Effect of polymer structure on solubility in solvents and oils, Chemical resistance of polymers, Accelerated weathering tests, outdoor weathering of plastics, Resistance of plastic materials to fungi and Bacteria and limitations of accelerated microbial growth resistance testing.

Module V

Viscoelastic properties of Polymer: Experimental determination, mechanical models, polymer rheology, creep, stress relaxation and set, stress relaxation, tensile stress relaxation, compress stress relaxation and set, fatigues, dynamic fatigue of polymeric materials.

Text Book:

1. Polymer Chemistry: A Practical Approach (The Practical Approach in Chemistry Series) 1st Edition Fred J. Davis Oxford University Press 2004
2. A Practical Course in Polymer Chemistry, S. H. Pinner, Borough Polytechnic, London, Pergamon Press, 1961
3. PVC Technology, A. S. Athalye and PrakashTrivedi, Multi-Tech Publishing Co, 1994
4. Polymer Science by Gowarikar, John Wiley and Sons 1986.

References Book:

1. Encyclopedia of Polymer Science and Technology, Johan Wiley and Sons, 1965.
2. Encyclopedia of Polymer Science and Engineering, Johan Wiley and Sons, 1988.
3. PVC Technology, A. S. Athalye and PrakashTrivedi, Multi-Tech Publishing Co, 1994
4. Principles of polymerization, G.Odian, Wiley – Interscience 1981

NPT 463: Water-Borne Coatings

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.

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;RLambourne&T.A Strivens,WoodheadPublishingLtd.
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 ByH.F.Payne
8. Basics of Paint Technology (Part II), By: Malshe&Sikchi

NPT-481 Industrial Training

L	T	P	C
0	0	4	2

OBJECTIVE: The objective of this course is to enable the students

- Make students observe and learn practical knowledge of processing or manufacturing of coatings
- Understand professional ethics and discipline required in industry
- Understand and analyze product planning and implementation in industry.
- Communicate their experiences in the form of project report and power point presentation

Course Outcome

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

CO1	Acquire practical skills in any paint and allied industry.	Understand
CO2	Understand professional ethics and discipline required in industry.	Understand & Ethics
CO3	Analyze problems in products and process and resolves by working on short term project.	Analyze & Apply
CO4	Understand and analyze product planning and implementation in industry.	Understand and Analyze
CO5	Communicate their experiences in the form of project report and power point presentation.	Apply & Analyze

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

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

OPT 401: Basics of Paint Manufacturing

L	T	P	C
2	0	0	2

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	To understand the steps of paint manufacturing	Understand
CO2	Study the principles of coating manufacture and their applications	Apply
CO3	Study basic equipment and machinery used in paint manufacture, their selection, calculations involved in efficient operation, economic considerations, etc.	Apply
CO4	Study modern manufacturing equipment	Apply
CO5	Study heavy duty machine for paint manufacturing	Apply

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

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

SYLLABUS

Module-I: Prerequisites of Paint Manufacturing

Prerequisites, Steps of Manufacturing, Oil Absorption Value, mechanism, Methods for Determining Oil Absorption, Spatula Rub-Out Method, Gardner–Coleman Method, Useful Equations Based upon CPVC Calculated from Oil Absorption Data PVC, CPVC, LCPVC, RCPC, % Volume solids, Relationship between PVC and physical, permeability and optical film properties, P/B ratio; Porosity, Steps in Paint manufacturing, Phenomenon of Mixing, Soaking, wetting, grinding, dispersion and stabilization. Dispersion processes, Daniel wet & flow point.

Module-II: Principles of Coating Manufacture

Classification of grinding equipment, important considerations in pigment dispersion and stabilization. Dispersion for aqueous media, high solids coatings. Mill Base Composition, Rheology of Mill base, Concept of F(PVC), MBC (Mill base concentration), RTM (Ratio of Total Paint volume to Mill base volume), let down vehicle, Let down troubles, Optimum let down conditions, Stabilization of Mill base. Smearing versus Smashing Dispersion Equipment

Module-III: Ball Mills, Attritors, Sand Mills

Ball and Pebble mills: 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, 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 a& disadvantages of sand mill, Dyno Mill.

Module-IV: High Speed Dispersion Equipment

High speed disc disperser: description; size, positioning & speed of disperser blades, mill base rheology, power input, advantages & limitations of sand mill, Basket Mill, 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.

Module-V: Heavy Duty Machines

Heavy duty mixtures, double blade mixers, sigma mixture, Warner &P'flauder 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.

References and suggested readings:

1. Organic Coating Technology, Vol. I & II, By: H.F.Payne
2. Outlines of Paint Technology, By: W.M.Morgan
3. Basics of Paint Technology, Part I & II, by V.C.Malshe&MeenalSikchi
4. Surface Coatings, Volume I & II; by OCCA Australia
5. The chemistry of organic film-formers, by D.H.Solomon, R.E. Krieger Pub.
6. Introduction to paint chemistry; by G.P.A. Turner, Chapman and Hall
7. Paint and surface coating theory and practical II edition R.LamBournee and TA Striven

NPT 491: Minor Project

L	T	P	C
0	0	12	6

OBJECTIVE: The objective of this course is to enable the students

To identify a coating system that can be manufactured in India or a research problem and conduct experiment.

To prepare a feasibility report for a project based on manufacturing of product.

To present a lecture on the topic on power point format.

To improve the communication skill of the students.

Course Outcome

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

CO1	Understand a topic of latest developments/innovative technology.	Understand
CO2	Apply the knowledge to prepare a feasibility/dissertation report on this topic.	Apply Analyze
CO3	Deliver a lecture on the topic on power point format.	Apply
CO4	Improve the communication skills of the students.	Apply
CO5	Analyze environment and sustainability of related technology	Analyze

Course Articulation Matrix (CO-PO Matrix)

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**3**	**3**
CO1	3			1		3	3		3			3	3	3
CO2	3	2	2	1	1	3	3		3	3	3	3	3	3
CO3										3		3	3	3
CO4							3			3		3	3	3
CO5						3	3		3			3	3	3
Total	**3**	**2**	**2**	**1**	**1**	**3**	**3**		**3**	**3**	**3**	**3**	**3**	**3**

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

NPT-471 Seminar

L	T	P	C
0	0	4	2

OBJECTIVE: The objective of this course is to enable the students

To study a topic of latest developments/innovative technology on their own andto prepare a dissertation report on this topic.

To present a lecture on the topic on power point format.

To improve the communication skill of the students.

Course Outcome

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

CO1	Understand a topic of latest developments/innovative technology.	Understand
CO2	Apply the knowledge to prepare a dissertation report on this topic.	Apply
CO3	Deliver a lecture on the topic on power point format.	Apply
CO4	Improve the communication skill of the students.	Apply
CO5	Analyze environment and sustainability of related technology	Analyze

Course Articulation Matrix (CO-PO Matrix)

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**3**	**3**
CO1	3			1		2	3					3	3	3
CO2	3	2	2	1	1	2	3		1	3	2	3	3	3
CO3	3									3		3	3	3
CO4	3								2	3		3	3	3
CO5	3	2				2	3	1				3	3	3
Total	**3**	**2**	**2**	**1**	**1**	**2**	**3**	**1**	**1.5**	**3**	**2**	**3**	**3**	**3**

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

NPT 422: High Performance Pigments

L	T	P	C
3	1	0	4

OBJECTIVE: The objective of this course is to enable the students
To understand inorganic high performance pigments, its manufacturing and applications.
To study synthesis and application of complex inorganic color pigments.
To understand organic high performance pigments
Application of HPP in plastics, inks and cosmetics
To get knowledge about regulatory affairs and emerging trends in HPP

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

CO1	Study manufacturing, properties and application of inorganic HPP	Understand and Apply
CO2	Study chemistry and application of various types complex inorganic HPP	Understand, Apply
CO3	Study chemistry and application of various types organic high performance pigments	Apply and Analyze
CO4	Study and analyses specific application of HPP	Understand
CO5	Study of regulation and emerging trends in High-Performance Pigments	Analyze

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	1	1	2	1	1	2	1	1
CO2	3	2	1	1	1	1	2	1	1	2	1	1
CO3	3	2	1	1	1	1	2	1	1	2	1	1
CO4	3	2	1	1	1	1	2	1	1	2	1	1
CO5	3	1	-	-	-	1	2	2	1	2	1	1
Avg	3.0	1.8	0.8	0.8	0.8	1.0	2.0	1.2	1.0	2.0	1.0	1.0

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

SYLLABUS

Module I

Inorganic High Performance Pigments: Introduction, Bismuth Vandates: Manufacturing, properties and applications, Conformity of Pigments for Plastics Coloration to Food and Drug Regulations, Toxicology, Cadmium Pigments: Chemistry of Cadmium, Selenium and Cadmium Sulfide, Method of Pigment Manufacture, properties, applications and regulatory issues, Cerium Sulfide Pigment: Manufacture, Properties and Applications.

Module II

Complex inorganic colour pigments (CICP): Introduction, Structures of CICPs, Production of CICPs, Synthesis, properties and applications of - Titanate Pigments: Rutile Titanates, Doped-Rutile (DR) Pigments, Priderite Pigments, Pseudobrookite Pigments, Spinel Titanates, Aluminate Pigments, Cobalt Aluminates, Cobalt Chromium Aluminates, Chromites and Ferrites, Black CICPs, Brown Pigments, Green Chromites. Pigments Based on Liquid Crystal Polymers, Diffractive Pigments, Pigments Based on Holography and Gratings.

Module III

Organic high performance pigments: Benzimidazolone Pigments and Related Structures, Diketopyrrolopyrrole (DPP) Pigments, Dioxazine Violet Pigments, Disazocondensation Pigments, Isoindoline Pigments, Isoindolinone Pigments, Perylene Pigments, Imidazolone-Annellated Triphenedioxazine Pigments.

Module IV

Specific application of HPP

a) Applications of High-Performance Pigments in Plastics: Coloration of plastics,UV stabilization and weather resistance Heat stability and processing conditions, Special effects in plastic products
b) Applications of High-Performance Pigments in Printing Inks: Flexographic inks, Gravure inks, Offset inks, Screen printing inks, Digital printing inks.
c) Applications of High-Performance Pigments in Cosmetics: Color cosmetics (lipsticks, eyeshadows, blushes), Sunscreen and UV protection products, Hair care products, Nail polishes

Module V:

Regulatory affairs and emerging trends in High-Performance Pigments: Toxic Substances Control Act, Toxic Release Inventory Reporting, Food and Drug Administration, Color Pigments in General, PBT-TRI Rules, Nanotechnology and Regulation, High Production Volume (HPV) Substances, Classification and Labeling, Restrictions of Marketing and Use, REACH, Novel applications and market trends, Future prospects and challenges in the field of HPPs

Text Book

1. Hugh M. Smith, High Performance Pigments, ISBN: 3527403078, Ist edition, Wiley-VCH, 2002
2. W. Herbst, K. Hunger, Industrial Organic Pigments, ISBN: 3527305769, 3rd edition, Wiley-VCH, 2004

Reference Book:

1. Oil and Colour Chemists' Association(OCCA), Pigments, dyestuffs and lakes, part six, Paint Technology Manuals, OCCA, 1966
2. H.F.Payne, Organic Coating Technology, Vol. II- Pigments and Pigmented Coatings, John Wiley & Sons, 1961.

NPT 424: Speciality and Smart Coatings

L	T	P	C
3	1	0	4

OBJECTIVE: The objective of this course is to enable the students
To understand the concept of smart coatings.
Study of various types of smart coatings
Fabrication method and application of smart coatings

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

CO1	Study and apply self-healing and anti-fouling smart coating	Understand and Apply
CO2	Study and analyze anticorrosive smart coatings	Understand, Analyze
CO3	Study and apply super- hydrophobic and self-cleaning coatings	Understand, Apply
CO4	Study about smart fire-retardant coatings	Understand
CO5	Study various type specialty coatings	Understand, Analyze

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	2	1	1	1	-	2	1	2
CO2	3	2	1	1	2	1	1	1	-	2	1	2
CO3	3	2	1	1	2	1	1	1	-	2	1	2
CO4	3	2	1	1	2	1	1	1	-	2	1	2
CO5	3	2	1	1	2	1	1	1	-	2	1	2
Avg	3.0	2.0	1.0	1.0	2.0	1.0	1.0	1.0	0.0	2.0	1.0	2.0

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

SYLLABUS

Module I:

Self-healing and Anti-Fouling Coatings

Fundamentals of smart coatings for material protection, self-healing mechanism, self-healing coatings against biofilm formation with nano-/microcapsules and nano-/microspheres, Synthesis of micro/nano capsule, application of self-healing coatings. Anti-fouling coatings, deposition of fouling, mechanism of foul release, application of antifouling coatings.

Module II:

Smart Anti-Corrosion Coatings

Corrosion of different metals: mechanisms, monitoring and corrosion inhibitors, Strategies for corrosion inhibition: design, materials and protective coatings. Smart anti-corrosion nanocoatings, Sol–gel coatings with corrosion inhibitors, Developing layer-by-layer (LbL) coatings with active feedback properties, Methods for formation of LbL coatings for corrosion inhibition, Electro-active polymer (EAP) coatings for corrosion protection of metals. Self-healing Coatings for Corrosion protection.

Module III:

Superhydrophobic and Self Cleaning Coatings

Contact angle, Lotus effect, Developing super-hydrophobic coatings: materials, processing and characterization, Flame treatment for super-hydrophobicity, Types of self-cleaning coatings, Techniques for developing self-cleaning coatings: materials and method. Evaluation and application of Super-hydrophobic and Self-cleaning coatings.

Module IV:

Smart Fire-Retardant Coatings

Fire retardancy of flammable materials, mechanism of fire retardancy, Boron-based fire retardant coatings, Phosphorus-based fire retardant coatings, Coatings with synergistic flame retardants, Intumescent fire retardant coatings, transparent fire retardant coatings, Nanocomposite coatings, Sol-gel method, Fire resistance of timber.

Module V: Other Speciality coatings

Anticoutnerfeit coatings, thermochromic coatings, anti-skid coatings, anti-fog coatings, anti-ice coatings, conductive coatings, stimuli responsive coatings. Smart Coatings for Healthcare and Biomedical Applications : Biocompatible coatings and their significance in medical devices, Drug delivery systems and smart coatings in pharmaceuticals, Bio-sensing coatings and their applications in diagnostics. Photovoltaic and solar thermal coatings, Smart coatings for energy efficiency and heat management.

Text Book:

1. A. S. H. Makhlouf, Handbook of Smart Coatings for Materials Protection, ISBN: 9780857096807 (print), Ist edition, Woodhead Publishing, 2014
2. V. S. Kathavate, P. P. Deshpande,Smart Coatings- Fundamentals, Developments, and Applications, ISBN: 9781032060798, Ist edition, CRC Press, 2022

Reference Book:

1. A. Tiwari, L. Hihara, J. Rawlins, Intelligent Coatings for Corrosion Control, ISBN: 9780124114678, 1st edition, Elsevier, 2014.
2. A. A. Tracton, Coatings technology handbook, ISBN: 10:1574446495 (Hardcover),3rd edition, CRC press. 2006.

NPT 426: Artificial Intelligence in Surface coating

L	T	P	C
3	1	0	4

OBJECTIVE: The objective of this course is to enable the students
To get an overview of artificial intelligence in surface coating.
Deep learning techniques and computer vision for surface coating.
Natural language processing and fundamentals of machine learning
Industrial application of AI and ML in surface coating.

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

CO1	Understand the components of artificial Intelligence and its classification models for surface coating applications.	Understand
CO2	Understand neural networks, deep learning architectures and computer vision for surface coatings	Understand
CO3	Study natural language processing (NLP) techniques, AI in materials development, image analysis approach for smart surface and supply chain optimization for coating industry	Understand
CO4	Understand fundamentals of machine learning, statistical analysis and data visualization for quality control	Understand
CO5	Study AI-ML approach for the growth of global coating market and emerging trends and future directions in AI for surface coating	Understand

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	2	1	1	1	-	2	1	2
CO2	3	2	1	1	2	1	1	1	-	2	1	2
CO3	3	2	1	1	2	1	1	1	-	2	1	2
CO4	3	2	1	1	2	1	1	1	-	2	1	2
CO5	3	2	1	1	2	1	1	1	-	2	1	2
Avg	3.0	2.0	1.0	1.0	2.0	1.0	1.0	1.0	0.0	2.0	1.0	2.0

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

SYLLABUS

Module I: Introduction to Artificial Intelligence in Surface Coating

Overview of artificial intelligence and its applications in surface coating, problems addressed by AI, Components of Artificial Intelligence, Advantages of AI technique, Computerized and AI-equipped approaches in materials discovery; Understanding supervised, unsupervised, and reinforcement learning algorithms, Exploring regression and classification models for surface coating applications, Feature engineering and data pre-processing techniques

Module II: Deep Learning Techniques and Computer Vision for Surface Coating

Introduction to neural networks and deep learning architectures, Training and fine-tuning deep learning models for surface coating, Convolutional neural networks (CNN) for image analysis in surface coating, Image acquisition and preprocessing for computer vision applications, Image segmentation and object detection algorithms for surface coating, Image recognition and defect detection in surface coatings. AI in surface pre-treatment: Monitoring, Control, Laser Decorating, Acoustic Monitoring; Other Material Pre-treatment Processes: Managing and monitoring methods, Sensory processes, VUV technologies, Digital Solutions, Plasma Coating, Surface Inspection, Geospatial Analysis

Module III Natural Language Processing for Surface Coating

Introduction to natural language processing (NLP) techniques, Text mining and sentiment analysis for customer feedback in surface coating, Role of AI in materials development for coating industry, AI: materials design and image analysis approach for smart surface, AI application in: Supply chain optimization, SKU management/inventory planning, Marketing programs, Customer service (Chabots), Sales forecasting, Component design, Knowledge sharing, Lean production planning

Module IV Fundamentals of Machine Learning

Coating performance optimization through AI and machine learning (ML), Analysis on tri-biological behaviour of the coating through AI: Online condition monitoring, Material composition design, Wear loss prediction of the coating using ML algorithm, Development of strong protective coating through artificial intelligence, Exploratory data analysis techniques for surface coating datasets, Statistical analysis and data visualization for quality control viz. detection of corrosion, coating wear in ships, offshore structures.

Module V Industry Applications and Case Studies

AI-ML approach for the growth of global coating market; Market size, Segment analysis, Regional analysis, Global green coating market, Emerging trends and future directions in AI for surface coating, Case studies on quality improvement, defect detection, and process optimization

Reference:

1. Jyotirmay Banerjee and Anindya Deb "Artificial Intelligence in Surface Coating Technology"
2. Atul Tiwari and Balasubramanian Viswanathan "Intelligent Coatings for Corrosion Control"
3. NJ Nilsson, “Artificial Intelligence: A New Synthesis”, Elsevier Publications.
4. Charnick, “Introduction to AI”, McGraw-Hill Publication.
5. Rich & Knight, “Artificial Intelligence”, McGraw-Hill Publication.
6. Winston, “LISP”, Addison Wesley.
7. Marcellous, “Expert System Programming”, PHI.
8. Elamie, “Artificial Intelligence”, Academic Press.

OPT 402: Testing of Raw Materials and Paints

L	T	P	C
2	0	0	2

OBJECTIVE: The objective of this course is to enable the students
To understand various coating ingredients and testing of solid component
To understand the testing of liquid component of paint
To understand the Testing of liquid paint
To understand the testing of dry paint films

Course Outcome

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

CO1	To understand the paint ingredients and evaluation of solid components of paint	Understand and Evaluate
CO2	Determine the properties of liquid component of paint's raw material	Analyze
CO3	To understand testing methods of liquid paint	Understand and analyse
CO4	Test various Optical, physical, chemical and mechanical properties of paint	Evaluate
CO5	Test weathering and ageing properties of paint films	Apply and analyse

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	1	1	1	1	1	3	2	2
CO2	3	2	2	2	2	1	1	1	1	3	2	1
CO3	3	2	2	2	2	1	1	1	1	3	2	1
CO4	3	2	2	2	2	1	1	1	1	3	2	1
CO5	3	2	1	2	2	1	1	1	1	3	2	1
Avg	3.0	2.0	1.8	2.0	1.8	1.0	1.0	1.0	1.0	3.0	2.0	1.2

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

SYLLABUS

Module-I: Tests of raw materials (solid components of paint)

Introduction to ingredients of paint viz. pigments, extenders, oils, resins, solvents; Testing of pigments; volatile matter, colour, residue on sieve, oil absorption, tinting strength, reducing power, relative density, bulk density.

Module-II: Test of liquid raw materials (liquid components of paint)

Classification of oils-drying, semi drying and non-drying; properties of glyceride oils; physical & chemical testing of oils and resins – colour, viscosity, specific gravity, refractive index, acid value, iodine value, saponification value, epoxide value etc.

Volatile Solvents and Other Components: General classes of solvents, properties of solvents e.g. solvent (cutting) power, rate of evaporation, boiling point &vapor pressure, distillation range, flash point, auto ignition temperature, toxicity; solvent mixture (thinners) – true solvents, latent solvents and diluents; evaporation properties of solvent mixtures.

Module-III: Quality control test of liquid paints

Test methods of liquid paints as per BIS, ASTM, ISO, BS, DIN etc.); Pigment content, binder or solid vehicle content (% NV), volume solid %, density, fineness of grind, consistency, spreading capacity, wet opacity, dry hiding, spreading time, drying time, wet and dry film thickness, etc.

Module-IV: Optical, Physical, Chemical and Mechanical Properties of paints

Testing methods as per BIS, ASTM, ISO, BS, DIN etc. for dry coatings; Optical properties; colour, gloss, haze and clarity, orange peel, DOI (Distinctiveness of Image), transparency, hiding power, Shade matching. adhesion, flexibility, impact resistance, hardness, mar resistance, abrasion resistance, tensile strength, slip resistance and stress phenomenon in organic coatings. water and moisture resistance; water vapour transmission, PAC and salt spray test, chemical resistance of coatings, resistance to heat and fire, air permeability etc.

Module-V: Weatherability of paint films

Natural & accelerated outdoor weathering tests, weather-o-meter (QUV and Atlas weather-o-meter and their correlation with real life situation), defects observed in paint film on exposure & its evaluation, evaluation of water based paints

References and suggested readings:

1.Organic Coating Technology, Vol, I & II by H.F. Payne
2.Surface Coatings, Vol, I & II by OCCA, Australia
3.Outlines of Paint Technology by W. M. Morgan
4.Paint& Coating Testing Manual, Gardener-Sward Handbook),15th Edition, ASTM International.
5.Organic Coatings, Science and Technology: By Frank N. Jones, Nichols & Pappas,4th Edition, Wiley
6.Specifications BIS, ISO, BS etc.
7.BIS Specifications, IS:33-.1992, IS:74.1979, IS:101.1964

NPT 492: Project

L	T	P	C
0	0	24	16

OBJECTIVE: The objective of this course is to enable the students
To develop/ synthesize a paint/coating in laboratory.
To prepare a feasibility report for a project based on manufacturing of product.
To present a lecture on the topic on power point format.
To improve the communication skill of the students.

Course Outcome

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

CO1	Understand a topic of latest developments/innovative technology.	Understand
CO2	Apply the knowledge to prepare a feasibility/dissertation report on this topic.	Apply Analyze
CO3	Deliver a lecture on the topic on power point format.	Apply
CO4	Improve the communication skills of the students.	Apply
CO5	Analyze environment and sustainability of related technology	Analyze

Course Articulation Matrix (CO-PO Matrix)

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**3**	**3**
CO1	3			1		3	3		3			3	3	3
CO2	3	2	2	1	1	3	3		3	3	3	3	3	3
CO3										3		3	3	3
CO4							3			3		3	3	3
CO5						3	3		3			3	3	3
Total	**3**	**2**	**2**	**1**	**1**	**3**	**3**		**3**	**3**	**3**	**3**	**3**	**3**

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