SEMESTER WISE COURSE STRUCTURE
& EVALUATION SCHEME

for

B. TECH. DEGREE PROGRAMME

IN

CHEMICAL TECHNOLOGY

PAINT TECHNOLOGY

(Effective from the session 2019-20)

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

Department of Chemical Technology-Paint Technology

Vision

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

Mission

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

- **M1 :** To develop state-of-the-art facilities to impart technical knowledge and skill to the graduate & post graduate students for plastic 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 and consultancy for industry and society.
- **M4 :** To cultivate strong ethical values to be a successful professionals and to become life-long learners.

Program Educational Objectives (PEOs)

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

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

Program Specific Outcomes:

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

SEMESTER WISE COURSE STRUCTURE & EVALUATION SCHEME
(Effective from: 20119-20)
B. TECH. CHEMICAL TECHNOLOGY- PAINT TECHNOLOGY

Semester-I

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	CT	TA	Lab.	Total		
1	BSC	Engineering Chemistry	BCY 151	4	3	0	2	15	20	15	50	50	100
2	BSC	Mathematics I	BMA 151	4	3	1	0	30	20	-	50	50	100
3	ESC	Electronics & Instrumentation Engineering	EET 151	3	3	0	0	30	20	-	50	50	100
4	ESC	Engineering Graphics	ECE 151	3	0	0	6	30	20	-	50	50	100
5	ESC	Computer Concepts & Programming	ECS 151	4	3	0	2	15	20	15	50	50	100
6	ESC	Workshop Practice	EWS 151	2	0	0	4	--	20	30	50	50	100
7	MC (Non-Credit)	Environment & Ecology	ECE 153	0	2	0	0	30	20	-	50	50	100
Total Credits 20													**600**

Semester-II

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks ESE					Total Marks
					L	T	P	CT	TA	Lab	Total		
1	BSC	Physics	BPH 152	4	3	0	2	15	20	15	50	50	100
2	BSC	Mathematics II	BMA 152	4	3	1	0	30	20	-	50	50	100
3	ESC	Electrical Engineering	EEE 152	4	3	0	2	15	20	15	50	50	100
4	ESC	Engineering Mechanics	EME 152	3	3	0	0	30	20	-	50	50	100
5	HSMC	English Language & Composition	HHS 152	2	2	0	0	30	20	-	50	50	100
6	HSMC	Professional Communication	HHS 154	3	3	0	2	15	20	15	50	50	100
Total Credits 20													**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

Semester-III

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	CT	TA	Lab	Total		
1	BSC	Mathematics III	BMA 251	4	3	1	0	30	20	-	50	50	100
2	PCC	Introduction to Surface Coatings and their Components	TPT 251	4	3	1	0	30	20	-	50	50	100
3	PCC	Introduction to Surface Coatings and their Components Lab	TPT 253	2	0	0	4	-	20	30	50	50	100
4	ESC	Fluid Mechanics and Mechanical operation	TPT 255	5	3	1	2	15	20	15	50	50	100
5	PCC	Materials & Energy Balance	TPT 257	4	3	1	0	30	20	-	50	50	100
	HSMC	Organizational Behavior	HHS 253	3	3	0	0	30	20	-	50	50	100
7	MC (Non Credit)	Cyber Security	ECS 255	0	2	0	0	30	20	-	50	50	100
Total Credits 22													**600**

Semester IV

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	CT	TA	Lab	Total		
1	BSC	Modern Analytical Techniques	BCY 252	4	3	0	2	15	20	15	50	50	100
2	BSC	Computer Oriented Numerical Methods	BMA 252	4	2	1	2	15	20	15	50	50	100
3	PCC	Technology of Natural Resins, Alkyds and Polyesters	TPT 252	5	3	1	2	15	20	15	50	50	100
4	ESC	Heat Transfer Operations	TPT 254	3	2	1	0	30	20	-	50	50	100
5	PCC	Chemical Engineering Thermodynamics	TPT 256	3	2	1	0	30	20	-	50	50	100
6	HSMC	Engg Economics & Management	HHS 252	3	3	0	0	30	20	-	50	50	100
7	MC (Non Credit)	Indian Constitution	HHS 256	0	2	0	0	30	20	-	50	50	100
Total Credits 22													**600**

Semester-V

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	CT	TA	Lab	Total		
1	PCC	Technology of Inorganic Pigments and Extenders	TPT 351	4	3	1	0	30	20	-	50	50	100
2	PCC	Pigments and Extenders Lab	TPT 353	2	0	0	4	-	20	30	50	50	100
3	PCC	Technology of Synthetic Resins and Polymers	TPT 355	5	3	1	2	15	20	15	50	50	100
4	PCC	Mass Transfer Operations	TPT 357	4	3	1	0	30	20	-	50	50	100
5	PCC	Chemical Reaction Engineering	TPT 359	4	3	1	0	30	20	-	50	50	100
6	OEC (Humanities)	Open Elective Course –I	HHS 351	3	3	0	0	30	20	-	50	50	100
	Total Credits			**22**									**600**

Semester-VI

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab.	Total		
1	PCC	Characterization, Analysis and Evaluation of Coatings	TPT 352	3	2	0	2	15	20	15	50	50	100
2	PCC	Technology of Organic, Functional and Effect Pigments	TPT 354	3	2	1	0	30	20	-	50	50	100
3	PCC	Technology of Formulation and Manufacture of Coatings	TPT 356	4	3	0	2	15	20	15	50	50	100
4	PCC	Technology of Printing Inks and Coatings	TPT 358	3	2	1	0	30	20	0	50	50	100
5	PCC	Technology of Paint and Coating Additives	TPT 360	3	3	0	0	30	20	0	50	50	100
6	PCC	Instrumentation & Process Control	TPT 362	3	2	1	0	30	20	-	-	50	100
7	OEC (Maths)	Open Elective Course -II Operations Research	BMA 352	3	3	0	0	30	20	-	50	50	100
		Total Credits		**22**									**700**

Semester-VII

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	CT	TA	Lab	Total		
1	PCC	Technology of Industrial and Specialty Coatings	TPT 451	2	2	0	0	30	20	-	50	50	100
2	PCC	Technology of Surface Preparation, Treatments and Coating Applications	TPT 453	3	2	0	2	15	20	15	50	50	100
3	PEC	**Program Elective Course I** (Technology of Architectural & Eco-friendly Coatings OR Corrosion Control Technology)	TPT 455 OR TPT 457	3	3	0	0	30	20	-	50	50	100
4	PEC	**Program Elective Course II** (Technology of Industrial and Automotive Coatings OR Nanotechnology in Surface Coatings)	TPT 459 OR TPT 461	3	3	0	0	30	20	-	50	50	100
5	OEC (Paint Tech.)	**Open Elective Course –III** Basic Paint Technology	OPT 433	3	3	0	0	30	20	-	50	50	100
6		Industrial Training	TPT 493	2	0	0	4	-	50	-	50	50	100
7		Seminar	TPT 495	2	0	0	4	-	50	-	50	50	100
8		Project	TPT 497	4	0	0	8	-	50	-	50	50	100
Total Credits 22													**800**

Semester-VIII

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	CT	TA	Lab	Total		
1	PEC	***Program Elective Course III** (High Polymeric Engineering OR Technology of Packaging & Waste Management)	TPT 452 OR TPT 454	4	3	1	0	30	20	-	50	50	100
2	PEC	***Program Elective Course IV** (Process Modeling & Simulation OR Computer Aided Process Equipment Design)	TPT 456 OR TPT 458	4	3	1	0	30	20	-	50	50	100
3	OEC (Chemical Engg.)	***Open Elective Course –IV** (Transport Phenomena)	OCH 444	4	3	1	0	30	20	-	50	50	100
4		Project	TPT 498	10	0	0	20	-	50	-	50	50	100
Total Credits 22													**400**

*** Online Courses**

List of Program Elective Courses

S. No.	PEC Names	Subject Name	Subject Code	C (L-T-P)
1.	Program Elective Course I	Technology of Architectural & Eco-friendly Coatings	TPT 455	3 (3-0-0)
		Corrosion Control Technology	TPT 457	
2.	Program Elective Course II	Technology of Industrial and Automotive Coatings	TPT 459	3 (3-0-0)
		Nanotechnology in Surface Coatings	TPT 461	
3.	Program Elective Course III	High Polymeric Engineering	TPT 452	4 (3-1-0)
		Technology of Packaging & Waste Management	TPT 454	
4.	Program Elective Course IV	Process Modeling & Simulation	TPT 456	4 (3-1-0)
		Computer Aided Equipment Design	TPT 458	

List of Open Elective Courses

S. No.	OEC Names	Subject Name	Subject Code	C (L-T-P)
1.	Open Elective Course I (Humanities)	Entrepreneurship Development	HHS 351	3 (3-0-0)
2.	Open Elective Course II (Maths)	Operations Research	BMA 352	3 (3-0-0)
3.	Open Elective Course III (Paint Technology)	Basic Paint Technology	OPT 433	3 (3-0-0)
4.	Open Elective Course IV (Chemical Engg.)	Transport Phenomenon	OCH 444	4 (3-1-0)

Semester 1

BCY151: ENGINEERING CHEMISTRY

L	T	P	C
3	0	2	4

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

CO1	Interpret UV-Visible and IR-Spectra	Understand, Analyze
CO2	Describe reaction rates for reactions of various orders	Understand, Apply, Analyze
CO3	Understand different aspects of corrosion and thermodynamic view of electrochemical processes, reversible and irreversible cells	Understand, Apply
CO4	Understand the stereochemistry of molecules and identify organic reactions on the basis of their mechanism	Remember, Apply, Analyze
CO5	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	Understand, Apply, Evaluate, Create

BCY101/ 102	PO 1	PO 2	PO 3	PO4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO12	**PSOs**	
CO1	3	3	1	3	2	-	2	-	-	-	-	3	1	2
CO2	3	3	1	3	2	-	2	-	-	-	-	3	2	2
CO3	3	3	1	3	2	-	2	-	-	-	-	3	1	2
CO4	3	3	1	3	2	-	2	-	-	-	-	3	2	2
CO5	3	3	1	3	2	-	2	-	-	-	-	3	1	2
Average	3	3	1	3	2	-	2	-	-	-	-	3	1.4	2

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

SYLLABUS

Module I
(i) Bonding: CFT, 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.

(Lectures: 7-8)

(ii) Spectroscopy: Basic Principles, Instrumentation and Applications of UV-VIS and IR Spectroscopy.

(Lectures: 5-6)

Module II
(i) 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 in terms of enzyme catalysis.
(Lectures: 4-5)

Module III
(i) Electrochemistry: Dry and fuel cells, electrochemical cell, Solar cells, Disensitized cell, Photovoltaic cell. (Lectures: 3-4)
(ii) 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. (Lectures: 5-6)

Module IV
(ii) 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. (Lectures: 5-6)

(i) 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- Meerweir Rearrangement
d) Umpolung Reactions
e) Reaction of vision **(**Lectures: 4-5)

Module V

(i) Polymers: Introduction and their classifications, types of polymerization, Free radical, anionic and cationic polymerization, Preparation, Rheological properties and uses of some common polymers. Synthetic Polymers (carbon framework, silicon framework, fluorinated polymer), Conducting and Biodegradable polymers. (Lectures: 4-5)

(ii) 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.

(Lectures: 4-5)

List of Experiments:

1. Determination of alkalinity in given water sample.
   a. Sodium Carbonate & Sodium Bicarbonate
   b. 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 determination of given sample.
9. Determination of iron content of water by Mohr's Method.
10. Determination of Dissociation constant of weak acids by conductometric Titration.

Reference Books:

1. Advance Organic Chemistry by Jerry March, Third Edition Wiley Eastern Limited, New Delhi.
2. Organic Chemistry by Morrision & Boyd, Allyn and Bacon, Inc. Boston.
3. Physical Chemistry by Puri, Sharma & Pathania, Peter Atkins & Julio de Paula, Arun Bahl, B.S. Bahl & G.D.Tuli.
4. Textbook of Physical Chemistry by S. Glasstone, Macmillan and Co. Ltd., London.
5. Chemical Kinetics and Reaction Dynamics by Puri, Sharma & Pathania.
6. Principles of Polymerization by George Odian.
7. Polymer Science by V. R. Gowarikar, N. V. Vishwanathan and J. Shridhar, Wiley Eastern Ltd., New Delhi.
8. Principles of Instrumental Analysis by Douglas and Skoog, Saunder College Publishing Co., New York.
9. Engineering Chemistry by Jain & Jain, Dhanpat Rai Publication Co., New Delhi.
10. Application of Absorption Spectroscopy of Organic Compounds by John R. Dyer, Prentice Hall of India Pvt. Ltd., New Delhi.
11. Spectroscopy of Organic Compounds by P.S. Kalsi, Y.R. Sharma.

BMA 151: 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 find convergence of series and improper integrals.	Understand, Apply
CO2	find partial differentiation and evaluate area and volume using multiple integrals.	Apply, Evaluate
CO3	convert line integrals to surface integrals and volume integrals, determine potential functions for irrotational force fields.	Apply, Evaluate
CO4	solve linear system of equations and determine the eigen vectors of the matrix.	Apply, Analyze Evaluate,
CO5	learn concept of optimization and optimization techniques.	Apply, Analyze, Evaluate,

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	**PSOs**	
CO1	3	3	2	1	2	-	-	1	-	1	-	3	**1**	**2**
CO2	3	3	2	1	2	-	-	1	-	1	-	3	2	1
CO3	3	3	2	1	2	-	-	1	-	1	-	3	2	1
CO4	3	3	2	1	2	-	-	1	-	1	-	3	2	2
CO5	3	3	2	1	2	-	-	1	-	1	-	3	2	2
Average	3	3	2	1	2	-	-	1	-	1	-	3	1.8	1.6

Detailed Syllabus:

Unit I- Functions of One Real Variable:

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:

Limit, Continuity, Partial differentiation, Total differential and approximations, Jacobian, Euler's theorem Expansion of functions, Beta and Gamma Functions, Multiple integral, Change of order, Change of variables, Applications to area, volume, mass, surface area etc. Dirichlet's Integral & applications.

Unit III- Vector Calculus:

Point functions, differentiation, Gradient, 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:

Vector space and subspace, linear dependence, dimensions and basis, Linear transformation and its matrix representation, Elementary transformations, Echelon form, rank & nullity, Consistency of linear system of equations and their solutions, characteristic equation, Cayley Hamilton theorem, Real and complex eigenvalues and eigenvectors, diagonalisation, quadratic forms, complex, orthogonal, and unitary matrices, Application to Cryptography, discrete, Compartmental models and system stability.

Unit V- <u>Optimization:</u>

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

Books Recommended:

1. R.K. Jain & S. R. K. lyengar; Advanced Engineering Mathematics, Narosa Publishing House 2002.
2. Erwin Kreyszig: Advanced Engineering Mathematics. John Wiley & Sons 8th Edition.
3. Dennis G. Zill & Michael R Cullen; Advanced Engineering Mathematics, Jones & Bartlett Publishers, 2nd Edition.
4. S.S. Rao; Optimization: Theory & application Wiley Eastern Limited.
5. T.M. Apostol, calculus, Vol. I, 2nd ed., Wiley 1967.
6. T.M. Apostol, Calculus, Vol. II, 2nd ed**.,** Wiley 1969.
7. Gilbert Strang, Linear Algebra & its applications, Nelson Engineering 2007.
8. Calculus & Analytic Geometry, Thomas and Finny.

EET 151: Electronics & Instrumentation Engineering

L	T	P	C
3	0	0	3

OUTCOMES:
Upon Completion of the course the students will be able to:

1. To understand the basic concept of diodes, transistor, and Operational Amplifier.
2. To apply the knowledge in the calculation of the parameters of the diode, transistor, and Operational Amplifier.
3. To design the simple digital circuits.
4. Having the basic knowledge of measurement and applying it in the transducer.
5. To apply the knowledge of measurement with the help of electronic instruments and displaying it on electronic devices.

Syllabus

P-N Junction Diode, V-I Characteristics, Diode Application as Rectifier (Half Wave & Full Wave), Zener Diode and its Applications.
Introduction to Bipolar Junction Transistor, Operational Amplifier and FET: Applications, demo, explanation, Applications
Boolean Algebra, Logic Gates, Concept of Universal Gate, Minimization using K map, Number system
Basic Combinational Circuits: Adder, Subtractor.
Sequential Circuits: Flip-Flops, Registers.
Functional Elements of Instruments, Classification & Characteristics, Types of Errors, Active and Passive Transducers and their Characteristics
Display Devices: Seven Segment Display, Alphanumeric Display, LCD, LED, Plasma, Projectors.
Electronic Ammeter and Voltmeter, Digital Multi-meter, Digital Storage Oscilloscope (DSO)

Text Books:

1. Malvino, A.P. / "Electronics Principles" / Tata McGraw-Hill.
2. Boylestad, Robert &Nashelsky, Louis / "Electronic Devices & Circuit Theory" / Prentice Hall of India.
3. H.S. Kalsi / "Electronic Instrumentation" / Tata McGraw-Hill
4. Malvino& Leach / "Digital Principles & Applications" / Tata McGraw-Hill.

Reference Books:

1. Sedra, Adel S., Smith, Kenneth C. / "Microelectronic Circuits"/ Oxford University Press.
2. Sawhney AK/ "Electrical and electronic Measurement and Instrumentation"/ DhanpatRai& sons.
3. Lectures of NPTEL

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ECE 151: ENGINEERING GRAPHICS (ECE 101/102)

L	T	P	C
0	0	6	3

Syllabus

Unit-I
Lettering and Dimensioning: Introduction, lettering practice, Elements of dimensioning - systems of dimensioning.
Geometric Constructions: Free hand sketching, Conic sections, Special curves.
Engineering Scales

Unit-II
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.

Unit-III
Projection of Solids and Section of Solids
Projection of solids: Classification of solids, Projection of solids in simple position, Projection of solids inclined to one plane. Sections of Solids: Right regular solids and auxiliary views for the true shape of the sections.

Unit-IV
Development of Surfaces
Development of surfaces for various regular solids.
Isometric Projection and Perspective Projection
Isometric Projection: Isometric scales, Isometric projections of simple and combination of solids;
Perspective Projection: Orthographic representation of a perspective views – Plane figures and simple solids - Visual ray method.

Unit-V
Orthographic Projection
Conversion of pictorial view into orthographic Projection.
Introduction to auto CAD

References:

1. K. Venugopal and V. Prabhu Raja, “Engineering Graphics”, New AGE International Publishers, 2015.
2. N. D. Bhatt, Engineering Drawing, Charotar Publishing House.
3. K.V.Natarajan, A Text book of Engineering Graphics, Dhanalakshmi Publishers, 2012.
4. K.L.Narayana, P. Kannaiah & K.Venkata Reddy New Age International Publishers.

ECS 151: COMPUTER CONCEPTS & PROGRAMMING

L	T	P	C
3	0	2	4

Course Outcomes:

1. Identify the parts of the computer system and explain the functioning of its componentsalongwith the process of problem solving. (Remember, Understand)
2. Design an algorithmic solution for a given problem and translate it into a program. (Design)
3. Understand different operating systems, related concepts and their functions. (Understand)
4. Use the appropriate control statements to solve the given problem. (Apply)
5. Implement different Operations on arrays and use functions to solve the given problem. (Apply)
6. Understand pointers, structures and unions &Implement file Operations in C programming. (Understand, Apply)

		PO												PSO	
CO	**Statement**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1		3	3	2	1	2	-	-	1	-	1	-	3	**1**	**2**
CO2		3	3	2	1	2	-	-	1	-	1	-	3	2	1
CO3		3	3	2	1	2	-	-	1	-	1	-	3	2	1
CO4		3	3	2	1	2	-	-	1	-	1	-	3	2	2
CO5		3	3	2	1	2	-	-	1	-	1	-	3	2	2
CO6		3	3	2	1	2	-	-	1	-	1	-	3	2	1
Average		3	3	2	1	2			1		1		3	1.8	1.3

Course Content:

Unit-1:

Introduction to Computers: Computer hardware Components, peripherals and their functions, Number Systems and conversion methods, Concept of an algorithm; termination and correctness. Algorithms to programs: specification, top-down development and stepwise refinement, Introduction to programming environment, use of high level programming language for the systematic developmentof programs. Introduction to the design and implementation of correct, efficient and maintainable programs, Structured Programming, Trace an algorithm to depict the logic.

Unit-2:

Basic operating System Concepts: Introduction of MS-DOS, WINDOWS, and LINUX Operating Systems, Functional Knowledge of these operating systems, Introduction of basic commands of LINUX and Editors, Managing Files and Directories in LINUX, Programming Environment in LINUX, Writing and executing programs in LINUX.

Unit-3:

Programming in C: History, 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.

Unit-4:

Operators: Unary operators, Arithmetic & logical operators, Bit wise 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, Multi-file programs. Arrays: linear arrays, multidimensional arrays, passing arrays to functions, Arrays and strings.

Unit-5:

Structure and Union: definition and differences, self-referential structure. Pointers: value at (*) and address of (&) operator, pointer to pointer, Dynamic Memory Allocation, calloc and malloc functions, array of pointers, function of pointers, structures and pointers. File Handling in C: opening and closing a data file, creating a data file, read and write functions, unformatted data files.

Lab Work:

1. Write C program to find largest of three integers.
2. Write C program to check whether the given string is palindrome or not.
3. Write C program to find whether the given integer is
   (i). a prime number
   (ii). an Armstrong number.
4. Write C program for Pascal triangle.
5. Write C program to find sum and average of n integer using linear array.
6. Write C program to perform addition, multiplication, transpose on matrices.
7. Write C program to find Fibonacci series of iterative method using user-defined function.
8. Write C program to find factorial of n by recursion using user-defined functions.
9. Write C program to perform following operations by using user defined functions:
   (i) Concatenation
   (ii) Reverse
   (iii) String Matching
10. Write C program to find sum of n terms of series: n – n*2/2! + n*3/3! - n*4/4! + ...
11. Write C program to interchange two values using
    (i). Call by value.
    (ii). Call by reference.
12. Write C program to sort the list of integers using dynamic memory allocation.
13. Write C program to display the mark sheet of a student using structure.
14. Write C program to perform following operations on data files:
    (i) Read from data file.
    (ii) Write to data file.
15. Write C program to copy the content of one file to another file using command line argument.

Text and References Books:

1. Kernighan, Ritchie, “The C Programming Language”, PHI
2. V. Rajaraman, “Fundamentals of Computers”, PHI
3. Peter Norton’s, “Introduction to Computers”, TMH
4. Gottfried, “Programming in C”, Schaum’s Series, Tata McGraw Hill
5. YashwantKanitkar, “Working with C”, BPB
6. E. Balagurusamy, “Programming in ANSI C”, TMH

EWS 151: WORKSHOP PRACTICE

L	T	P	C
0	0	4	2

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

Course Outcome

- Acquire skills in basic engineering practice
- Identify the hand tools and instruments.
- Obtain practical skills in the trades.
- Gain measuring skills.

Course Outcome (CO)		Bloom's Knowledge Level (KL)
At the end of the course the student should be able to :		
CO 1	Study and practice on machine tools and their operations	Understand
CO 2	Practice on manufacturing of components using workshop trades including fitting, carpentry, foundry, black - smithy and welding work	Apply
CO 3	Identify and apply suitable tools for machining processes including plain turning, step turning, taper turning, facing, thread cutting operations	Analyze
CO 4	Understand and practice welding and forging operations	Understand
CO 5	Select the appropriate tools required for specific operation	Understand, Apply
CO 6	Comprehend the proper safety measures required to be taken while using different tools.	Remember, Understand

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

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO(	PO10	PO11	PO12	**PSOs**	
CO1	2	-	-	1	1	1	-	-	-	-	-	1	**1**	**2**
CO2	2	-	-	1	1	1	-	-	-	-	-	1	2	1
CO3	2	-	-	1	1	1	-	-	-	-	-	1	2	1
CO4	2	-	-	1	1	1	-	-	-	-	-	1	2	2
CO5	2	-	-	1	1	1	-	-	-	-	-	1	2	2
Avg.	2	-	-	1	1	1	-	-	-	-	-	1	1.8	1.6

1. Slight (Low) 2. Moderate (Medium) 3. Substantial (High)

Course level Assessment Question :

Course Outcome 1 (CO1)

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

Course Outcome 2 (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.

Course Outcome 3 (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.

Course Outcome 4 (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.

Course Outcome 5 (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.

Course Outcome 6 (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.

Semester 2

BPH: 152 PHYSICS (Theory & Lab)

L	T	P
3	0	2

Sessional Marks: 50
End Semester Exam Marks: 50

Course Objectives (COs)

Pre-requisites	Basic knowledge of Maths (12^{th} level)

CO –

CO 1	To understand and apply principle of conservation of momentum, theory of relativity	**Understand and apply**
CO 2	To understand the basics of quantum mechanics and apply its principles to learn the phenomena that occur at subatomic dimensions.	**Understand and analyze**
CO 3	To understand the Maxwell's equations of electromagnetic theory with aim to apply in communication systems.	**Understand and analyze**
CO 4	To apply the fundamentals of material Science especially dielectric materials, semiconducting materials and nano-materials, to apply them in different areas	**Understand and apply**
CO 5	To understand the statistical behavior of the constituent particles and apply the principles of statistical mechanics and basics of laser	**Apply**

PO Matrix

Course	CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSOs	
BPH 101/102	CO1	3	3	1	2	1	2						1	**2**	**2**
	CO2	3	3	1	2	1	2						1	2	2
	CO3	3	3	1	2	1	2						1	2	2
	CO4	3	3	1	2	1	2						1	2	2
	CO5	3	3	1	2	1	2						1	2	2
	Average	3	3	1	2	1	2						1	2	2

Syllabus

MODULE- 1 (Lectures: 08)

Introductory Mechanics & Theory of Relativity: Potential energy function $F = -\text{grad}\,(V)$, equipotential surfaces, meaning of gradient, divergence, curl and their physical significance, Conservative and Non-Conservative forces, Curl of a force, Central forces, Examples of Central forces, Conservation of Angular Momentum,.

Inertial and Non- Inertial Frames of reference, Galilean transformation, Michelson Morley Experiment, Lorentz Transformation, Length contraction, Time dilation and Evidences for time dilation, Relativistic velocity addition formula, Relativistic variation of mass with velocity, Evidence of mass variation with velocity, Einstein's Mass energy equivalence, Examples from nuclear physics, Relativistic energy momentum relation.

MODULE -2 (Lectures: 08)

Quantum Mechanics-Schrodinger Equation and its Applications:

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

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

MODULE – 3 (Lectures: 08)

Electromagnetic Theory: Ampere's law and Faraday's law of electromagnetic induction, Maxwell's equations, Correction of Ampere's law by Maxwell (concept of displacement current), transformation from integral to differential form, Physical significance of each equation,Poyntingtheorem, Maxwell's equations in free space, velocity of electromagnetic wave, Transverse character of the wave and orthogonality of **E**, **H** and **v** vectors, Maxwell's equation in dielectric medium and velocity 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.

MODULE – 4 (Lectures: 09)

Materials of Technological Importance:

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

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.

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

MODULE: 5 (Lectures: 09)

Statistical Mechanics & Lasers: Phase space, the probability of distribution, most probable distribution, Maxwell-Boltzmann Statistics, Applicationsof Maxwell-Boltzmann Statistics, derivation of average velocity, RMS velocity and most probable velocity in the above case, Bose-Einstein Statistics, application to black body radiation, distribution law of energy, Planck's radiation formula and Stefan's law. 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, properties of laser beams, mono-chromaticity, coherence, directionality, and brightness, applications of lasers

References:

1. Physics, Marcelo Alonso, J. Finn Edwards, Addison Wesley
2. Perspectives of Modern Physics, Arthur Beiser, McGraw Hill
3. Engineering Physics, R. K.Shukla, Pearson Education
4. Electrical Engineering Materials, R.K.Shukla, McGraw Hill
5. Introduction to Electrodynamics, David Griffiths, Cambridge University Press
6. Principles of Engineering Physics, R.K.Shukla, Ira Books
7. Introduction to Solid State Physics, Charles Kittel, Willey

List of Experiments:(Any ten experiments)

1. To determine the energy of band gap of a N-type Ge-semiconductor using four probe method

2. Verification of Stefan's fourth power law for black body radiation, determination of the exponent of the temperature
3. Study of thermoelectricity: Determination of thermo-power of Copper-constantan thermo-couple
4. To study the variation of magnetic field with distance along the axis of current carrying coil and then to estimate the radius of the coil
5. Study of Carrey Foster's bridge: determination of resistance per unit length of the bridge wire and of a given unknown resistance
6. Determination of specific charge (charge to mass ratio; e/m) for electron
7. Study of tangent galvanometer: determination of reduction factor and horizontal component of earth's magnetic field
8. Determination of the wavelength of sodium light using Newton Rings' method
9. To determine the concentration of sugar solution using half shade polarimeter
10. Determination of wavelength of spectral lines of mercury (for violet, green, yellow-1 and yellow-2) using plane transmission grating
11. Determination of charge sensitivity and ballistic constant of a ballistic galvanometer

12.To determine the wavelength of spectral lines of hydrogen & hence to determine the value of Rydberg Constant

13.Draw the V-I characteristic of Light Emitting Diode (LED) and determine the value of Planck's constant

BMA -152: 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.	Apply, Analyse Evaluate,
CO2	Find series solutions of ordinary differential equations and learn Bessel's and Legendre's function and its applications.	Apply, Analyse Evaluate,
CO3	Solve IVP_S and BVP_S using Laplace Transform.	Apply, Analyse Evaluate,
CO4	Find Fourier series expansion of given function and solve partial differential equations.	Apply, Analyse Evaluate,
CO5	solve boundary value problems using variable separable method etc.	Apply, Analyse Evaluate,

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
Average	3	3	2	1	2	-	-	1	-	1	-	3

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

Detailed Syllabus:

Unit- I: Ordinary Differential Equations:

First order ordinary differential equations, Existence and uniqueness of solutions of initial value problems, Solution of higher order linear differential equation with constant coefficients, Solution of second order differential equations by changing dependent and independent variables, Cauchy- Euler equations, Methods of diagonalization, undetermined coefficients and variation of parameters: Nonlinear equations, Linear and nonlinear models, Initial value and boundary value problems, Systems of equations. Application of differential equations as mathematical models, Models from population dynamics, Newton's Law of cooling, electric circuit, Oscillation of spring.

Unit-II: Series Solutions of Ordinary Differential Equations & Special Functions

Ordinary and singular points of an 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:

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

Unit-IV: Fourier Series and Partial Differential Equations:

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:

Classification of second order partial differential equations, Derivation of heat and wave equations, solutions in rectangular coordinates by separation variable method, solution of Laplace equation, D'Alemberts solution of wave equation, Non-homogeneous equations and boundary conditions, Orthogonal series expansions, Fourier series in two dimensions, Boundary value 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 & Bartlett Publishers. 2nd Edition.

4. R.K. Jain & S.R.K. Iyengar; Advanced Engineering Mathematics, Narosa Publishing House, 2002.

5. Erwin Kreyszig; Advaced Engineering Mathematics, John Wiley & Sons 8th Edition.

EEE-152: Basic Electrical Engineering

L	T	P	C
3	0	2	4

OBJECTIVE: The objective of this course is to educate the students about:
Various electrical components, connections, DC circuit analysis and basic network theorems applicable to dc network
Single-phase AC fundamentals and its analysis
Three-phase AC circuit connections and analysis under various load conditions
Various measuring instruments with construction, working principle and applications
Basic structure of power system
Concept of magnetic circuits, magnetic coupling and losses occurred in magnetic circuit
Construction and working of single-phase transformers
Basic principle of electrical ac/dc machines with their construction, working principle and applications

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

CO1	An exposure to common electrical components and their ratings.
CO2	Learning of electrical connections by wires of appropriate ratings.
CO3	Learning the usage of common electrical measuring instruments.
CO4	Understanding the basic characteristic of magnetic circuits and transformers
CO5	Understanding the basic characteristic of electrical machines.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO1O	PO11	PO12
CO1	**3**	**3**	**2**	**2**	**2**	**2**	**2**	**2**	**1**	**1**	**1**	**2**
CO2	**3**	**3**	**1**	**1**	**2**	**2**	**1**	**1**	**2**	**2**	**1**	**1**
CO3	**3**	**3**	**2**	**2**	**2**	**2**	**1**	**2**	**2**	**2**	**1**	**1**
CO4	**3**	**3**	**2**	**2**	**2**	**2**	**1**	**2**	**2**	**2**	**1**	**2**
CO5	**3**	**3**	**2**	**2**	**2**	**2**	**1**	**2**	**2**	**2**	**1**	**2**
Avg.	**3**	**3**	**1.8**	**1.8**	**2**	**2**	**1.2**	**1.8**	**1.8**	**1.8**	**1**	**1.6**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) ifthere is no correlation, put "-'

Syllabus

Module I : DC Circuit Analysis and Network Theorems: (9 hours):

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)

Module II: Steady – State Analysis of Single Phase AC Circuits: (8 hours):

AC Fundamentals: 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, Bandwidth and Quality Factor. (Simple Numerical Problems)

Module III:

Three Phase AC Circuits: (3 hours)

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)

Measuring Instruments: (4 hours):

Types of instruments: Construction and Working Principles of PMMC and Moving Iron type Voltmeter & Ammeters, Single Phase Dynamometer Wattmeter and Induction Type Energy Meter, use of Shunts and Multipliers. (Simple Numerical Problems on Energy Meter, Shunts and Multipliers)

Module IV

Introduction To Power System: (2 hours):

General layout of Electrical Power system and functions of its elements, standard transmission and distribution voltages, concept of grid.

Magnetic Circuit: (3 hours):

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

Single Phase Transformer: (3 hours):

Principle of Operation, Construction, e.m.f. equation, equivalent circuit, Power losses, efficiency, introduction to auto transformer. (Simple Numerical Problems)

Module V (8 hours):

Electrical Machines: Principles of electro mechanical energy conversion.

DC Machines:

Types of dc machines, e.m.f. equation of generator and torque equation of motor, characteristics and 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:
Principle of Operation and introduction to methods of starting, applications.

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

Text Books:

1. V. Del Toro, " Principles of Electrical Engineering" Prentice Hall International
2. D. P. Kothari and I. J. Nagrath, "Basic Electrical Engineering", Tata McGraw Hill, 2010.
3. D. C. Kulshreshtha, "Basic Electrical Engineering", McGraw Hill, 2009.
4. L. S. Bobrow, "Fundamentals of Electrical Engineering", Oxford University Press, 2011.
5. E. Hughes, "Electrical and Electronics Technology", Pearson, 2010.
6. V. D. Toro, "Electrical Engineering Fundamentals", Prentice Hall India, 1989.

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

Experiments list.

1. Verification of Kirchhoff's laws.
2. Verification of (1) Superposition Theorem (2) Thevenin's Theorem (3) Maximum Power Transfer Theorem.
3. Measurement of power and power factor in a 1 – Ø ac series inductive circuit and study improvement of power factor using capacitor.
4. Study of phenomenon of resonance in RLC series circuit and obtain the resonant frequency.
5. Measurement of power in 3 – Ø circuit by Two Wattmeter method and determination of its power factor.
6. Determination of parameter of ac 1 – Ø series RLC Circuit.
7. Determination of (1) Voltage Ratio (2) Polarity and (3) Efficiency by load test of a 1 – Ø Transformer.
8. To Study speed control of dc shunt motor using (1) Armature Voltage Control (2) Field Flux Control.
9. Determination of Efficiency of a dc shunt motor by load test.
10. To study running and speed reversal of a 3 – Ø induction motor and record its speed in both direction.
11. To measure energy by a 1 – Ø energy meter and determine error.
12. Department may add any three experiments in the above list.

EME-152: ENGINEERING MECHANICS

L	T	P
3	0	2

Sessional Marks: 50
End Semester Exam Marks: 50

Objective: To provide the basic fundamentals of forces, moments, stresses and strains.

Prerequisite: Class XII Mathematics & Physics

Course Outcomes (COs)
At the end of this course students should be able to:

CO1	Apply basic principal of mechanics and its application in engineering problems.	Understand,Apply
CO2	Determine resultants and apply conditions of static equilibrium to plane force systems.	Apply
CO3	Identify and evaluate all forces associated with a static framework.	Evaluate
CO4	Analyze and sketch shear force and bending moment diagrams.	Analyze
CO5	Derive and apply stress and strain relationships in single and compound members subject to axial force, bending moment and torsion.	Apply
CO6	Stress analysis for two dimensional stress systems.	Analyze

Course Articulation Matrix (CO-PO Matrix of the selected Courses)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSOs	
EME-101/ 102	CO1	3	3	3			1	1	1	1	1		1	3	3
EME-101/ 102	CO2	3	3	3									1	3	3
EME-101/ 102	CO3	3	3	3									1	3	3
EME-101/ 102	CO4		3	2	2								1	3	3
EME-101/ 102	CO5		3	2	2								1	3	3
EME-101/ 102	CO6		3	2	3								1	3	3
														3	**3**

Course Content:

Unit-1:

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-2:

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-3:

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 Inertia, Mass Moment of Inertia of Circular Ring, Disc, Cylinder, Sphere and Cone about their Axis of Symmetry.

Unit-4:

Simple Stress and Strain: 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.

Compound stress and strains: Introduction, state of plane stress, Principal stress and strain, Mohr's stress circle, Theories of Failure.

Unit-5:

Pure Bending of Beams: Introduction, Simple Bending Theory, Stress in beams of different cross sections.

Torsion: Introduction to Torsion of circular shaft, combined bending & torsion of solid & hollow shafts.

Text and Reference Books:

1. Engineering Mechanics by R.K.Bansal
2. Strength of Materials by R.K. Rajput
1. Engineering Mechanics by Irving H. Shames, Prentice-Hall
2. Mechanics of Materials by E. P. Popov, PHI
3. Strength of Materials by Ryder
4. Mechanics of Material by Gere & Timoshenko
5. Engineering Mechanics by A. Nelson
6. Engineering Mechanics by U.C. Jindal
7. Engineering Mechanics Statics by J. L. Meriam & L.G.Kraige

HHS 152: ENGLISH LANGUAGE AND COMPOSITION

L	T	P
2	0	0

Sessional Marks:50
End Semester Exam:50

Course Outcome:

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

CO1	Understand the various techniques of writing effectively and write professional statements & organizational communications.	Apply, Understand
CO2	Develop writing skills by applying different strategies on organization system.	Understand and apply
CO3	Will write articles, reports, projects and different organizational proposals differently and efficiently.	Apply, Create
CO4	Write in concise with brevity and coherency all the messages of the organization.	Analyze and Create

Course	CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
IHU 101/102	CO1	0	0	0	0	0	0	0	0	2	3	0	1	**1**	**2**
	CO2	0	0	0	0	0	0	0	0	2	3	0	1	1	2
	CO3	0	0	0	0	0	0	0	0	2	3	0	1	1	2
	CO4	0	0	0	0	0	0	0	0	2	3	0	1	1	2
Average										2	3		1	1	2

Syllabus

UNIT I Basic Applied Grammar and Usage:
constituent of a sentence- noun, verb, adjective, preposition, etc.; use of articles, adjectival forms, prepositions, adverbs; verb forms; finite and non-finite verbs, gerund and participles, auxiliary verbs. Tense and mood, Subject- verb concord, pronoun concord

UNIT II Sentence Structure-2:
(i) adverb clause, adjective clause, noun-clause; (ii) negation and interrogation; (iii) passive; (iv) exclamatory; (v) transformations; (vi) tense forms; (vii) varieties of sentences; (viii) placement of modifiers

UNIT III Paragraph Writing:
Structure of Paragraph, Topic Sentence, Construction of Paragraph, Technique of Paragraph writing, Unity, Coherence, Emphasis

UNIT IV Comprehension and Précis Writing
Reading and listening comprehension, improving comprehension skills, précis writing

UNIT V Short Essay Writing
Dimension of essay writing- literary, Scientific, Comparison and Contrast, Narrative, Descriptive, Reflective, Expository, Argumentative and Imaginative

References:

1. Das, B K and A David, 'A Remedial Course in English for Colleges', (Book -1,2,3) Oxford University Press, New Delhi.
2. Sinha, R P, 'Current English Grammar and Usage with Composition', Oxford University Press, New Delhi.
3. Wren, P C & Martin, 'English Grammar and Composition', S Chand & Co Ltd. New Delhi.
4. A. S. Horne, Guide to Pattern and usage in English, Oxford University Press, N.D.
5. M.L. Tickoo& A. E. Subramanian, Intermediate Grammar, usage & composition, Orient Longman

HHS 154: PROFESSIONAL COMMUNICATION

Course: B. Tech & MCA	Branch: All	Year / Semester: Ist Year
Sessional Marks:	50	Credit: 3
End Semester Exam:	50	LTP: 3 0 2

Course Outcome:

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

CO1	Understand the basics of technical communication	Apply, Understand
CO2	Developing the skills of variety of the words like synonyms and writing skills.	Understand
CO3	Draft a business letters and resume for to develop for industry.	Apply, Create
CO4	Explore the body language for perfect professional presentation.	Analyze and Create
CO5	To develop the humanistic & scientific approach towards life.	Create
CO6	Present themselves effectively and in a confident manner in the contemporary competitive market.	Apply

CO-PO Matrix

Course	CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSOs	
HHS 103/104	**CO1**	0	0	0	0	0	0	0	0	2	3	0	1	**1**	**2**
	CO2	0	0	0	0	0	0	0	0	2	3	0	1	2	1
	CO3	0	0	0	0	0	0	0	0	2	3	0	1	2	1
	CO4	0	0	0	0	0	0	0	0	2	3	0	1	2	1
	CO5	0	0	0	0	0	0	0	0	2	3	0	1	2	2
average										2	3		1	1.8	1.4

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, 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, visual aids, nuances of delivery, extemporaneous, manuscripts, impromptu, non- verbal strategies.

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

Text Books:

1. 'Improve Your Writing' ed. By V N Arora and Laxmi Chandra, Oxford University Press, New Delhi
2. 'An Anthology of English Short Stories', edited by R P Singh, Oxford University Press.
3. 'Technical Communication- Principles and Practices' by Meenakshi Raman &Sangeeta Sharma, Oxford University Press, New Delhi.

Reference Books:

1. Effective Technical Communication, by Barun K Mitra, Oxford University Press
2. Business Correspondence & Report Writing by R.C. Sharma & Krishna Mohan, Tata McGraw Hill, N.D.
3. Developing Communication Skills by Krishna Mohan & Meera Banerjee, Macmillan India
4. 'Technical Communication- Principles and Practices' by M R S Sharma, Oxford University Press, New Delhi

Semester- 3

BMA 251: MATHEMATICS-III

L	T	P	C
3	1	0	4

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

- various mathematical tools likes Laplace/ Fourier transforms and their applications.
- concepts and principle of complex analysis in solving various real life problems.
- various statistical methods and tests for analyzing experimental data.

Course Outcome

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

CO1	solve boundary value problems using Laplace transform and Fourier transform methods and solve difference equations and BVP_S using z transform.	Apply, Evaluate
CO2	construct conformal mapping between many kinds of domains.	Understand, Apply
CO3	evaluate complex integrals, improper real integrals using various formulae/theorems. find Taylor and Laurents series expansion of complex functions.	Apply, Evaluate
CO4	estimate relationship between two variable using curve fitting, regression and its strength using correlation.	Understand, Apply
CO5	various parametric and nonparametric tests parameter estimation, hypothesis testing and ANOVA.	Understand, Apply

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	**PSOs**	
CO1	3	3	3	3	2	1	2	1	1	-	1	3	**2**	**2**
CO2	3	3	3	3	2	1	2	1	1	-	1	3	2	1
CO3	3	3	3	3	2	1	2	1	1	-	1	3	2	1
CO4	3	3	3	3	1	1	-	-	-	-	-	2	2	2
CO5	3	3	3	3	1	2	3	2	2	1	1	2	2	2
Average	3	3	3	3	1.6	1.2	1.8	1	1	.5	.8	2.6	2	1.6

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

Detailed Syllabus:

Unit – I: <u>Transform Methods:</u>

Fourier integral, conditions of convergence, Fourier sine and cosine integrals, complex form, applications, Fourier transform pairs, existence conditions, operational properties. Applications of Laplace transform and Fourier transform to solve boundary value problems, Discrete and Fast Fourier transforms and its applications.

Development of difference equations as models, operator method, method of undetermined coefficients, Z-transform pairs, ROC. Operational properties, limiting- value theorems, its applications to solve difference equations and BVP, systems of difference equations.

Unit- II: Functions of a Complex Variable and Conformal mapping:

Limit, continuity, differentiability and analyticity, Cauchy-Riemann equations, harmonic functions, complex functions as mappings, liner transformation, inverse transformation, bilinear transformations, conformal mapping, applications.

Unit- III: Integration of Complex Functions:

Contour integrals and evaluations, Cauchy- integral theorem, Cauchy's integral formulae, Liouville's theorem, convergence of power series, Taylor series, Laurent series, zeros and singularities of a complex function, residues and residue theorem, Fundamental theorem of algebra Rouche's theorem, Argument Principle and maximum modules theorem, evaluation of definite and improper integrals.

Unit- IV: Curve- Fitting, Correlation, Regression and Probability:

Curve-fitting, method of least- squares, fitting of straight lines, polynomials, non-linear and exponential curves etc., correlation analysis, linear, non-linear and multi-regression analysis, probability, random variables and probability distributions, expectation, moments and transform methods, Binomial, Poisson and Normal distributions.

Unit- V: Statistical Methods:

Sampling theory (small and large), parameter estimation, confidence intervals, tests of hypotheses and significance; Overview of t-distribution, F-distributions and χ^2-distribution. Z-, t-, F-, and χ^2 tests, goodness of fit test- χ^2 test, analysis of variance, non-parametric tests (Simple application). time series analysis, index numbers, quality control charts.

Books Recommended:

1. Dennis G, Zill & Michael R. Cullen; Advanced Engineering Mathematics, Jones & Bartlett Publishers. 2nd Edition.
2. R.K. Jain & S.R.K. Iyengar; advanced Engineering Mathematics, Narosa Publishing House, 2002.
3 Erwin Kreyszig; Advanced Engineering Mathematics, John Wiley & Sons 8th Edition.
4. R.V. Churchill and J.L. Brown, Complex Variables and Applications, McGraw Hill, 1990.
5. J.N. Kapur and H.C. Saxena, Mathematical Statistics, S.Chand. & Co., 2001.
6. H.C. Saxena, Practical Mathematical Statistics, S. chand & Co., 2000.
7. J.H. Mathews and R.W. Howell, Complex analysis for Mathematics and Engineering, 3rd Ed. Narosa, 1998.

TPT 251: 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 "-"*

Course Level Assessment Questions

Course Outcome 1(CO1)
1. Ingredients of Paints.
2. Applications of Paints and film formations.
3. Indian and Global scenario of Paint industry.

Course Outcome 2(CO2)
1. Triglyceride structure of oils.
2. Physical properties and chemical composition of oils.
3. Testing and analysis of oils.

Course Outcome 3(CO3)
1. Deficiencies in oil films.
2. Physically treated oils.
3. Chemically modified oils.

Course Outcome 4(CO4)
1. Active/ auxiliary and Surface/ Through driers.
2. Composition and properties of various driers .
3. Driers dosages and their effect on film properties.

Course Outcome 5(CO5)
1. Chemical classification of volatile solvents.
2. Various characteristics of solvents and their determination.
3. Preparation of thinners: Conventional and eco-friendly.

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; modern 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; 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 and characteristics of individual oils; classification of glyceride oils-drying, semi drying and non-drying oils; 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 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: Coating Driers: 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.

Module--V : 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, 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.

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, Edward Arnold
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.

Course contents and lecture schedule

Module No.	Topic	No. of Lectures
1.	Surface Coatings	
1.1	Definitions and general classifications; paints, varnishes and lacquers; their components and functions	01
1.2	Coating Binders, media/vehicles, pigmentations	01
1.3	Paint making; Coating Applications; mechanism of film formation	02
1.4	Modern Surface Coatings	01
1.5	Film Ageing	01
1.6	Indian and Global picture of Paint Industry; Career in paint technology	01
2.	Fixed Oils	
2.1	Essential, Mineral and Fixed oils; sources and composition of glyceride oils	01
2.2	Molecular structure of tri-glyceride oils; non-glyceride components of oils	02
2.3	Constitution and molecular structure of fatty acids; distribution of fatty acids in oil molecules	02
2.4	Extraction of oils; processing of oils	02
2.5	Evaluation & characterization of oils – physical and chemical; fatty acid composition and characteristics of individual oils	01
2.6	Classification of glyceride oils-drying, semi drying and non-drying oils; properties and uses of glyceride oils; yellowing and non-yellowing oils	02
2.7	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.	02
3.	Modifications of Oils	
3.1	Deficiencies in oil films	02
3.2	Chemical modifications of triglyceride oils- heat bodied/thermally polymerized (stand) oils, blown oils, boiled & double boiled oils;	01
3.3	Solvent segregation; isomerized oils; dehydrated castor oils; maleinized oils & water soluble oils	02
3.4	Co-polymerized oils; reconstituted (semi-synthetic) oils; limed oils	01
3.5	Catalyzed oils; methyl esters and biodiesel.Refining of oils, Contamination: sources, causes and effects.	01
4.	Coating Driers	
4.1	Constitution; active & auxiliary, primary and secondary	02
4.2	Surface & through driers; metal part and organic acid part of driers;; drier dosage	01
4.3	Properties and uses of individual driers; mechanism of drier action; manufacture of driers	01
4.4	Evaluation of driers; combination of driers	02
4.5	Drier substitutes; drier related paint film defects; driers of water based coatings; future trends	01
5.	Volatile Solvents and Other Components	
5.1	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, aromatic content etc.	02
5.2	Chromatographic techniques for solvent analysis; criteria of solubility; thermodynamics of solubility; solubility parameters; solvent mixture (thinners) – true solvents, latent solvents and diluents;	01
5.3	Evaporation properties of solvent mixtures; azeotropes; activity coefficients; evaporation from polymer films;	02
5.4	Sources and properties of individual solvents. Water as coating solvent; effect of volatile solvents on film properties;	01
5.5	Use of supercritical fluids as solvents; uses of solvents with different binder systems; safety, health & environmental aspects.	01
Total Hours		**40**

TPT 253: 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 glyceride oils: Colour, Specific Gravity, Refractive index, Viscosity, Solubility, Drying Time

II. Chemical Examination/ Characterization of glyceride 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 oils, 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, No. 74, 548 Part (I)
2. AOCS Specifications
3. ASTM Specifications

Course contents and lecture schedule

Laboratory experiments		
1.1	Determination of colour, specific gravity, refractive index, viscosity, solubility, drying time of glyceride oil sample	03
2.1	Determination of acid value, iodine value, saponification value, hydroxyl value of glyceride oil sample	03
3.1	Preparation of heat-bodied (stand) oils, boiled oils, dehydrated castor oils, oil-splitting and reconstituted oils, co-polymerized oils, maleinized oils, water-soluble oils	03
4.1	Preparation of salts of lead/ cobalt/ manganese, as naphthenates and octoates	03
4.2	Determination of non-volatile content, metal content of drier sample	02
5.1	Purification of solvent by washing and determination of yield	03
5.2	Determination 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 of volatile solvent,	04
5.3	Determination of purity of solvent by gas chromatography	02
6.1	Preparation of different types of oil-based coating media by using various drying oils/ natural resins combinations	03
6.2	Determination of colour, specific gravity, refractive index, viscosity, drying time (with various driers), non- volatile (solids) content of coating media	04
Total hours		30

TPT 255: FLUID MECHANICS&MECHANICAL OPERATIONS

L	T	P	C
3	1	2	5

Assessment:

Sessional: 50 marks

End Semester: 50 marks

Course Objective:

To understand basic concept of fluid flow and its application to chemical process industries including pipe flow, fluid machinery and agitation & mixing.

Course outcomes:

CO 1	Understand the need of fluid mechanics for chemical engineers	Understand
CO 2	Understand the basic terms and their concepts of fluid flow	Understand
CO 3	Apply the knowledge to develop a dimensional number for the fluid flow	Apply, Create
CO 4	Understand the fundamentals in characterization and classification of solids	Apply, Analyze
CO 5	Understand the sieving performances using different sieve size	Analyze, Evaluate
CO 6	Calculate the crushing efficiency of different size reduction equipment using crushing laws	Analyze, Evaluate

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	**PSOs**	
CO1	3	3	1	1	-	-	2	-	-	1	-	2	**3**	**2**
CO2	3	3	3	-	-	1	1	-	-	1	-	2	3	3
CO3	3	3	3	3	2	1	1	-	-	1	-	2	3	2
CO4	3	2	1	-	-	2	2	-	-	1	-	2	3	3
CO5	3	3	1	3	1	2	1	-	-	1	-	3	3	2
CO6	3	2	2	2	1	2	1	-	3	1	-	3	3	3
Avg.	3.00	2.67	1.83	1.50	0.67	1.33	1.33	-	0.5	1	-	2.33	3	2.5

Syllabus

Module I (8 hours)

Introduction to process fluid mechanics; Fundamental concepts: Definition of a fluid; Continuum hypothesis; Velocity field; Stress field; 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 (8 hours)

Macroscopic Balances: derivation of integral balances for mass, energy and momentum; Derivation of engineering Bernoulli equation with losses, Application of macroscopic balances: Losses in expansion, Force on a reducing bend, Diameter of a free jet; Jet ejector. Flow measurement: Orifice meter, venturi meter, Pitot tube, and Rota meter.

Module III (8 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 and Compressors.

Module IV (8 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

Module V (8 hours)

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,

Reference:

1. McCabe and Smith, Unit Operations of Chemical Engineering: McGraw Hill

2. Coulson & Richardson , Chemical Engineering Vol. I: Pergamon, 1979 McGraw hill

3. Gupta, Vijay and S. K. Gupta, “Fluid Mechanics and its Applications”, Wiley Eastern, New Delhi (1984).

4. W.L.Badger and J.T.Banchero, Introduction to Chemical Engineering, TMH (1979)

TPT 257: MATERIAL AND ENERGY BALANCE

Assessment:

Sessional: 50 marks

End Semester: 50 marks

L	T	P	C
3	1	0	4

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.	Understand, Apply, Remember
CO2	Select appropriate basis and conduct degree of freedom analysis before 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.	Analyse, Evaluate
CO4	Perform process calculations utilizing psychometric charts and steam tables.	Understand, Apply, Evaluate
CO5	Apply simultaneous material and energy balance calculations for steady state continuous flow systems and unsteady state systems	Understand, Apply, Evaluate

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	**PSOs**	
CO1	3	3	2	1	-	-	-	-	-	-	1	1	**1**	**3**
CO2	3	3	3	2	-	-	-	-	-	-	-	1	2	3
CO3	3	3	3	3	2	2	1	-	-	1	1	1	2	3
CO4	3	3	2	2	1	-	-	-	-	1	1	1	1	3
CO5	3	3	2	1	-	-	-	-	-	-	1	1	2	3
Avg	3	3	2.4	1.8	0.6	0.4	0.2	-	-	0.4	0.8	1	1.6	3

Syllabus

Module 1 (9 hours)

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

Module 2 (7 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 (8 hours)

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

Module 4 (8 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, neutralization and solution. Enthalpy-concentration charts. Orsat analysis Calculation of theoretical and actual flame temperatures

Module 5 (8 hours)

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

Suggested Text books

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

Suggested Reference Books

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

HHS 253: ORGANIZATIONAL BEHAVIOR

Course: IIIrd B. Tech	Branch: CS/IT	Year / Semester: IIIrd Year
Sessional Marks:	50	Credit: 3
End Semester Exam:	50	LTP: 3 0 0

Objective:

- To identify organizational objectives, components and models for better results in attaining organizational goals;
- To understand individual behavior dimensions and interpersonal behavior;
- To analyze group, group behaviour, team and team building with its key role in organization;

Course Outcomes (COs)

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

CO1	Understand organisation, features, key elements, components, types and OB Models	Understand
CO2	Demonstrate individual behavioural dimensions, learning theories, perceptual process, values & ethics with motivational techniques in stressed situations.	Understand and apply
CO3	Identify mechanism for conducive survival of individual in an organization with interpersonal understanding.	Analyze and apply
CO4	Ascertain group, group behaviour, team building with its key role in organization	Analyze, evaluate and apply
CO5	Demonstrate organisational structure, organisational change, organisational development for achieving higher productivity and accomplishing goals of organisation	Analyze and evaluate

CO-PO Matrix

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSOs	
CO1	0	0	0	1	0	1	1	1	2	2	1	3	**3**	**3**
CO2	0	0	0	1	0	1	1	3	3	3	1	3	3	3
CO3	0	0	0	1	0	2	1	3	3	3	2	3	3	3
CO4	0	0	0	2	0	2	2	3	3	3	2	3	3	3
CO5	0	0	0	2	0	1	2	2	2	2	2	3	3	3
Average				1.4		1.4	1.4	2.4	2.6	2.6	1.6	3	3	3

Syllabus

Unit 1: Introduction to organizations

What is an organization, components of organization, nature and variety of organizations (in terms of objectives, structure etc.), models of analyzing organizational phenomena, organizational and business variables, organizations in the Indian context, institutions and structures,

Unit 2: Dimensions of Individual Behavior

Individual Behavior, Dimensions of individual behavior: Perceptions, Learning, Motivation, Personality, Commitment, Attitudes, Values & Ethics, Stress Management

Unit 3: Dimensions of Interpersonal Behavior

Transactional Analysis, Interpersonal communication, Listening, Feedback, Counseling,

Unit 4: Group Behavior

Leadership, Communication, Group: Formal Vs Informal Groups, Group Decision making, Team: Team building, team problem solving.

Unit 5: Organizational Dimensions

Organizational Structure: Elements of Organizational Structure, Dimensions of Organizational Structure, Organizational change, Organizational Development, Power, Authority, Politics

Test Books:

1. Luthans Fred., "Organizational Behavior", McGraw Hill, 1998
2. Pareek, Udai, "Understanding Organizational Behavior, Oxford university press

Additional Reference Books:

1. Robbins (4th ed.), "Essentials of organizational behavior", Prentice Hall of India Pv1. Ltd., New Delhi, 1995
2. Keith Davis, "Organisational Behaviour,
3. Hersey and Blanchard (6th ed.). "Management of organizational behavior L utilising human resources", Prentice Hall of India Pv1. Ltd., New Delhi, 1996.
4. Nancy J. Adler, “International Organisational behavior’, Cengage Learning
5. Nelson Quick, ‘Organizational Behaviour Function Learning’ Fifth Edition

Semester- 4
BCY 252: MODERN ANALYTICAL TECHNIQUES

L	T	P	C
3	0	2	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												
BCY101/ 102	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 there is no correlation put "-".

Syllabus

Module I

(i) Infrared Spectroscopy: Introduction, Principle, Instrumentation, mechanics of measurements, Selection rules, fundamental vibration modes, Factors influencing the Band Position and intensities, some characteristics frequencies and co-relation of IR spectra with molecular structures, effect of Hydrogen Bonding on vibrational frequencies.

(Lectures: 6-7)

(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.

(Lectures: 4-5)

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, DEPT NMR, C^{13} NMR, P^{31}NMR, F^{19}NMR. (Lectures: 4-5)

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

(Lectures: 3-4)

(iii) ESR (Electron Spin Resonance) - Basic Principles and Magnetic Interactions, 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: 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 (Lectures: 4-5)

Module V

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

CHEMISTRY LAB

List of Experiments:

1. Estimation of vitamin C in commercial soft drink / Glucon D.
2. Determine the strength of oxalic acid conductometrically using sodium hydroxide solution.
3. Separation of amino acids by thin layer chromatography.
4. Determination of Rf value of Methyl Orange and Phenolphthalein using paper/ thin layer chromatography.
5. Separation of metal ions by paper/thin layer 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. Prepare 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. Evaluation of Dissociation Constant k for a weak acid using conductometry.
12. Elution of chemicals by Column Chromatography.
13. Elution of genomic DNA from plants suspension.
14. Estimation of Phosphoric acid from coca cola.

Reference Books:

1. Instrumental Analysis, Douglas A. Skoog, F. James Holler & Stanley R. Crouch.
2. Instrumental Methods of Analysis, Willard, Merit and Dean.
3. Handbook of Instrumental Techniques for Analytical Chemistry Ronald A. Hites, Indian University, School of Public and Environmental Affairs and Department of Chemistry.
4. Applications of absorption spectroscopy of organic compounds, John R. Dyer.

5. Instrumental Methods Analysis, B. K. Sharma.
6. Text book of Quantitative Inorganic Analysis, A. I. Vogel.
7. Spectroscopy of Organic Compounds by P.S. Kalsi, Y.R. Sharma, Robert M. Silverstein & Francis X. Webster.

BMA 252: COMPUTER ORIENTED NUMERICAL METHODS

L	T	P	C
2	1	2	4

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

- various numerical methods for solving linear and non linear equations.
- various numerical techniques of interpolation, integration and differentiation with their applications.
- various numerical methods to solve IVP_S and BVP_S.
- developing computer programs of numerical methods using C/C^{++} language.

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.	Apply, Evaluate
CO2	use interpolation techniques and to find numerical differentiation/ integration of data function.	Apply, Evaluate
CO3	use numerical methods for finding solutions of ordinary differential equations, simultaneous and higher order equations.	Apply, Evaluate
CO4	learn numerical methods for finding solution of initial and boundary value problems, partial differential equations.	Apply, Evaluate
CO5	learn basic concepts of some Finite element methods.	Apply, Evaluate
CO6	developing computer programs of numerical methods using C/C^{++} language.	Apply, Evaluate, Create

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

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	-	-	-	-	3
CO4	3	2	3	3	1	1	1	-	-	-	-	3
CO5	3	2	3	3	1	1	1	-	-	-	-	3
CO6	3	2	2	2	3	2	1	2	2	2	2	3
Average	3	2	2.83	2.83	1.33	1.16	1	.33	.33	.33	.33	3

Syllabus:

UNIT I: Nonlinear Equations and Simultaneous Linear Equations

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, a system of nonlinear equations: Newton-Raphson and Iteration methods, Polynomial equations: Bairstow's method, convergence analysis of above methods.

Linear systems: Introduction, Direct methods, Operation count, Pivoting, III 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

Curve fitting: Polynomial interpolation, error, Existence and Uniqueness, Truncation error bounds, difference operators, Newton forward and backward difference interpolations, Lagrange, Newton divided difference and Iterated interpolations, stirling and Bessel's interpolations, Spline interpolation, Least squares and Chebyshev approximations. Numerical Differentiation: Methods based on interpolation, Error analysis. Numerical Integration: Methods based on interpolations (Trapezoidal, Simpson's 1/3, simpson's 3/8 rule), Gauss quadrature methods, Romberg integration, Error bounds and estimates.

UNIT III: Numerical Solution of Ordinary Differential Equations

Initial-value problems, Single step methods: Taylor's, Picard's, Euler's, Modified Euler's method and Runge-Kutta method (fourth Order), Error estimates, Multi-step methods: Adam's-Bashforth and Milne's methods, convergence and stability analysis, Simultaneous and Higher order equations: RK Fourth order method.

UNIT IV: Initial & Boundary Value Problems and Iterative Solvers

BVP: Shooting method and Finite difference methods for Ordinary Differential Equations, Solution of Partial differential equation; solution of Laplace, Poisson equations: Standard 5- point and diagonal 5- point formulae, Jacobi method, Gauss Seidel method (Liebmann's iterative method) Relaxation method. Solution of heat equation: Crank – Nicolson method, Solution of wave equation.

UNIT V: Finite Element Method

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 Simpson 3/8 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, Intoductory Methods of Numerical Analysis, Eastern Economy Edition.
3. S. Rajasekaran, Numerical Method in Science and Engineering, Wheeler Publishing House.
4. B.S. Grewal, Numerical Method in Engineering & Science, Khanna Publishers.

TPT – 252: TECHNOLOGY OF NATURAL RESINS, ALKYDS AND POLYESTERS

L	T	P	C
3	1	2	5

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
CO6												
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 "-"*

Course Level Assessment Questions

Course Outcome 1(CO1)

Resinous state and fossil resins.
Production of rosin and its various modifications.
Production of shellac and its various modifications.

Course Outcome 2(CO2)

Cellulosic polymers such as N.C., CAB, CMC; Properties and uses.
Chlorinated and cyclized rubber resins; and their use in surface coatings.
Types of plasticizers; their properties and use.

Course Outcome 3(CO3)

Functionality, non-convertible and convertible film formers.
Oil-free alkyds: preparation, properties and uses.
Unsaturated polyester resins for use in eco-friendly and radiation curable coatings.

Course Outcome 4(CO4)

Chemistry and raw materials involved in alkyd preparation.
Concepts of oil length, excess hydroxyls and alkyd constants related to alkyds.
Application of Carothers's equation for safe processing of alkyds and water soluble alkyds.

Course Outcome 5(CO5)

Bitumen, gilsonites and petroleum resins.
Coumarone-indene and terpene resins.

CNSL resins, ketonic resins, polycarbonates.
Suspension polymerization techniques.
Learn about other polymerization techniques.

SYLLABUS

Module- I: Natural Resins and Their Modifications

Resins and polymers, resinous state and degree of polymerization, classification of resins, classification of natural resins, sources, availability and properties of fossil &semifossil resins, processing of natural resins- congo, copal, kauri etc. 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, toll oil rosin), properties of rosins, structure-property relationship, deficiencies of rosin films, disproportionate 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. 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 polishes, uses of shellac in surface coatings.

Module-II: Natural Polymers and Their Modifications

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 viscosity, grades of NC based on solubility, structure-property relationship, organic 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). 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.Rubber resins: 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/ latices.

Module-III: Introduction to Synthetic Polymers

Polymerisable monomers vs. Monomeric chemicals, functionality of molecules and its determination; degree of polymerization and molecular weight; non-convertible and convertible film-formers.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 cure compositions, water soluble polyesters.

Module-IV: Alkyd resins

Raw materials & their properties, oils & fatty acids for alkyds, chemistry and formulation of various alkyds, oil length & its effect on alkyds and film properties, excess hydroxyls, Carother's equation and its applications, alkyd constant, tailor-making of alkyds, formula calculation, manufacturing processes and commercial plant (batch & continuous), gelation tendency & safe processing, classification, properties and application of various types of alkyds, modification of alkyds such as co-polymerized alkyds, natural and synthetic resin modified alkyds, water soluble alkyds. Alkyd emulsion, secondary alkyd invert emulsion

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 :fluoro polymers, PVDF resin, PTFE, ketonic resins, polycarbonates, CNSL & BSNL resins etc.

Module-VI:

I. Physical Examinations of natural resins: Softening point, Solubility in solvents of varying polarity, Viscosity & non-volatile contents of resin solutions.

II. Chemical examination of natural resins: Acid value, hydroxyl value, Molecular weight (viscosity method, Gel Permeation Chromatography)

III. Preparation and testing of rosin modifications:

(i) Lime, Zinc oxide, Magnesium oxide hardened rosin
(ii) Rosin esters (ester gum and penta ester gum)
(iii) Rosin-maleic adduct (normal)
(iv) Rosin-maleic adduct (water-soluble)
(v) Maleic Resin (normal)
(vi) Maleic Resin (spirit soluble)
(vii) Maleic Resin (water soluble)
(viii) Rosin modified phenolics
(ix) Lime, zinc, magnesium hardened maleic adduct.
(x) Methyl-esters of rosin.

IV. Chemical modifications of shellac

V. Preparation of clear lacquers (NC and Acrylics), and determination of their viscosity, solids content and drying time

VI. Evaluation of plasticizers for their efficiency

VII. Preparation and application (brush/spray) of varnishes based on rosin esters, and testing them for viscosity, non-volatile (solids) content and drying time

VIII. Water solubility of casein, HEC, SCMC

IX. Evaluation of various grades of NCs, chlorinated rubbers and cyclized rubbers by their solubility behaviors, solids content and viscosity of solutions.

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 &Meenal Sikchi.
4. Modern Surface Coatings, by P.Nylon 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.

Course contents and lecture schedule

Module No.	Topic	No. of Lectures
1.	Natural resins and their modifications	
1.1	Resins and polymers; and their classification	01
1.2	Processing of natural resins	01
1.3	Rosin production and types	01
1.4	Modification of rosins	01
1.5	Maleic resin	01
1.6	Production and composition of shellac	01
1.7	Chemical modification of shellac and their uses in coatings	01
2.	Natural polymers and their modifications	
2.1	Deficiencies of natural cellulose as coating binder	01
2.2	Nitro cellulose, DS and DP	01
2.3	Cellulose ethers and their properties & uses	01
2.4	Chlorinated rubbers and cyclized rubber	01
2.5	Plasticizers, mechanism of plasticization	01
2.6	Evaluation of plasticizers and their efficiency	01
3.	Introduction to synthetic polymers	
3.1	Monomers, oligomers, polymers and high polymers	01
3.2	Convertible and non-convertible film formers	01
3.3	Saturated polyester resins, properties and uses	01
3.4	Unsaturated polyester resins, high solids and radiation curable coatings	01
3.5	Water soluble polyesters	01
4.	Alkyd resins	
4.1	Drying and non-drying alkyds, short, medium and long oil alkyds	02
4.2	Monoglyceride and fatty acid methods; fusion and solvent processes	02
4.3	Gelation tendency, excess hyroxyls, alkyd constant and Carothers's equation	01
4.4	Modified alkyds	01
5.	Hydrocarbon and other resins	
5.1	Bitumen and asphalts; gilsonite and petroleum resins	02
5.2	Coumarone-indene resins, terpene resins	02
5.3	Fluoro polymers and ketonic resins	01
5.4	Polycarbonates and CNSL resins	01
Total hours		**30**
LAB		
6.1	Physical examination of natural resins	04
6.2	Chemical examination of natural resins	04
6.3	Preparation and testing of rosin modifications	16
6.4	Preparation and application of varnishes based on Rosin esters and testing them for viscosity, non-volatile content and drying time	04
6.5	Water solubility of HEC and SCMC	02
6.6	Evaluation of various grades of NC, Chlorinated rubber and Cyclized rubber	04
Total hours		**34**
Grand Total (hours)		**64**

TPT 254: HEAT TRANSFER OPERATIONS

Assessment:

Sessional: 50 marks

End Semester: 50 marks

Course Objective: To understand the fundamentals of heat transfer mechanisms in fluids and solids and their applications in various heat transfer equipment in process industries.

Course outcomes:

CO 1.	Understand different modes of heat transfer.	Understand
CO 2	Apply the concepts of one-dimensional and multi-dimensional; steady and unsteady state conduction heat transfer, and relevant boundary and initial conditions in problem solving.	Apply, Analyze ,Evaluate
CO 3.	Apply the knowledge of analytical and graphical (temperature charts) techniques in solving specific transient heat conduction problems, including lumped and one-dimensional systems	Apply, Evaluate
CO 4	Understand the concept of temperature-dependent buoyancy which causes natural free convection, and apply the dimensionless Grashof number used in correlations for free convective heat transfer calculations	Understand, Analyze, Evaluate
CO 5.	Understand phase-change phenomena and latent heat of vaporization, including free convective, nucleate and film boiling, as well as dropwise and film condensation	Understand, Analyze

		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	**PSOs**	
CO1		3	2	1	1	-	-	2	-	-	1	-	1	**1**	**2**
CO2		3	3	3	3	2	1	1	-	-	1	-	1	2	2
CO3		3	3	3	3	3	1	1	-	-	1	1	1	1	2
CO4		3	2	3	3	3	2	2	-	-	1	1	1	2	2
CO5		3	3	3	3	1	2	1	-	-	1	1	1	1	2
Avg.		3	2.6	2.6	2.6	1.8	1.2	1.4	-	-	1	0.6	1	1.4	2

Syllabus

Module 1 (6 hours)

Introduction ot heat transfer and general concepts of heat transfer by conduction, convection and radiation, 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 materials, critical and optimal, 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, heat transfer in molten metals.

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 vapours, film wise and drop wise condensation, eat 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, tube and tube distribution, tubes to tube sheet joint, 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.

BOOKS:

1. "Heat Transfer principles and applications" Dutta, B. K., PHI
2. "Heat Transfer" Holman J. P, 9th Ed. McGraw Hill.
3. "Process Heat Transfer". Kern D. Q. McGraw Hill Book
4.Heat and Mass Transfer Fundamentals and Applications, Cengel Y. A. and Ghajar A. J., McGraw Hill,5th edition, 2016.

TPT 256: CHEMICAL ENGINEERING THERMODYNAMICS

Assessment:
Sessional: 50 marks

End Semester: 50 marks

L	T	P	C
2	1	0	3

Course 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:

CO 1	Understand the basic of thermodynamics and the terminology associated with engineering thermodynamics	Understand
CO 2	Understand the knowledge of contemporary issues related to chemical engineering thermodynamics	Understand
CO 3	Understand and apply the knowledge of phase equilibria in two-component and multi-component systems	Understand, Apply
CO 4	Analyse the thermodynamic properties of substances in gas or liquid state of ideal and real mixture	Apply
CO 5	Understand intermolecular potential and excess property behaviour of multi-component systems	Understand

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	**PSOs**	
CO1	3	2	1	1	-	-	1	-	-	1	-	1	**1**	**2**
CO2	3	1	1	1	-	3	3	-	-	1	-	1	2	2
CO3	3	3	2	2	3	-	-	-	-	1	-	1	1	2
CO4	3	3	3	2	3	1	1	-	-	1	-	1	2	2
CO5	3	2	2	3	2	1	1	-	-	1	-	1	2	2
Avg.	3	2.2	1.8	1.8	1.6	1	1.2	-	-	1	-	1	1.6	2

Syllabus

Module 1 (8 hours)

Basic Concepts & First Law of Thermodynamics: Scope of thermodynamics, System & Surroundings, Properties -Force, Temperature & pressure, Equilibrium, Processes- Reversible & Irreversible, Work, Heat, Energy ,Phase rule, Joule's Experiment, Internal energy, Enthalpy, Heat capacities, Application of first law to closed & open systems.Volumetric properties of pure fluids: PVT behavior of pure substances, Virial equation of state and its application ,ideal gas and cubic equation of state, Generalized correlations for gases and liquids.

Module 2 (6 hours)

Second Law of Thermodynamics: Heat engine and its efficiency, Heat pump, Refrigerator, COP, Second law of Thermodynamics, Kelvin–Planck statement &Clausius Statement, Carnot's cycle and Carnot theorems, Clausius inequality, Entropy balance for open systems, ideal work and lost work, Principle of entropy.

Module 3 (6 hours)

Residual properties, two phase systems: Clapeyron equation, Estimation of thermodynamic properties by using graphs and tables. Solution thermodynamics Theory: Fundamental property relation, Chemical potential and phase equilibria, Partial properties ,Ideal gas mixture model.

Module 4 (6 hours)F

Fugacity and fugacity coefficient for pure species, and in solution. Ideal solution model and excess properties. Solution thermodynamics Application: Liquid phase properties from VLE data, Models for the excess Gibbs energy, Property changes of mixing.

Module 5 (4 hours)

Phase Equilibria: Nature of equilibrium, phase rule, VLE qualitative behavior, Simple Models for VLE, VLE by Modified Raoult's law and VLE from K-value charts.

Reference

1. "Introduction to Chemical Engineering Thermodynamics" by J.M. Smith and H.C. Van Ness, McGraw Hill International Ltd, 2005.
2. "Chemical Engineering Thermodynamics" by Y.V.C. Rao, Universities Press (India) Ltd. Hyderabad.
3. "Chemical and Process Thermodynamics", Kyle B.G., 3rd ed., Prentice Hall. 1999
4. "Chemical Engineering Thermodynamics", by Narayanan, K.V., Prentice Hall. 2007

HHS 252: ENGINEERING ECONOMICS AND MANAGEMENT

L	T	P	C
3	0	0	3

Course: B. Tech.	**Branch:** All Branches	**Year: 2nd Year**
Sessional Marks:	**50**	**Credit: 3**
End Semester Exam:	**50**	**LTP: 3 0 0**

Objective:

- ✓ To provide useful knowledge to engineering students in their professional career particularly in corporate and manufacturing sector.
- ✓ To understand essential economic principles for solving economic problems with suitable policy alternatives.
- ✓ To study and analyze the contemporary market situations, market strategy to manage the business and industry.
- ✓ To understand fundamental of business management and apply management techniques for the benefit of business and society.

Course Outcome (COs)

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

CO1	Understand essential economic principles for solving economic problems with suitable policy alternatives	Understand
CO2	Understand and evaluate the production system with different type of cost.	Understand, evaluate
CO3	Study and analyse the market, structure, types and characteristics	Analyze and apply
CO4	Understand fundamentals of management principles and functions	Understand and apply
CO5	Know various forms of business ownership, formation and their relevance	Analyze, evaluate and apply

CO-PO Matrix

Course	CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSOs	
HHS-201/202	CO1	0	0	0	1	0	2	1	3	1	3	3	3	**1**	**2**
	CO2	1	0	0	0	0	2	1	3	3	3	3	3	2	1
	CO3	0	0	0	1	0	2	2	3	2	3	3	3	1	2
	CO4	0	0	0	0	0	2	2	3	3	3	3	3	1	2
	CO5	0	0	0	0	0	2	3	3	3	2	3	3	3	2
Average		0.2	0	0	0.4	0	2	1.8	3	2.4	2.8	3	3	1.6	1.8

Syllabus

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

UNIT II Production and Cost:
Factors of production, production function, law of variable proportion, isoquant analysis, return to scale, economies of scale;
Types of costs: direct and indirect costs, explicit and implicit costs, opportunity cost, economic cost, fixed cost and variable costs, average and marginal costs, short-run and long-run costs, optimal combination of factor-inputs.

UNIT III Market Structure:
Perfectly Competitive Market, Imperfect market: Monopoly, Oligopoly, Monopolistic Market

UNIT IV Fundamentals of Management:
Development of Management Thoughts, Objectives, Functions of Management: Planning, Organising, Directing, Controlling and Coordination.

UNIT V Business Enterprises-
Business Ownership: Sole Proprietorship, Partnership, Company: Promotion, Formation & Development, Cooperative Firms.

Text Books:

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

Additional Reference Books:

1. **Armstrong, Michel**, "A Handbook of Management Techniques", Kogan Page Limited
2. **Babcock, DL and Lucy C. Morse**, "Managing Engineering and Technology", 3rd edn, Pearson Education, 2006
3. **Pindyck, R S, Rubinfeld, D L &Mehta** , 'Microeconomics', 6th Edition, Pearson Education India.
4. **Barthwal, R R , Microeconomic Analysis**
5. **Samuelson, Paul A** , 'Economics', 5th edition, McGraw Hill New York.
6. **Henderson, J M and Quadnt, R E** , 'Microeconomic Theory: A Mathematical Approach.', Tata MacGraw Hill, New Delhi,2003
7. **H. Varian,** 'Intermediate Micro Economics'
8. **G. Mankiw,''**Principles of Micro Economics

SEMESTER - 5

TPT – 351: TECHNOLOGY OF SYNTHETIC RESINS AND POLYMERS

L	T	P	C
3	0	3	4

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

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

CO1	Understand the 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 "-"*

Course Level Assessment Questions

Course Outcome 1(CO1)

1. Pigments and their characteristics.
2. Extenders and their characteristics.
3. Selection of pigments and extenders for various applications.

Course Outcome 2(CO2)

1. Classification of pigments and their manufacturing
2. Effect of surface treatment of pigments and extenders
3. Function of nano-pigments

Course Outcome 3(CO3)

1. Role of extenders in paints and varnishes.
2. Type of extenders.
3. Cost and performance effect of extenders on coating.

Course Outcome 4(CO4)

1. White and blackpigments, their manufacturing and properties
2. Colour pigments, their manufacturing and properties
3. Role of pigments in coating performance.

Course Outcome 5(CO5)

1. Types of inorganic colour pigments
2. Toxicity in pigments.
3. Particle size and their effect on colour and other properties.

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 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, cadmium pigments, prussian and ultramarine blue, mercuric sulphide, cobalt blue, cadmium pigments, synthetic inorganic complexes and mixed pigments e.g. Sprinel pigments etc.

References and suggested readings:

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

Course content and lecture schedule

Module No.	Topic	No. of Lectures
1.	Properties of pigments and extenders	
1.1	Particle size, shape and surface area	01
1.2	Colour, mass tone and reducing power	01
1.3	Sp. Gravity and bulking value	01
1.4	Residue on sieve, water soluble matter	01
1.5	Hiding power, oil absorption	01
1.6	Physico-chemical	02
1.7	Functional and thermal	02
2.	Introduction to pigments and extenders	
2.1	Definition and classification	01
2.2	Methods of manufacturing	01
2.3	Nano pigments	01
2.4	Surface treatment of pigments and extenders	01
3.	Extender pigments	
3.1	Source, manufacturing and classification of extenders	01
3.2	Carbonate extenders	01
3.3	Silicate extenders	02
3.4	Sulfate extenders	01
3.5	Miscellaneous extenders	01
4.	White and black pigments	
4.1	Titanium dioxide, properties and manufacturing	02
4.2	Zinc oxide and other white pigments	02
4.3	Carbon black	02
4.4	Iron and other black pigments	02
5.	Colour pigments	
5.1	Iron oxide natural and synthetic	02
5.2	Chrome pigments	02
5.3	Prussian and ultramarine blue	02
5.4	Miscellaneous and inorganic complexes	02
5.5	Composite colour pigments	01
Total hours		**36**
6.	Laboratory experiments	
6.1	Testing of general properties	04
6.2	Testing and evaluation of characteristic properties.	05
6.3	Chemical testing	05
6.4	Preparation and characterization of inorganic pigments	05
6.5	Preparation and characterization of organic pigments	04
6.6	Preparation and characterization of extenders	04
6.7	Analysis of pigments and extenders	03
Total hours		**30**
Grand total hours		**66**

TPT – 353: TECHNOLOGY OF SYNTHETIC RESINS AND POLYMERS LAB

L	T	P	C
0	0	3	4

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

Course Outcome

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

CO1	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 "-"*

Syllabus

(A) 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, etc.

(B) Preparation of pigments

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

(C) Preparation of Extenders

Calcium carbonate, Barium sulphate, Silica, etc.

Course content and lecture schedule

Laboratory experiments		
1.1	Testing of general properties	06
1.2	Testing and evaluation of characteristic properties.	06
1.3	Preparation and characterization of inorganic pigments	10
1.4	Preparation and characterization of extenders	04
1.5	Analysis of pigments and extenders	04
Total hours		**30**

References:

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

NOTE: The modern instrumentation techniques should also be used in Evaluation, Testing, Analysis and Characterization is to be done by using modern instrumentation.

TPT 355: TECHNOLOGY OF INORGANIC PIGMENTS AND EXTENDERS

L	T	P	C
3	1	2	5

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
CO6	Preparation of various synthetic resins and their emulsions and analyze them for various properties	Create, Analyze

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
CO6	3	3	3	3	3	-	3	-	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 "-"*

Course Level Assessment Questions

Course Outcome 1(CO1)
1. Pure and reduced phenolics.
2. Novolacs and resols.
3. Urea and melamine formaldehyde resins.

Course Outcome 2(CO2)
1. Degba type of epoxy resins.
2. Epoxy esters and their characterization.
3. Polyamide resins, their properties and uses.

Course Outcome 3(CO3)
1. Various isocynates, polyols and castor oil for the preparation of PU resins.
2. Classification of PU resins.
3. Single and two pack coating systems.

Course Outcome 4(CO4)
1. Silicate binders, their properties and uses.
2. Silicone resins and silicone oils.
3. Pure and modified silicones.

Course Outcome 5(CO5)
1. PVC copolymers, properties and uses.
2. TPAs and TSAs.
3. Emulsions/ latexes and water reducible TSAs.

Course Outcome 6(CO6)
1. Preparation of U/F, M/F resins.
2. Preparation of epoxy and polyurethane resins.
3. Preparation of emulsions/ latexes based on acrylics.

SYLLABUS

Module-I: Formaldehyde resins:
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. 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 resins
Epoxy resins : Chemistry, raw materials, BPA, hydrogenated &BPF epoxies, diepoxide resins, polyepoxide resins, manufacture of epoxy resins, epoxide equivalent, hydroxyl 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 novolacresis, high functionality poly phenols for high solid, low viscosity resins, UV stable epoxy resins (hydrogenated bpa and hydrogenated di amino di phenyl methane resins. Di cyan di amide curing agents, thermoplastic epoxies etc. various epoxy modified resins and their applications, water borne epoxies. Polyamide resins : polyamines and acids used, dimerized fatty acids, properties and applications of various polyamides, reactive and non-reactive polyamides, epoxy amine adducts

Module-III: Polyurethane Resins
Various isocyanates, blocked & polymeric isocynates, polyols, castor oils, catalysts,. NCO/ OH ratio, reactions of isocyanate groups, isocyanate hazards, classification of polyurethanes, urathane oils and uralkyds, properties and applications of various single and two-pack systems, aqueous PU systems, PUDsdimethylol propionic acid), film forming and non-film forming PU resins for flexible packaging, non- isocyanate route to PU .

Module-IV: Silicone resins
Silicate binder (alkali & alkyl), 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 silicones intermediates and their modifications.

Module-V: Ethylenic resins
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. 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

Module-VI: Laboratory Experiments
Bitumen emulsion, CNSL emulsion, rubber emulsion, emulsions based on acrylics, vinyl acetate, PUD , micro emulsions, secondary alkyd emulsion, homopolymers and copolymers by emulsion polymerisation

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 & Meenal Sikchi
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. BIS Specifications
9. AOCS Specification
10. ASTM Specification
11. B.S Specification
NOTE: Evaluation / Testing/ Analysis/ Characterization is to be done by using modern instrumentations.

Course contents and lecture schedule

Module No.	Topic	No. of Lectures
1.	Formaldehyde resins	
1.1	Pure and reduced phenolics	01
1.2	Effect of F/P ratio on resin properties	01
1.3	Novolac and Resoles	01
1.4	Reactive and non-reactive phenolics	01
1.5	U/F and M/F resins	01
1.6	Methylol products	01
1.7	Water soluble amino and phenolic resins	01
2.	Epoxy resins	
2.1	Phenols, Bisphenols and Epichlorohydrins	01
2.2	Chemistry and manufacture of epoxy resins	02
2.3	Epoxy equivalent and hydroxyl equivalents	01
2.4	Curing agents for epoxy resins	01
2.5	Polyamide resins, as curing agents for epoxy resins	01
3.	Polyurethane resins	
3.1	Aliphatic and aromatic isocyanates, polyols and castor oils for use in PU resins formulations	01
3.2	Chemistry of isocyanates groups	01
3.3	Classification of PU resins	01
3.4	Urethane oils and Uralkyds	01
3.5	Aqueous PUDs for eco-friendly coatings	01
4.	Silicone resins	
4.1	Alkali and alkyl silicates in inorganic coatings	02
4.2	Synthesis of Silicone resins	02
4.3	Structure-properties relation ship	01
4.4	Pure and modified silicones	01
5.	Ethylenic resins	
5.1	Homopolymers and co-polymers based on various vinyl monomers	02
5.2	Properties and uses of Vinyl homopolymers and polymers in surface coatings	01
5.3	Monomers for TPAs and TSAs	01
5.4	Tg and MFFT of copolymers	01
5.5	Emulsions and latexes based on acrylics	01
	Total hours	**30**
6.	Laboratory Experiments	
6.1	Preparation of all type of alkyds (solvent and water based) and testing of their acid value	4
6.2	Preparation and testing of alcohol and oil soluble phenolic resins	2
6.3	Preparation and testing of butylated and methylated UF and MF resin	2
6.4	Preparation and testing of epoxy resins and epoxy esters	2
6.5	Preparation and testing of saturated and unsaturated polyester resins	4
6.6	Preparation and testing of acrylic resins	3
6.7	Preparation and testing of polyurethane resins	2
6.8	Preparation and testing of oil-in-water & water-in-oil type emulsions	2
6.9	Preparation and testing of water reducible & water dispersible media	4
6.10	Preparation and testing of water soluble alkyds	4
6.11	Preparation and testing of water soluble epoxies	4
6.12	Preparation and testing of bitumen emulsion, CNSL emulsion, rubber emulsion	2
6.13	Preparation and testing of homopolymers and copolymers by emulsion polymerisation	4
6.14	Preparation and testing of emulsions based on acrylics& vinyl acetate, PUDs, micro-emulsions, secondary alkyd emulsion	4
	Total hours	**43**
	Grand total hours	**73**

TPT 357: MASS TRANSFER OPERATION

L	T	P	C
3	1	0	4

Assessment:

Sessional: 50 marks

End Semester: 50 marks

Course Objectives: The purpose of this course is to introduce the undergraduate students with the most important separation equipments in the process industry, and provide proper understanding of unit operations.

Course outcomes:

CO 1	Understand the principles of molecular diffusion and basic laws of mass transfer.	Understand,
CO 2	Ability to determine mass transfer rates using Fick's Law	Apply
CO 3	Estimate diffusion coefficients and apply to practical problems	Apply
CO 4	Ability to determine convective mass transfer rates	Apply
CO 5	Analyze the Similarity of mass, heat and momentum transfer – Analogy and understand the humidification processes and use of psychometric chart	Analyze

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	**PSOs**	
CO1	3	2	2	1	-	-	-	-	-	1	1	1	**1**	**2**
CO2	3	2	1	1	-	-	-	-	-	1	1	1	2	1
CO3	3	2	3	2	3	-	-	-	-	1	1	1	1	2
CO4	3	3	2	2	3	-	-	-	-	1	1	1	1	2
CO5	3	3	3	3	2	-	-	-	-	1	1	1	3	2
Avg	3	2.4	2.2	1.8	1.6	-	-	-	-	1	1	1	1.6	1.8

Syllabus

Module I (8 hours)

Mass Transfer and Diffusion: Steady-state ordinary molecular diffusion: Fick's law of diffusion; Velocities in mass transfer, Equimolar counter diffusion; unimolecular diffusion, Diffusion coefficients: Diffusivity in gas mixtures, diffusivity in liquid mixtures, Diffusivity in solids, One-dimensional, steady-state, molecular diffusion through stationary media, Mass transfer in turbulent flow: Reynolds analogy; Chilton-Colburn analogy; Other analogies, Models for mass transfer at a fluid-fluid interface: Film theory; Penetration theory; surface-renewal theory; film-penetration theory, Two-film theory and overall mass transfer coefficients. Introduction to absorption.

Module II (8 hours)

Distillation: Pressure-composition, Temperature-composition, Enthalpy-composition diagrams for ideal and non-ideal solutions; Raoult's law and its application; Maximum and minimum boiling mixtures; Concept of relative volatility; Single Stage Distillation-Differential distillation, Flash vaporization; Vacuum, molecular and steam distillations.

Module III (8 hours)

Liquid-Liquid Extraction: Applications; Ternary liquid-liquid equilibria; Triangular graphical representation; Equipment used for single stage and multistage continuous operation; Analytical and graphical solution of single and multistage operation.

Module IV (8 hours)

Solid-Liquid Extraction: Applications; Solid-liquid equilibrium; Equipment used in solidliquid extraction; Single and multistage crosscurrent contact and countercurrent operations; Overall stage efficiency; Determination of number of stages. Introduction to Humidification and drying.

Module V (8 hours)

Adsorption: Description of adsorption processes and their application, Types of adsorption, Nature of adsorbents; Adsorption isotherms and adsorption hysteresis; Stagewise and continuous contact adsorption operations, Determination of number of stages, Equipments; Ion exchange, Equilibrium relationship; Principle of ion-exchange, techniques and applications. Introduction to Crystallization theory.

BOOKS:

1. Treybal, R.E. “Mass Transfer Operations”, 3rd ed. New York: McGraw-Hill, (1980).

2. Seader, J.D. and Henley, E.J., “Separation Process Principles”, 2nd ed., Wiley India Pvt. Ltd., New Delhi (2013).

3. Sherwood, T. K., Pigford, R. L. and Wilke, C.R. “Mass Transfer” McGraw Hill (1975).

4. Geankoplis, C.J. “Transport Processes and Separation Process Principles”, 4th ed., PHI Learning Private Limited, New Delhi (2012).

TPT 359 CHEMICAL REACTION ENGINEERING

L	T	P	C
3	1	0	4

Assessment:

Sessional: 50 marks
End Semester: 50 marks

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, and to 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	Able to develop an understanding of the basic concepts involved in using reaction rate equations and kinetic constants	Understand, Apply
CO 2	Perform derivations of rate equations for non-elementary reactions both in homogenous and in heterogeneous reacting systems	Apply
CO 3	Able to understand the role of temperature and concentration in the rate equation	Understand
CO 4	Perform constant volume batch reactor calculations	Apply
CO 5	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	**1**	**2**
CO2	3	3	3	1	-	1	-	-	-	1	-	1	2	1
CO3	3	3	3	2	-	2	-	-	-	1	-	1	1	2
CO4	3	3	1	-	2	1	-	-	-	1	-	1	1	2
CO5	3	3	2	2	2	1	-	-	2	1	-	3	3	2
Avg.	3	2.8	2.4	1	0.8	1	-	-	0.2	1	-	1.4	1.6	1.8

Syllabus

Module I (8 hours)

Rate of Reaction, Elementary and non-elementary homogeneous reactions, Molecularity and order of reaction, Mechanism of reaction, temperature dependency from thermodynamics, collision and activated complex theories. Integral and differential methods for analyzing kinetic data, interpretation of constant volume reactor, zero, first, second and third order reactions, half life period, irreversible reaction in parallel and series, catalytic reaction, auto catalytic reaction, reversible reactions.

Module II (8 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 (8 hours)

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

Module IV (8 hours)

Introduction to multiple reactions, qualitative discussion about product distribution, quantitative treatment of product distribution and of reactor size, selectivity, the side entry reactor, irreversible first-order reactions in series, Quantitative treatment: plug flow or batch reactor, Quantitative treatment: mixed flow reactor, Successive irreversible reactions of different orders, reversible reactions, irreversible series-parallel reactions, the Denbigh reactions and their special cases, Heat of reaction from thermodynamics, equilibrium constants from thermodynamics, General graphical design procedure for non-isothermal reactors, Optimum temperature progression, Heat effects: Adiabatic operations and non-adiabatic operations, Exothermic reactions in mixed flow reactors.

Module V (8 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.

Reference Books:

Levenspiel, O., “Chemical Reaction Engineering”, 3rd edition, John Wiley (1998).

EME355: ENERGY CONVERSION SYSTEMS & DEVICES

L	T	P	C
3	0	0	3

Course Objective:

This course is meant for technology branches students, offered by mechanical engineering department is basically designed for making them aware with some common mechanical concepts, laws and systems which is used by technology branch students.

Course Outcome:

After studying this subject students will be able to:

CO1	Apply fundamentals of thermodynamics to analyze systems that use steam as working substance.	Apply
CO2	Use and apply basic laws of thermodynamics basic laws of thermodynamics to analyze thermal systems like Boilers and condensers	Analyze
CO3	Elucidate working and performance of hydraulic pumps like centrifugal pump and reciprocating pump.	Evaluate/Apply
CO4	Gain knowledge to various thermal systems used in normal practice like centrifuges, atomizers, homogenizers etc. also to design pressure vessels - thick and thin cylinders, pipe and joints, flanges and valves	Evaluate/ Design
CO5	Be knowledgeable to Two stroke/ Four stroke IC Engines and their cycles	Evaluate

CO-PO Matrix

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	**PSOs**	
CO1	3	2	3		1		1					1	**1**	**2**
CO2	3	2	3		1		1					1	2	1
CO3	3	2	3		1		1					1	1	2
CO4	3	2	3		1		1					1	2	2
CO5	3	2	3		1		1					1	2	2
Average	3	2	3		1		1					1	1.6	1.8

Unit I

Properties of steam

Pure substance, Property of steam, Triple point, Critical point, Sub-cooled liquid, Saturation states, Superheated states, Phase transformation process of water, Graphical representation of pressure, volume and temperature, P-T & P-V diagrams, T-S and H-S diagrams, use of property diagram, Steam- Tables & Mollier charts, Dryness factor and it's measurement, Simple Rankine cycle.

Unit II

Zeroth Law, First Law and Second Law of Thermodynamics, Entropy, Enthalpy.

Boilers: Steam generators-classifications. Working of fire-tube and water-tube boilers, boiler mountings & accessories, Draught & its calculations, air pre heater, feed water heater, super heater. Boiler efficiency, Equivalent evaporation. Boiler trial and heat balance.

Condenser: Classification of condenser, Air leakage, Condenser performance parameters

Unit III

Classifications of centrifugal pumps, Vector diagram, Work done by impellor, Efficiencies of centrifugal pumps, Specific speed, Model testing, Cavitation, Separation and their control, Performance characteristics.

Positive Displacement Pumps: Reciprocating pump theory, Slip and coefficient of discharges, Indicator diagram, Effect and acceleration, Work saved by fitting air vessels, Comparison of centrifugal and reciprocating pumps, Positive rotary

pumps, Gear and Vane pumps, Performance characteristics. Hydraulic accumulator, Special duty pumps, Intensifier, Hydraulic press, Air lift pumps.

Unit IV

Compressors, their classification**,** Atomizers, Centrifuges, Steam ejectors, homogenizers, chillers
Design of pressure vessels - thick and thin cylinders, pipe and joints, flanges and valves.

Unit V

Internal Combustion Systems, Introduction: Otto Diesel cycles, 2/4 stroke engines, thermal efficiency. Knocking and detonation.

Textbooks:

1. Thermodynamics : An Engineering Approach by Cengel & Boles, Mc Graw Hill
2. Hydraulic Machines: Theory & Design, V.P.Vasandhani, Khanna Pub

Reference Books:

1. Hydraulic Machines by Jagdish Lal, Metropolitan book co. pvt ltd.
2. Thermodynamics by J.P. Holman, McGraw Hill.

HHS 351: ENTREPRENEURSHIP DEVELOPMENT

L	T	P	C
3	0	0	3

Sessional Marks: 50
End Semester Exam: 50

Course Outcome (COs)

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

CO 1	Describe what it takes an Entrepreneur; describe multiple ways to become an entrepreneur; including, entrepreneur, and manager, woman entrepreneur rural & urban: highlights motives to become entrepreneur	Understand
CO2	Apply the beginner concept, ownership and various forms with focus on small scale enterprises	Understand, Analyse, Apply
CO3	Identify opportunities using identification; project conceptualisation, formulation & evaluation	Analyse, Apply, Evaluate
CO4	Identify potential contribution of human resources, marketing, financial and strategic management with fund, opportunities	Analyse, Create
CO5	Decipher the role of Institution support and policy framework of Government for enterprises in India	Analyse, Apply

CO-PO Matrix

Course	CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSOs	
HHS 341/342	**CO1**	0	0	0	0	0	1	1	1	0	0	3	2	**2**	**2**
	CO2	0	0	1	0	0	1	1	1	1	0	3	2	2	2
	CO3	1	2	2	1	2	1	1	1	1	0	3	1	2	1
	CO4	0	0	1	0	1	1	1	2	1	1	3	2	2	2
	CO5	1	1	1	0	0	1	1	1	0	1	2	2	2	1
average		0.4	0.6	1	0.2	0.6	1	1	1.2	0.6	0.4	2.8	1.8	2	1.6

Syllabus

UNIT I Entrepreneurship:
Definition, requirements to be an entrepreneur, entrepreneur and intrapreneur, entrepreneur and manager, growth of entrepreneurship in India, women entrepreneurship, rural and urban entrepreneurship.
Entrepreneurial Motivation: motivating factors, motivation theories-Maslow's Need Hierarchy Theory, McClelland's Acquired Need Theory, 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, capital structure and source of finance.

UNIT III Project Management:
Identification and selection of projects; project report: contents and formulation, concept of project evaluation, methods of project evaluation: internal rate of return method and net present value method.

UNIT IV Management of Enterprises:

Strategy & policy, introduction to human resource management, marketing strategies, financial management & strategies: raising and managing capital, shares, debentures and bonds, cost of capital; break- even analysis.

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

References:

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

SEMESTER- 6

TPT – 352: CHARACTERIZATION, ANALYSIS AND EVALUATION OF COATINGS

L	T	P	C
2	0	2	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
CO6	Analyze the surface coatings and evaluate their optical, mechanical, chemical, 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	1	2	1	1	1	1	2	-	1	2
CO2	3	2	2	2	2	-	-	-	2	1	2	2
CO3	3	2	2	2	3	1	1	1	2	2	2	2
CO4	3	2	2	2	2	1	-	-	2	2	2	2
CO5	3	2	2	2	2	1	3	1	2	2	2	2
CO6	3	2	2	2	2	1	2	1	2	2	2	2
Avg	3.0	2.0	1.83	2.0	2.0	0.83	1.17	0.67	2.0	1.5	1.83	2.0

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

Course Level Assessment Questions
Course Outcome 1(CO1)
1.Paint analysis
2. Dispersion and wetting of pigments.
3. Rheological behaviour.

Course Outcome 2(CO2)
1.Optical properties eg. gloss, colour etc.
2. Opacity and hiding power.
3. Colour matching

Course Outcome 3(CO3)
1. Quality control and quality assurance
2. Concept of quality circle and six sigma
3. Testing andevaluation of liquid paints

Course Outcome 4(CO4)
1.Mechanical properties e.g. adhesion, flexibility, impact etc.
2. Corrosion resistance, water resistance, chemical resistance, salt spray
3. Heat, fire and electrical resistance

Course Outcome 5(CO5)
1. Natural and accelerated weathering.
2. Evaluation of water based paints.
3. Specific tests e.g. Traffic paints, automotive paints, marine coatings, aircraft coatings.

Course Outcome 6(CO6)

1. Learn and conduct Testing and evaluation of surface coatings.
2. Evaluation of physical and mechanical properties of coatings
3. Evaluation of chemical properties of coatings
4. Evaluation of coating life

SYLLABUS

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

Module-II: Optical Properties of coatings and complete application in colour development
Optical properties; colour, gloss, haze and clarity, orange peel, DOI (Distinctiveness if Image) transparency, hiding power, Concept of Kubelka-munk equation etc, Shade matching, opacity, spectrophotometry, charactrization of polymer for molecular weight and molecular weight distribution. (Mw, Mn, Mz, definitions and significance with coating performance properties, flow properties of solutions)

Module-III: Quality control
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 on liquid paints, density, dispersion, viscosity, consistency, application of films, spreading capacity, wet opacity, dry hiding, spreading time, drying time, wet and dry film thickness, etc.

Module-IV: Physical, Chemical and Mechanical Properties of Coatings
Newtonian and non-Newtonian flow behaviours, factors affecting viscosity and influence on rheological behavior. 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.

Module-V: Weather resistance and ageing properties of coatings
Natural & accelerated outdoor weathering tests, weather-o-meter (QUV and Atlas weather-o-meter and their correlation with real life situation), paint film and their classifications, defects observed in paint film on exposure & its evaluation, evaluation of water based paints, Exterior test protocol, in-can preservation and dry film preservation, hygiene surfaces, biological effects on water based paint films. Specific product testing (traffic paints, can & coil coatings, automotive paints, pipeline coatings, marine coatings, aircraft coatings, radiation resistant coatings etc.

Module-VI: Laboratory Experiments
Analysis of paints. Evaluation of physical, optical, electrical, chemical and mechanical properties of paints and varnishes as per BIS, ASTM, IS, BS specifications.

References and suggested readings:

Organic Coating Technology, Vol, I& II by H.F. Payne
Surface Coatings, Vol, I& II by, OCCA, Australia
Outlines of Paint Technology by W. M. Morgan
Testing of Organic Coatings by Norman I. Gaynes
Paint Testing Manual-Gardener
Organic Coatings Analysis by Konstandt
Organic Coatings : Science and Technology Vol 01 by Jones, Wicks and Pappas
Specifications BIS, ASTM, ISO, BS etc.

Course contents and lecture schedule

Module No.	Topic	No. of Lectures
1.	Analysis of coatings and classification of their properties	
1.1	Coating analysis as binder, pigments, solvents etc.	01
1.2	Physical, chemical and mechanical properties of coatings	01
1.3	Adhesion and cohesion,	01
1.4	Wetting and contact angles	01
2.	Optical properties of coatings	
2.1	Colour, Kubelka-Munk equation and colour matching	02
2.2	Opacity and hiding power	01
2.3	Gloss, haze /clarity and DOI	02
3.	Quality control	
3.1	Quality control and quality assurance procedure	01
3.2	Specifications e.g., BIS, ASTM, BS, ISO, DIN etc.	01
3.3	Concept of quality circles and six sigma methodology	01
3.4	Testing and evaluation of liquid paints e.g. dispersion, viscosity consistency, density, application of coating, wet opacity	02
3.5	Wet film thickness, volume solids, wt. solids, drying time, over coating interval	02
3.6	Spreading capacity, storage stability, pot life	01
4.	Physical, chemical and mechanical properties of coatings	
4.1	Newtonian and non-Newtonian flow behaviours, factors affecting viscosity	01
4.2	Adhesion, flexibility, impact resistance, hardness, mar resistance	02
4.3	Abrasion resistance, tensile strength, slip resistance and stress phenomenon in organic coatings.	02
4.4	Water and moisture resistance; water vapour transmission, PAC and salt spray test	02
4.5	Chemical resistance of coatings, resistance to heat and fire, air permeability etc. Electrical resistance properties-conductivity, dielectric constant etc.	03
5.	Weather resistance and ageing properties of coatings	
5.1	Natural & accelerated outdoor weathering tests, weather-o-meter, defects observed in paint film on exposure & its evaluation	02
5.2	Evaluation of water based paints, Exterior test protocol, in-can preservation and dry film preservation,	02
5.3	Specific product testing (traffic paints, can & coil coatings, automotive paints, pipeline coatings, marine coatings, aircraft coatings, radiation resistant coatings etc	02
5.4	Hygiene surfaces, biological effects on water based paint films	01
	Total hours	**34**
6	Laboratory experiments	
6.1	Analysis of paints	06
6.2	Physical tests e.g. dispersion, consistency/viscosity, solid content by wt and by volume, density, drying time, pot life	12
6.3	Hiding power/covering capacity by pyknometer and by weight method, wet film thickness, dry film thickness colour, gloss, over coating interval	15
6.4	Adhesion and flexibility, impact resistance, abrasion resistance, using different methods	09
6.5	Electrical resistance, pin hole tests by holiday detector, salt spray test, corrosion resistant test, durability (weather-o-meter)	12
6.6	Chemical resistance (water, kerosene, MTO, alcohol, petrol, diesel, acid, alkali etc.), thermal shock resistance.	09
Total hours		**63**
Grand total hours		**97**

TPT 354: TECHNOLOGY OF ORGANIC, FUNCTIONAL AND EFFECT PIGMENTS

L	T	P	C
2	1	0	3

OBJECTIVE: The objective of this course is to enable the students
To understand various properties of pigment and extender.
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, "-"*

Course Level Assessment Questions

Course Outcome 1(CO1)
1. Colour systems
2. Pigments, dyes, toners and lakes
3. Auxochromes and chromophores

Course Outcome 2(CO2)
1. Raw materials and intermediates for organic pigments
2. Chemical reactions for various intermediates
3. Colour striking

Course Outcome 3(CO3)
1. Synthesis of Azo Pigments
2. Diazotisation and coupling reactions.
3. Rubines and naphtholsazo condensation.

Course Outcome 4(CO4)
1. Metallic pigments
2. Pearlescent and luminescent pigments
3. Anti-corrosive and anti-fouling pigments

Course Outcome 5(CO5)
1. Metal free phthalocyanine pigments
2. Quinacridones, perylene and anthraquinone pigments
3. Composite and mixed pigments..

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, pigments 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 : coaltar distillation products, mordants and precipitants, bases for colour striking and lakes, miscellaneous salts and chemicals. Chemical reactions for synthesis of various intermediates from benzene, naphthalene and anthracene etc.

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.

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 azocondensation, 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 indexname 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

Course contents and lecture schedule

Module No.	Topic	No. of Lectures
1.	Colour phenomena	
1.1	Comparison of organic and inorganic pigments	01
1.2	Colour mechanism	02
1.3	Dimension of colour	01
1.4	Dyes, pigments, toners and lakes,	01
1.5	Auxochromes and chromophores	02
1.6	Colour aesthetic and safety standards,	02
2.	Industrial organic pigments	
2.1	Raw materials	02
2.2	Chemical reactions	01
2.3	Colour striking	01
2.4	Intermediates	02
3.	Classical azo pigments	
3.1	Preparation of azo pigments	03
3.2	Lake pigments	01
3.3	Rubines and naphthols	02
4.	Metallic, functional and miscellaneous pigments	
4.1	Metallic pigments	03
4.2	Pearlescent and nacreous pigments	02
4.3	Luminescent pigments	02
4.4	Anticorrosive pigments	04
4.5	Functional pigments	02
4.6	Camouflage pigments	01
5.	High performance and composite pigments	
5.1	Non metallicphthalocyanine pigments	02
5.2	High performance pigments	02
5.3	Composite and mixed pigments	02
5.4	Vat colours	02
5.5	Colour coding system	01
	Total hours	**44**

TPT-356: TECHNOLOGY OF FORMULATION AND 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 "-"*

Course Level Assessment Questions

Course Outcome 1(CO1)
1. Definition and dosage of additives.
2. Additives for water-based paints.
3. Additives for solvent-based paints.

Course Outcome 2(CO2)
1. solvent-based paints.
2. Prerequisites and mathematics involved in paint formulation.
3. Formulations of different types of paints.

Course Outcome 3(CO3)
1. Pigment-binder geometry and Daniel flow point.
2. Mill base composition and mill base rheology.
3. Let down vehicles and let down troubles.

Course Outcome 4(CO4)
1. Grinding equipment classification.
2. Important considerations in pigment grinding and mill base dispersion.
3. Different manufacturing equipment for manufacture of paints.

Course Outcome 5(CO5)
1. Human planning and production planning

2. Factory lay-out of factory.
3. Health and Fire protection and safety.

Course Outcome 6(CO6)
1. Preparation and testing of different types of paints.
2. Preparation of surfaces for the application of paints.
3. Application of paints by different techniques.

SYLLABUS

Module-I: Coating Additives and Principles of Coating Formulation

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

(i)For solvent thinned paints : Wetting and dispersing agents, anti-settling , anti-sag, bodying agents/ thickeners, anti-skinning agents, anti-flood & anti-float agents, biocides (bactericides and fungicides), thixotropic agents, leveling and flow control, mar and slip aids, adhesion promoters, heat and light stabilizers , metal carboxylates (driers), Waxes and surfactants

(ii)For water- thinned /latex (emulsion) paints : surface active agents (dispersing agents and stabilizers), anti-foam agents/defoamers , protective colloids and thickeners, Biocides (in-can and dry-film) preservatives, Algecides, pH buffers, coalescing aids, wet-edge additive, base-tinter compatiblizers , freeze-thaw stabilizers, sequestering agents, miscellaneous- organoclays and silicone additives. Prerequisites, Mathematics & Steps; PVC, CPVC, LCPVC, RCPC, % Volume solids, Relationship between PVC and film properties, Theoretical Covering Capacity, P/B ratio; Typical formulations of dry distempers, cement Paints and skim coats. Typical formulations of solvent base Primers, Undercoats, Intermediate coats and Finish coats. Typical formulations of water base Primers, Acrylic washable distempers, Plastic emulsion Paints- Interiors & Exteriors.

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.

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 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-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.

Module-V: Computers and modeling in paint resin formulating

Introduction, Software in the laboratory, 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.

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

Course contents and lecture schedule

Module No.	Topic	No.of Lectures
1.	Coating Additives and Principles of Coating Formulation	
1.1	Coating Additives: Definition, nomenclature, role.	01
1.2	(i)For solvent thinned paints : Wetting and dispersing agents, anti-settling , anti-sag, bodying agents/ thickeners.	01
1.3	Anti-skinning agents, anti-flood & anti-float agents, biocides (bactericides and fungicides), thixotropic agents.	01
1.4	Leveling and flow control, mar and slip aids, adhesion promoters, heat and light stabilizers , driers	01
1.5	(ii)For water- thinned /latex (emulsion) paints : surface active agents (dispersing agents and stabilizers), anti-foam agents/defoamers , protective colloids and thickeners, preservatives.	01
1.6	pH buffers, coalescing aids, wet-edge extenders, freeze-thaw stabilizers, sequestering agents, miscellaneous organo-clays and silicone additives.	01
1.7	Prerequisites, Mathematics & Steps; PVC, CPVC, LCPVC, RCPC, % Volume solids, Relationship between PVC and film properties, Theoretical Covering Capacity, P/B ratio.	01
1.8	Typical formulations of dry distempers, cement Paints and skim coats.	01
1.9	Typical formulations of solvent base Primers, Undercoats, Intermediate coats	01

	and Finish coats.	
1.10	Typical formulations of water base Primers, Acrylic washable distempers, Plastic emulsion Paints- Interiors & Exteriors.	01
2.	Principles of Coating Manufacture	
2.1	Steps in Paint manufacturing, Phenomenon of Mixing, Soaking, wetting, grinding, dispersion and stabilization.	01
2.2	Dispersion processes, Daniel wet & flow point, Composition of grinding vehicle, Classification of grinding equipments, important considerations in pigment dispersion and stabilization.	01
2.3	Daniel Flow Point, Concept of F(PVC), MBC (Mill base concentration), RTM (Ratio of Total Paint volume to Mill base volume).	01
2.4	Let down vehicle, Let down troubles, Optimum let down conditions, Stabilization of Mill base.	01
3	Heavy Duty Machines and Ball Mills	
3.1	Heavy duty mixers, double blade mixers, sigma mixers, Warner &P'flauder sigma kneaders, pug mills.	01
3.2	Edge runner roller mills, Hammer mills, jet mills.Rotostator. Roll mills: Two roll mills, Triple roll mills.	
3.3	Vertical and horizontal construction, material balance, power input, Mill base compositions, Major uses.	01
3.4	Ball and Pebble mills: Advantages & disadvantages, physical factors affecting the performance of ball mill, critical & optimum speed of ball mill.	01
3.5	Types of grinding media and practical considerations for ball mills and other mills	01
4	Attritors and High Speed Machines	
4.1	Attritors and Bead Mills, Sand Mills: Vertical and Horizontal type (Pressurized and Normal)	01
4.2	Description, types of sand, selection of grinding media, impeller unit, mill base composition, production rates & economic considerations.	01
4.3	Advantages & Disadvantages of sand mill, Dyno Mill.	01
4.4	Mill base rheology, power input, advantages & limitations of sand mill, Basket Mill, Twin shaft disperser, Cowles dissolvers, KadyMills .	01
4.5	High speed stone and colloid mill: Description, stone grit size, mill base composition.	01
4.6	High speed impingement mill: Description, mill base composition, order of addition.	01
5	Production planning, Factory Layout and Safety, Health & Environment	
5.1	Human resource Planning: Importance and processes, Job analysis and Engagements, Training need analysis and Training of staff.	01
5.2	Factory lay out: Principles, general considerations, typical flow diagrams, single & multi storied buildings.	01
5.3	Different sections of a paint factory and their locations, Instrumentation and automation.	01
5.4	Safety considerations in storage of hazardous and inflammable raw materials.	01
5.5	Fire Protection and safety: Sources, types, Fire & explosion index, safety measures for protection.	01
5.6	Health and Hazards: Resources, competence & regulations, systems & tools, HAZOP guidelines, Environment: Eco-friendly, waste minimization & waste disposal, system efficiency, respiratory protective equipments	01
	Total hours	**30**
6	Laboratory Experiments	
6.1	Preparation and testing of a sample of Dry distemper	4

6.2	Preparation and testing of a sample of Cement Paint	2
6.3	Preparation and testing of a sample of Oxide floor colour	2
6.4	Preparation and testing of a sample of Skim coat (Wall Putty)	4
6.5	Preparation and testing of a sample of White Primer (Solvent base)	4
6.6	Preparation and testing of a sample of Red oxide Primer	4
6.7	Preparation and testing of a sample of Synthetic Enamel	4
6.8	Preparation and testing of a sample of Air drying cum stoving Enamel	4
6.9	Preparation and testing of a sample of Road Marking Paint	4
6.10	Preparation and testing of a sample of Zinc Rich Primer	4
6.11	Preparation and testing of a sample of N.C. Lacquer	4
6.12	Preparation and testing of a sample of chlorinated rubber paint	4
6.13	Preparation and testing of a sample of Oil bound distempers	4
6.14	Preparation and testing of a sample of Acrylic washable distemper	4
6.15	Preparation and testing of a sample of Interior and Exterior plastic emulsion paint	4
6.16	Preparation and testing of a sample of various types of coatings by vibro-shaker	4
	Total hours	**60**
	Grand total hours	**90**

TPT 358: TECHNOLOGY OF PRINTING INKS AND COATINGS

L	T	P	C
2	1	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 "-"*

Course Level Assessment Questions

Course Outcome 1(CO1)
1. Printing ink & its nature
2. Printing Processes
3. Classification of printing inks

Course Outcome 2(CO2)
1. Testing & Evaluation of Raw materials
2. Raw materials cap for radiation curable systems

Course Outcome 3(CO3)
1. Letterpress inks
2. Lithographic inks
3. Web offset inks for paper & board

Course Outcome 4(CO4)
1. Gravure inks
2. Flexographic inks

3. Formulating Principles

Course Outcome 5(CO5)
1. Manufacture of inks
2. Cap innovation in printing inks
3. Edible & Soluble packaging inks

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, inkjet printing, intaglio printing process, toner printing systems, pad printing process and non-impact type: inkjet inks, continuous and drop on demand type, 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, metal decorating inks, ink-related problems and their possible solution, web-offset inks for paper and board, 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 and 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

Course content and lecture Schedule

Module No.	Topic	No. of lectures
1	Printing processes	
1.1	Nature and classification of printing inks, nature of print, methods of drying of printing inks	02
1.2	Printing Processes	03
2	Raw materials for printing inks	
2.1	Raw materials for use in printing inks	03
2.2	Raw materials for radiation curing systems	01
3	Letterpress, Lithographic and Web offset inks	
3.1	Letterpress inks: General characteristics, Ink related problems	02
3.2	Lithographic inks: General characteristics, Ink related problems	01
3.3	Metal decorating Inks, Dry oh set Inks, Two-piece can decoration Ink	03
4	Gravure , Flexographic screen and specialty inks	
4.1	Gravure inks, General characteristics,	01
4.2	Formulating principles, Ink related Problems	01
4.3	Flexographic inks, General characteristics	01
4.4	Specialty screen inks	02
5	Ink manufacturing and testing	
5.1	Manufacture of inks, Mixing and Milling equipment	03
5.2	Modern production trends and innovations in printing inks	
5.3	Edible and soluble packaging inks	01
5.4	Health, safety and the environment,	01
	Total hours	**25**

TPT 360: TECHNOLOGY OF PAINT AND COATING ADDITIVES

L	T	P	C
3	0	0	3

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 "-"*

Course Level Assessment Questions

Course Outcome 1(CO1)
1. Additives and their classification
2. Thickeners
3. Levelling & coalescing agents

Course Outcome 2(CO2)
1. Wetting & dispersing agents
2. Defoamers & anti-foams

Course Outcome 3(CO3)
1. Biocides
2. Heat stabilizers
3. Light stabilizers

Course Outcome 4(CO4)
1. Corrosion inhibitors
2. Driers
3. Additives for special functions

Course Outcome 5(CO5)
1. Theory of surfactants
2. Types of surfactants
3. Properties of surfactants

Syllabus

Unit-1: General Discussion on Additives, Thickeners, Levelling Agents And Coalescing Agents
Definition, Classification According to Function, Quantities Used, Economic Significance of Coating Additives, Chemical Composition, Effectiveness; Inorganic Thickeners- Organoclays, 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, Fluorosurfactants, Solvents, Properties & Application of Levelling Additives; Coalescing Agents-Polymer Dispersions, Mode of Action, Performance Aspects, Ecology

Unit-2: 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, Organofunctional 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

Unit-3: Biocides and Heat & Light Stabilizers
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; Heat & Light Stabilizers- Photooxidation of polymers, Stabilization possibilities, UV Absorbers, Hindered Amine Light Stabilizers (HALS), Solubility, Compatibility, Volatility, and Requirements of light stabilizers, Stabilization of Clear/Colored/Powder/Wood Coatings;

Unit-4: Corrosion Inhibitors, Driers, and Additives for Special Function
Corrosion Inhibitors-Corrosion Mechanism, Electrical studies, Corrosion suppression, Inhibition mechanism, Types & Properties of Inhibitors, Flash-rust Inhibitors & Inhibitors for long term protection, Toxicology & Disposal; Driers- Composition, Manufacturing, Precipitation, Fusion, Direct Metal reaction, Drier metals, Active, Auxiliary and Combination of driers, Substitution of lead driers; Anti-settling agents; Anti-Sag; Anti-Skinning Agents; Anti-Flood & Anti-Float Agents; Mar and Slip Aids; Waxes and Surfactants; pH Buffers; Wet-Edge Additives; Base-Tinter compatiblizers; Freeze-Thaw Stabilizers, Sequestering agents,

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, Other Anionic Surfactants; Nonionic Surfactants- Types, Ethoxylated Alcohols and Alkylphenols, Fatty acid Esters, Nitrogenated Nonionic Surfactants; Cationic Surfactants- Linear Alkyl-amines and Alkyl-ammoniums, Other Cationic Surfactants, Nitrogenated Surfactants with a second hydrophile; Other Surfactants- Amphoteric Surfactants, Silicon Surfactants, Fluorinated Surfactants, Polymeric Surfactants, Bio surfactants, Novel surfactants, Association Polymers

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

Course content and lecture Schedule

Module No.	**Topic**	**No. of lectures**
1.1	Definition and classification of additives	02
1.2	Chemical composition and effectiveness	02
1.3	Inorganic thickeners	02
1.4	Organic thickeners	02
1.5	Leveling additives	02
1.6	Coalescing agents	01
2.1	Wetting & Dispersing agents	02
2.2	Defoamers & anti-foams	02
2.3	Adhesion promoters	02
2.4	Additives to improve surface wetting	01
2.5	Measurement of surface tension	01
3.1	Biocides and their action	02
3.2	In-can and In-film preservatives	01
3.3	Heat & Light stabilizers	02
4.1	Corrosion inhibitors, properties, toxicology and disposal	01
4.2	Driers	02
4.3	Additives for special functions	02
5.1	Theory of surface action, effect and behavior of surfactants	02
5.2	Micelle properties, measurement of micelle concentration	02
5.3	Anionic surfactants	02
5.4	Cationic surfactants	02
5.5	Non-ionic surfactants	02
5.6	Amphoteric surfactants	02
	Total hours	**41**

TPT 361: INSTRUMENTATION & PROCESS CONTROL

L	T	P	C
2	1	0	3

Assessment:

Sessional: 50 marks

End Semester: 50 marks

Course Objectives:

To gain the knowledge of different process instruments and various control processes for closed loop and open loop systems..

Course outcomes:

CO1	Understand and interpret control diagrams	Understand
CO2	.Design and tuning of controllers for specific applications	Apply
CO3	Calculate the dynamic response of closed loop systems	Analyze
CO4	Understand the principles involved in measurements, Attain knowledge on different measurement methods employed in industrial processing and manufacturing.	Understand
CO5	Understand and Analyze the different temperature measurement devices in Chemical industries.	Understand and Analyze

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	1	-	-	-	-	1	1	2	**2**	**2**
CO2	3	3	3	2	3	-	-	-	-	1	1	2	2	2
CO3	3	3	3	3	3	-	-	-	-	-	-	2	2	2
CO4	3	1	1	-	-	-	-	-	-	1	1	2	2	2
CO5	3	2	1	2	2	-	-	-	-	-	-	2	2	2
CO6	3	3	3	2	2	-	-	-	3	2	1	2	2	2
Avg	3	2.5	2.16	1.83	1.83	-	-	-	0.5	0.83	0.66	2	**3**	**2**

Module 1 (8 hours)

Introduction to Process control systems, Use of Laplace & Inverse Laplace Transformation in study of Process Dynamics & Control. Characteristics of measurement system; classification of measuring instruments.

Module 2 (8 hours)

Dynamic Modeling of a Process, Dynamic behavior of First order system, First order systems in series & second & higher order systems for various kind of inputs, Linearization of nonlinear systems, Transportation & Transfer Lag.

Module 3 (8 hours)

Classification of control systems, Regulator & Servo control, Feed Forward & Feed backward control, Negative & Positive Feedback Control, Modes of control action, Controllers & Final control Elements, Reduction of Block & Signal Flow Diagrams.

Module 4 (8 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 (8 hours)

Flow measurement: Inferential flow measurements, Quantity flow meters, Mass flow meters. Flow measurement, head types-area flow meters, mass flow meters, positive displacement type flow meters, electrical type flow meters and solid flow measurement.

Suggested Text Books

1. Coughnour and Koppel, " Process Systems Analysis and Control ", McGraw-Hill, New York, 1986.
2. George Stephanopolous, " Chemical Process Control ", Prentice-Hall of India Pvt-Ltd., New Delhi, 1990.
3. Singh, S. K. , Industrial Instrumentation and Control , Prentice Hall of India, 2016

4 .Eckman, D.P., Industrial Instrumentation, Wiley Eastern Ltd., New York, 1990

BMA 352: OPERATIONS RESEARCH

L	T	P	C
3	0	0	3

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

- mathematical formulation and solution of Linear programming problems by various method.
- transportation problems and assignment problems and their solutions.
- advanced LPP and Travelling salesman Problem and their solutions.
- fundamentals of Network problems and their solutions by CPM and PERT Methods.
- dynamic programming problem and genetic algorithm.

Course Outcome

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

CO1	Understand and solve linear programming problems.	Apply, Evaluate
CO2	Formulate and solve Transportations models, Assignment models and integer linear programming problems.	Apply, Evaluate, Create
CO3	Formulate and solve sequencing and scheduling models.	Apply, Evaluate, Create
CO4	Formulate and solve Replacement and inventory models.	Apply, Evaluate, Create
CO5	Learn and use Dynamic programming and Genetic Algorithms.	Apply, Evaluate

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

Detailed Syllabus:

UNIT I: Linear Programming Problems (LPP)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	**PSO1**	**PSO2**
CO1	3	3	3	3	3	2	3	1	2	-	3	3	**1**	**2**
CO2	3	3	3	3	3	2	3	1	2	-	3	3	3	3
CO3	3	3	3	3	3	2	3	1	3	-	3	3	3	3
CO4	3	3	3	3	3	2	3	1	3	-	3	3	3	3
CO5	3	3	3	3	3	2	3	-	3	-	3	3	3	3
Average	3	3	3	3	3	2	3	.8	2.6	-	3	3	3	3
													3	**3**

OR model, Formulation of LPP. model, Graphical LPP solution and sensitivity analysis, simplex method, M-method, Two-phase method, Special cases in simplex method application, Duality theory, Dual simplex method, Revised simplex method, Degeneracy, Sensitivity analysis, Various industrial application of LP.

UNIT II: Transportation Models, Assignment Models and Integer Programming:

Formulation and Optimal solution of transportation models, Assignment models, Transshipment models, Degeneracy in TP model, Industrial application, Formulation and Solution of integer linear programming problems; Cutting-plane algorithm, Branch and Bound algorithm, 0-1 ILPP, applications, Knapsack problem, facility-location problem.

UNIT III: Sequencing and Scheduling Model:

Sequencing problems- Travelling salesman problem, Machine-scheduling problem (Job shop), Network based planning models, Objectives of CPM and PERT, Characteristics of CPM/PERT projects, Network diagram, Terminology, Critical path, Project duration, PERT Network, Activity time, Probabilities of project completion, Optimal crashing of project activities.

UNIT IV: Replacement and Inventory models:

Replacement Problems: Optimal age of equipment replacement, capital equipment discounting cost, Replacement of items that fail, Individual and group replacement policies.
Inventory Models: Deterministic inventory models, Classic EOQ model, EOQ with price breaks, Multiterm, stochastic inventory models under probabilistic demand and lead times.

UNIT V: Dynamic Programming and Genetic Algorithms:
Dynamic programming: Bellman's principle of optimality, computations in DP, Forward and Backward recursions, Dynamic Programming formulations, Investment problem, General allocation problem, Storage coach problem, Production scheduling.
Genetic Algorithms: Working principles, similarities and differences between Gas and Traditional methods, Gas for constrained optimization, Applications of Gas to solve simple problems.

Text Books Recommended:
1. S.S. Rao, "Optimization: Theory and Applications" Willey Eastern Limited.
2. H.A. Taha, " Operations Research- AN Introduction", Macmillan.
3. Hiller, F.S., G.J. Lieberman, "Introduction to Operations Research", Hoiden-Day.
4. Kalyanmoy Deb, "Optimizaton for Engineering Design: Algorithms & Examples " Prentice- Hall of India.

5. B.E. Gillet, Introduction Operations Research- A Computer Oriented Algorithmic Approach, McGraw Hill 1989.

SEMESTER - 7

TPT-451: TECHNOLOGY OF INDUSTRIAL AND SPECIALTY COATINGS

L	T	P	C
2	0	0	2

OBJECTIVE: The objective of this course is to enable the students to:
Understand the composition and formulate the painting systems for functional coatings.
The appliance finishes and novelty finishes.
Electro-deposition of coatings: Theory and practice.
Specialty coatings.

Course Outcome

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

CO1	Understand the requirements and formulate automotive, industrial and marine coatings	Understand, Apply
CO2	Formulate and applyappliance finishes, heavy-duty coatings and electrical coatings	Apply
CO3	Formulate the novelty finishes, fire retardant and insulating coatings	Apply
CO4	Understand the electro-chemistry and method of applicationand formulate CED coatings	Apply
CO5	Formulate specialty coatings such as Phosphorescent/ Fluorescent coatings, In-tumescent coatings, Traffic paints, Self stratifying coatings.	Apply

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	3	1	1	1	1	1	2	-	2	3
CO2	3	1	3	1	1	1	1	1	2	-	2	3
CO3	3	1	3	2	2	1	2	1	2	-	2	3
CO4	3	1	3	1	1	2	3	2	2	-	2	3
CO5	3	1	3	2	2	1	2	1	1	-	2	3
Avg	3.0	1.0	3.0	1.4	1.4	1.2	1.8	1.2	1.8	0.0	2.0	3.0

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

Course Level Assessment Questions

Course Outcome 1(CO1)

1. Definition of Primer, primer surfacer, Filler, Base coat and Finish coat.
2. Composition and application of coatings on wood, aircraft and marine structures.
3. Anticorrosive and Etch primers.

Course Outcome 2(CO2)

1. Appliances finishes; Coil coatings, can coatings.
2. Coatings for paper, plastic, leather, textile etc.
3. Heavy duty coatings for nuclear power plants.

Course Outcome 3(CO3)

1. Wrinkle finishes, hammer tone finishes, Flamboyant coatings.
2. Anticorrosive and hear resistant coatings.
3. Electrical resistant coating and Temperature indicating coatings.

Course Outcome 4(CO4)

1. Electro-chemical aspects of Anodic and cathodicelectro-deposition.
2. Composition of CED coatings based on epoxies, acrylics and PUs .

3. Operation of CED plants, curing of coatings and throwing power.

Course Outcome 5(CO5)
1. Polyurea and phosphorescent/ fluorescent coatings.
2. In-tumescent coatings, traffic paints, aerosols.
3. Self-stratifying coatings and coatings for electronic appliances.

SYLLABUS

Module-I : Clear finishes , primers and marine coatings

Clear finishes for metals and woods. Furniture finishes e.g. Sanding sealers, lacquers and cold cure finishes, 2k clear pu. Automotive coatings: primers, primer-surfacer, fillers, base coats, top coats, clear coats, refinishing, etc. Air craft finishes, marine coatings: dock and harbor installations, offshore structures , ships paints, fouling, organisms, leaching rate, types of antifouling paints, recent developments.
Industrial structures and industrial buildings (chemical plants): primers undercoats, finish coats. Inhibitive primers. Non-convertible and convertible red oxide-zinc chromate, zinc phosphate, zinc rich primers(inorganic and organic) etch primers, conversion coatings, colour aesthetics and standards.

Module-II : Appliance and heavy duty coatings
(a) Appliance finishes. Coatings for swimming pool, can coatings, coil coatings, coatings for metal containers, papers, plastics, leathers, textiles, etc.
(b) Heavy duty coatings:. Coatings for nuclear power plants, radiation resistant coatings,
(c) Electrical steel coatings
(d) Wire enamel, electrical Coatings

Module-III : Novelty finishes, fire retardant and anti graffiticoatings
Novelty finishes: wrinkle, hammer tone, multicolour, stipple, polychromatic, crystal crackle, flamboyant etc. Special purpose coatings: heat resistant, fire retardant, electrical resistant (insulating), temperature indicating , anti-graffiti paints, etc.

Module-IV : Electro-deposition
Electrodeposition: principles of anodic and cathodic electrodeposition, coating compositions based on alkyds, epoxies, polybutadienes, acrylics polyurethanes, etc. Application methods, curing mechanisms, operating conditions, throwing power, merits and demerits, and uses.

Module-V : Miscellaneous coatings: Fluorescent, road marking and self-healing coatings
Miscellaneous coatings : polyurea, high visibility, phosphorescent, fluorescent, intumescent, putrescent coatings, traffic/road marking paints, rail road coatings, coatings for electronic appliances, aerosols , anti skid coatings, self-stratifying coatings etc., plastisols and organosols coatings, powder dispersion, self healing coatings.

Reference Books

1. Basics of Paint Technology, Part I & II, by V.C.Malshe &Meenal Sikchi.
2. Surface coatings vol.I& II by OCCA, Australia.
3. Surface coatings science and technology Swaraj Paul
4. Organic Coating Technology Vol. I &II by HFPayne.
5. Outlines of Paint Technology by W.M.Morgan.

Course content and lecture Schedule

Module No.	Topic	No. of Lectures
1	Classification	
1.1	Clear finishes for metals and woods. Furniture finishes e.g. Sanding sealers, lacquers and cold cure finishes	01
1.2	Automotive coatings: primers, primer-surfacer, fillers, base coats, top coats, clear coats, refinishing, etc.	02
1.3	Air craft finishes, marine coatings	01
1.4	Dock and harbor installations, offshore structures , ships paints, fouling, organisms, leaching rate, types of antifouling paints, recent developments..	02
1.5	Industrial structures and industrial buildings (chemical plants): primers undercoats, finish coats.	01
1.6	Inhibitive primers. Nonconvertible and convertible red oxide-zinc chromate, zinc phosphate, zinc rich primers(inorganic and organic) etch primers, conversion coatings,	01
1.7	Colour aesthetics and standards	01
2	Appliance and heavy duty coatings	
2.1	Appliance finishes. Coatings for swimming pool, can coatings, coil coatings, coatings for metal containers, papers, plastics, leathers, textiles, etc.	03
2.2	Heavy duty coatings:. Coatings for nuclear power plants, radiation resistant coatings,	02
3	Novelty finishes, fire retardant and anti-graffiti coatings	
3.1	Novelty finishes: wrinkle, hammertone, multicolour, stipple, polychromatic, crystal crackle, flamboyant	02
3.2	Special purpose coatings : anti corrosive , heat resistant, fire retardant, electrical resistant (insulating), temperature indicating	03
4	Electro-deposition	
4.1	Electro-deposition: principles of anodic and cathodicelectro-deposition	01
4.2	Coating compositions based on alkyds, epoxies, polybutadienes, acrylics polyurethanes,	01
4.3	Application methods, cure mechanisms, operating conditions, throwing power, merits and demerits, uses.	02
5	Miscellaneous coatings	
5.1	Polyurea, high visibility, phosphorescent, fluorescent	02
5.2	Intumescent, putrescent coatings, traffic/road marking paints	02
5.3	Rail road coatings, coatings for electronic appliances, aerosols	01
5.4	Anti-skid coatings, self-stratifying coatings	02
	Total hours	**30**

TPT-453: TECHNOLOGY OF SURFACE PREPARATION, TREATMENTS AND COATING APPLICATIONS

L	T	P	C
2	0	2	3

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 "-"*

Course Level Assessment Questions

Course Outcome 1(CO1)
1. Objectives of surface preparation
2. Different contaminants present on different surfaces
3. Different cleaning methods

Course Outcome 2(CO2)
1. Different pretreatment methods
2. Activation of surfaces prior to phosphating
3. Phosphating and passivation of ferrous surfaces

Course Outcome 3(CO3)
1. Brush, Roller and Dip application of paints
2. Spray application of paints
3. Electro-deposition of paints

Course Outcome 4(CO4)
1. Curing of wet films
2. Spray booth in paint application
3. Paint circulation systems

Course Outcome 5(CO5)

1. Paint shop troubles, inspection and service
2. Classification of paint defects.
3. Paint and varnish removers

Course Outcome 6(CO6)
1. Preparation of different surfaces prior to painting
2. Preparation of previously painted surfaces
3. Application of paints by powder coatings

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 &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 insituphosphating, 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.

Module-IV : Curing of film, effluent treatment, waste management
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) effluent treatment & waste disposal, paint circulation systems (need, flow diagram, air velocity & balance, dust level, filter pressure drop) spray booth management

Module-V : Paintshop services, paint defect and paint remover
Paint shop troubles inspection and services. Paint defects: 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 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

Course Content and lecture Schedule

Module No.	Topic	No. of Lectures
1	Objective	
1.1	Objectives of surface preparation, Surface preparation methods: Hand cleaning, Power cleaning.	01
1.2	Abrasive blasting; classification, selection & equipment.	01
1.3	Chemical cleaning: Solvent, Acidic, Alkaline, Emulsion Cleaning.	01
1.4	Equipment for surface preparation: Immersion, vapour, wiping & spray, operating conditions, bath analysis & control.	01
1.5	Surface preparation for new & previously painted surfaces.	01
2	Pretreatment	
2.1	Pretreatments of ferrous metal substrate: degreasing, de-rusting.	02
2.2	Pickling; compositions, operating conditions, bath analysis & control.	01
2.3	Pretreatments of non-ferrous metal substrates: anodizing	01
2.4	Chemical conversion coatings: phosphate coatings; classification, advantages & disadvantages of Zn and Fe phosphating.	01
2.5	Bath make-up & maintenance, operating parameters, tricationic treatment, nano technology in surface treatment.	01
2.6	Chromate conversion coating: classification, coating process, rinsing, accelerator, and passivation.	01
3	Coating Application	
3.1	Coating application: brush, roller, curtain, dip, flow, silk screen, knife coating, calendar coating.	02
3.2	Powder coating application, coil coating application	01
3.3	Spray application: conventional air spray, airless spray, hvlp spray, dual-feed spray, electrostatic spray.	03
3.4	Bell application, robot painting, transfer efficiency, overspray disposals.	01
3.5	Electro-deposition: anodic/ cathodic deposition, commercial ed installation.	02
3.6	Throwing power, bath control, ultra-filtration, variables, advantages & disadvantages, bath parameters, line monitoring.	01
3.7	Common paint film defects in CED plasma coating, chemical vapour deposition.	01
4	Coating of film , effluent treatment	
4.1	Curing of wet film. Spray booth (preparation zone, spray zone, flash-off zone).	01
4.2	Paint circulation systems(need, flow diagram, construction of paint containers, filters, pressure gauges & regulators.	02
4.3	Pumps, pipelines & insulations, ccv, flushing line, air supply & exhaust systems).	01
4.4	Promix (definition, need, construction & working principle, paint-hardener ratio, promix calibration).	01
4.5	Air handling units (definition, importance, construction & working principle, flow diagram., humidifier, filtration system, eliminator, plennum, dampers).	01
4.6	Ovens (types, zones & temperature curves), conveyors (need, types, I beam type,	01

	enclosed tack, floor conveyor, selection of conveyor, elements of conveyor.	
4.7	Unit, drive unit, safety mechanism, tension take up unit, anti back mechanism, drive synchronization, point load conveyor pitch).	01
4.8	Jigs & trolleys (guidelines for jig designing & its construction, importance of jig maintenance jig utilization) water in pretreatment shop: control of quality, economy, (DM/ RO plants)	01
4.9	Effluent treatment & waste disposal, paint circulation systems (need, flow diagram, air velocity & balance, dust level, filter pressure drop) spray booth management	01
5	Paint shop services	
5.1	Paint shop troubles inspection and services	01
5.2	Paint defects: classification, causes & remedies	01
5.3	Paint and Varnish Removers: Solvent & chemical paint removers, mechanism, methods.	01
	Total hours	30
6	Laboratory experiments	
6.1	Preparation of surface of wood for application of coatings.	3
6.2	Preparation of surface of glass for application of coatings.	2
6.3	Preparation of surface of concrete for application of coatings.	3
6.4	Preparation of surface of plastic for application of coatings.	3
6.5	Preparation of surface of ferrous metal for application of coatings.	2
6.6	Preparation of surface of non-ferrous metal for application of coatings.	3
6.7	Preparation of surface of previously painted surface for application of coatings.	2
6.8	Application of a sample of coating by brush, spray application.	4
6.9	Application of a sample of coating by powder coating plant	2
6.10	Application of a sample of coating by electro-deposition method	3
6.11	Characterize the converted coating structure on treated surface by imaging microscope	3
	Total hours	**30**
	Grand Total (hours)	**60**

TPT 455: TECHNOLOGY OF ARCHITECTURAL AND ECO-FRIENDLY COATINGS

L	T	P	C
3	0	0	3

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 "-"*

Course Level Assessment Questions

Course Outcome 1(CO1)
1. Aspect of Environmental Protection
2. Environmental Pollutant
3.Conventional& non-conventional Coatings

Course Outcome 2(CO2)
1.Effects of Solvents on coatings
2.Green building Concepts
3.Global Green Paints

Course Outcome 3(CO3)
1.Primer/Surfaces/Undercoats.
2.Water-based Coatings
3.Washable& Non-washable Coatings
Course Outcome 4(CO4)
1.High solids coatings & its formulation
2.UV curable coatings & their formulation
3.Powder coatings, formulation, manufacturing & properties

Course Outcome 5(CO5)
1.Coatings for wooden surface.
2.Coatings for cement floor.

3.Camouflage coatings & their properties

SYLLABUS

Module- I: Introduction To Eco-Systems - fundamental aspects of environmental protection related to coatingindustries (ozone layer, renewable resources, green coating, carbon neutral products, biodegradability of materials). Eco-friendly coatings: aspects of environmental pollution (volatile organic compounds, VOC and hazardous air pollutants, hap) 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 andecofriendly 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.

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, oilbound distempers, acrylic washable distempers. Plastic emulsion paints: interior and exteriors; properties and uses.

Module-IV: Eco-Friendly Coatings:-: designing, mechanism, application and merits &demarits coatings. high solids coatings: considerations, influence of solvents, temperature, pigments, additives, cross-linkers etc.radiation curable coatings: types of radiations, UV curing, fundamental of photopolymerisation, photo-initiators, photo sensitizers, oligomers, monomers, problems associated with RADC uses / areas of application of EB curing and other curing systems.URE cure systems, electron beam curing: EBgenerators, factors affecting EB generation and curing,

[8]

Module-V: Powder and Specialty Coatings:- thermoplastic and thermoset; manufacture of powders, powderclassifications, types of powder coatings, application methods; electrostatic, fluidization,/ electrofluidisation, 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 Hester

Course contents and lecture schedule

Module No.	Topic	No.of Lectures
1.	Introduction to eco-systems	
1.1	Fundamental aspects of environmental Protection	01
1.2	Green coatings	01
1.3	Volatile organic compounds (VOC)	01
1.4	Merits & demerits of water as a solvent	01
2.	Architectural coatings, eco-friendly coatings	
2.1	Selection of raw materials for architectural andecofriendly coatings	01
2.2	Green building concept	01
2.3	VOC and its calculation as per BIS and ASTM	01
2.4	Green paints	01
3.	Architectural coating systems	
3.1	Primer-surfacer/ Surfacer, undercoats, putties, sound deadeners &underseal	03
3.2	Water based coatings: Lime wash	01
3.3	Oxide floor colours	01
3.4	Acrylic washable distempers & coatings	01
4.	Eco-friendly coatings	
4.1	Designing, mechanism, application and merits &demeritscoatings.	02
4.2	High solids coatings	02
4.3	Radiation curable coatings	01
5.	Powder and specialty coatings	
5.1	Thermoplastic and thermoset powders, manufacture of powders & application	02
5.2	wood coatings & melamine wood finisher	02
5.3	Floor paints & concrete paints	01
5.4	Road marking paints	01
Total hours		**25**

TPT 457: CORROSION CONTROL TECHNOLOGY

L	T	P	C
3	0	0	3

OBJECTIVE: The objective of this course is to enable the students
To understand the various aspects of corrosion and its mechanism
To know environments responsible for corrosion
To develop coatings to protect materials from corrosion
To save the Nation from financial loss

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

CO1	Understand the various aspects of corrosion and its mechanism.	Understand
CO2	Understand the fundamentals of corrosion science.	Understand
CO3	Understand corrosion process, environments and deterioration of various materials	Understand, Apply
CO4	Know forms of corrosion in various conditions	Apply
CO5	Apply the knowledge to develop coatings to protect substrates from corrosion. Corrosion testing	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 "-"*

Course Level Assessment Questions

Course Outcome 1 (CO1)
1. Impact of corrosion on National economy.
2. Classification of corrosion process
3. Electrochemical process and environmental factors to affect the corrosion rate.

Course Outcome 2(CO2)
1. Oxidation reduction reaction.
2. Crystal imperfection, surface heterogeneity, macroscopic defects
3. EMF, differential couples, passivation.

Course Outcome 3 (CO3)
1. Chemical and electrochemical corrosion
2. Atmospheric corrosion, marine corrosion, underground corrosion, biological corrosion, hydrogen cracking.
3. Low temperature and high temperature corrosion.

Course Outcome 4 (CO4)
1. Pitting, inter granular, filiform corrosion, stress corrosion
2. Caustic embrittlement, hydrogen damage, radiation damage, dew point corrosion.
3. Iron pillar and statue of liberty, Bed worth ratio..

Course Outcome 5(CO5)

1. Chemical Industries, paint manufacture and application industries.
2. Corrosion testing, physico-chemical methods, humidity, salt spray.
3. NACE test methods, performance evaluation.
4. Protective coatings-anticorrosive coatings, barrier coatings.

SYLLABUS

Module-I: Introduction To corrosion : Definitions: corrosion science and corrosion engineering;consequences of corrosion, cost of corrosion; inter-disciplinary nature of corrosion; corrosive environment; functional aspect of corrosion; classifications of corrosion processes; corrosion quantification and corrosion rate expressions; electrochemical aspects to affect corrosion rate - polarization and passivity; environmental factors to affect the corrosion rate, C1-C5 Environmental conditions.

Module-II: Fundamentals of corrosion science : atom, atomic aggregation, electrolytes, oxidation andreduction reactions, acids, bases and salts, neutralization and hydrolysis, pH and pOH, metallurgy; metals and alloys and soid solutions, crystal imperfections, surface heterogeneity, macroscopic defects, heat treatment and slag inclusion in steel. Electrochemistry: electrical conduction, electrolysis, electrochemical (voltaic or galvanic) cell, electromotive force, electrode potentials, emfvs galvanic series. potential-pH (pourbax) diagram, thermodynamics - free energy. surface chemistry: electrified interface and electrical double layer. Differential couples: galvanic, concentration and electrolytic cells. Passivity: characteristic parameters for passivation, mechanism of passivation, passivators and inhibitors, theories of passivation , mechanism of passivation, mechanical passivity.

Module-III: Corrosion processes: Mechanism of corrosion processes-chemical and electrochemicalcorrosion. Nature of the environment-atmospheric corrosion, marine corrosion, underground corrosion, biological corrosion hydrogen cracking, radiation cracking, liquid-metal corrosion, molten salt corrosion, acid corrosion, alkali corrosion, corrosion in electrolytes. Type of corrosion deterioration-micro and macro corrosion, surface corrosion, local corrosion, intercrystalline corrosion, Type of corrosion reaction-film free chemical reactions, electrochemical reactions (inseparable and separable anode/cathode type, interfacial anode /cathode type). Mechanical forces on and within the metal-stress corrosion, corrosion fatigue, erosion corrosion, cavitation corrosion, fretting corrosion.Low temperature and high temperature corrosion. Corrosion in non metals- rubber/elastomers properties, plastics (thermoplastics and thermosets) , ceramics, carbon & graphite, wood; their properties and behavior towards corrosion.

Module-IV: Forms of corrosion : Chemical vs. electrochemical corrosion, uniform corrosion, non-uniform/localized attack - Galvanic/Bimetallic, Crevice &Filiform , Pitting , Inter granular corrosion, Selective leaching-dezincification & graphitization , Erosion corrosion - impingement attack, cavitation damage, fretting corrosion, Stress corrosion cracking & corrosion fatigue, Filiform (under film) corrosion, Selective corrosion or selective leaching, De-alloying corrosion, Exfoliation, Hydrogen damage, Radiation damage, stain corrosion, Pin point corrosion, caustic embrittlement. Animal body (in vivo) corrosion, aerospace, electronic equipments, dew point corrosion, high temperature corrosion, dry oxidation & Pilling-Bedworth ratio, catastrophic oxidation; iron pillar and statue of liberty.

Module-V: Corrosion in industries: chemical industries- pulp & paper, fertilizer, paint manufacture &application industries; petroleum refineries and petrochemical industries; building industry and rebar corrosion; boiler plants; automobile industry; nuclear power plants. Corrosion testing : Planning and preparation; destructive and non-destructive methods; physico-chemical methods-immersion, humidity, salt spray, special property tests for SCC, IGC etc.; electrochemical methods-E-Icurves/Evans diagrams/polarization diagrams; electrode potential measurements, polarization measurements-Tafel's extrapolation, linear polarization, polarization break, impedance measurement, cyclic voltametry; merits and demerits of various test methods; electronic instrumentations, NACE test methods; Performance evaluation of paints and protective coatings; corrosion of plastics and elastomers; nomographs for corrosion rates. Methods of corrosion control and corrosion prevention: Selection of materials of construction; alteration of corrosion environment; corrosion inhibitors; Rust converting coatings, change in design; coatings (metallic, inorganic & organic coatings); cathodic protection and anodic protection, Flash rust inhibitor, Vapour phase corrosion inhibitor (VCI). Organic-liquid passivators.

Reference Books and Suggested Readings :

1. Corrosion engineering, by Mars G. Fontana, McGraw-Hill Book Company
2. An introduction to science of corrosion and its inhibition, by S.N.Banerjee, Oxonian Press Pvt. Ltd.
3.Corrosion and corrosion protection handbook, by Philip A. Schweitzer (Ed.), Marcel Dekker Inc.
4.Corrosion and corrosion control by H.H.Uhlig&R.V.Revie Wiley-Interscience
5.The Corrosion Handbook, by H.H.Uhlig,John Wiley and Sons, Inc. London, 1961
6.Basic Concepts of Corrosion volume 1, pp 1:3–1:15, _ 2010 ,Shreir, L. L., Elsevier B.V.
7.Electrochemical Techniques in Corrosion: Status, Limitations, and Needs, Journal of ASTM International, Vol. 5, No 2, Feb. 2008 (paper ID JAI101241.Frnkel, S. Gerald.
8. Principles of corrosion engineering and corrosion control

Course contents and lecture schedule

Module No.	Topic	No.of lectures
1.	Introduction to corrosion	
1.1	Definitions: corrosion science and corrosion engineering; consequences of corrosion	01
1.2	Cost of corrosion; inter-disciplinary nature of corrosion.	01
1.3	Corrosive environment; functional aspect of corrosion. Classifications of corrosion processes.	02
1.4	Corrosion quantification and corrosion rate expressions; electrochemical aspects to affect corrosion rate - polarization and passivity; environmental factors to affect the corrosion rate.	03
2.	Fundamentals of corrosion science	
2.1	Atom, atomic aggregation, electrolytes, oxidation and reduction reactions, acids, bases and salts, neutralization and hydrolysis, pH and pOH	03
2.2	Metallurgy; metals and alloys and solid solutions, crystal imperfections, surface heterogeneity, macroscopic defects, heat treatment and slag inclusion in steel.	03
2.3	Electrochemistry: electrical conduction, electrolysis, electrochemical (voltaic or galvanic) cell, electromotive force, electrode potentials, EMFvs galvanic series. potential-pH (pourbax) diagram, thermodynamics - free energy.	02
2.4	Surface chemistry: electrified interface and electrical double layer. Differential couples: galvanic, concentration and electrolytic cells	02
2.5	Passivity: characteristic parameters for passivation, mechanism of passivation, passivators and inhibitors, theories of passivation , mechanism of passivation, mechanical passivity	02
3.	Corrosion processes	
3.1	Mechanism of corrosion processes-chemical and electrochemicalcorrosion. Nature of the environment-atmospheric corrosion, marine corrosion, underground corrosion, biological corrosion hydrogen cracking, radiation cracking, liquid-metal corrosion, molten salt corrosion, acid corrosion, alkali corrosion, corrosion in electrolytes	03
3.2	Type of corrosion deterioration-micro and macro corrosion, surface corrosion, local corrosion, inter crystalline corrosion	01
3.3	Type of corrosion reaction-film free chemical reactions, electrochemical reactions (inseparable and separable anode/cathode type, interfacial anode /cathode type).	02
3.4	Mechanical forces on and within the metal-stress corrosion, corrosion fatigue, erosion corrosion, cavitation corrosion, fretting corrosion	02
3.5	Low temperature and high temperature corrosion. Corrosion in non-metals: rubber/ elastomers properties, plastics (thermoplastics and thermosets) , ceramics, carbon & graphite, wood; their properties and behavior towards corrosion	03
4.	Forms of corrosion	
4.1	Chemical vs. electrochemical corrosion	01
4.2	Uniform corrosion, non-uniform/localized attack - Galvanic/Bimetallic, Crevice & Filiform , Pitting , Inter granular corrosion, Selective leaching-dezincification & graphitization , Erosion corrosion - impingement attack, cavitation damage, fretting corrosion	02
4.3	Stress corrosion cracking & corrosion fatigue, Filiform (under film) corrosion, Selective corrosion or selective leaching	02
4.4	De-alloying corrosion, Exfoliation, Hydrogen damage, Radiation damage, stain corrosion, Pin point corrosion, caustic embrittlement.	02
4.5	Animal body (in vivo) corrosion, aerospace, electronic equipments, dew point corrosion, high temperature corrosion, dry oxidation & Pilling-Bedworth ratio, catastrophic oxidation;	02

	iron pillar and statue of liberty	
5.	Corrosion in industries	
5.1	Chemical industries- pulp & paper, fertilizer, paint manufacture &application industries; petroleum refineries and petrochemical industries; building industry and rebar corrosion; boiler plants; automobile industry; nuclear power plants.	01
5.2	Corrosion testing : Planning and preparation; destructive and non-destructive methods; physico-chemical methods-immersion, humidity, salt spray, special property tests for SCC, IGC etc.; electrochemical methods-E-Icurves/Evans diagrams/polarization diagrams; electrode potential measurements, polarization measurements-Tafel's extrapolation, linear polarization, polarization break, impedance measurement, cyclic voltametry; merits and demerits of various test methods	02
5.3	Performance evaluation of paints and protective coatings; corrosion of plastics and elastomers; nomographs for corrosion rates	01
5.4	Methods of corrosion control and corrosion prevention: Selection of materials of construction; alteration of corrosion environment; corrosion inhibitors; change in design; coatings (metallic, inorganic & organic coatings); cathodic protection and anodic protection.	01
Total hours		**40**

TPT 459: TECHNOLOGY OF INDUSTRIAL AND AUTOMOTIVE COATINGS

L	T	P	C
3	0	0	3

OBJECTIVE: The objective of this course is to enable the students understand and apply.
The selection of industrial paints for various end-uses.
Various Mechanical and Chemical methods of Surface preparation before painting.
Application and quality control of paints.
Painting of Railroad bridges & structures.
Protection of pipelines and other underground structures.

Course Outcome

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

CO1	Select the industrial paints for different end-uses	Apply
CO2	Prepare the surface by mechanical and chemical methods before painting	Apply
CO3	Learn application and quality control of paints	Apply, Analyze
CO4	Learn the painting of rail road bridges and structures	Apply
CO5	Learn about protection of pipelines and underground structures	Apply

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	2	1		2	2	3			2	3
CO2	3	2	2	2	1	1	2	2			1	3
CO3	3	2	2	2	1	2	2	1	2	1	2	2
CO4	3	1	2					2	2		2	2
CO5	3	1	2	1	2	2		1			2	2
Average	3.0	1.40	2.0	1.2	0.80	1.40	1.2	1.80	0.80	0.20	1.80	2.40

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

Course Level Assessment Questions

Course Outcome 1(CO1)

1. Selection of paints for different industrial applications.
2. Various types of surfaces and application of paints on them.
3. Paint application on large surfaces.

Course Outcome 2(CO2)

1. Surface preparation by mechanical methods.
2. Surface preparation by chemical methods.
3. Various paint removers and their use.

Course Outcome 3(CO3)

1. Use and application of paints.
2. Quality control of paints.
3. Shop painting of steel in fabricating plants.

Course Outcome 4(CO4)

1. Painting of Rail road bridges and structures.
2. Painting of steel vessels for fresh water service.
3. Painting of steel in hydraulic structures.

Course Outcome 5(CO5)

1. Chemical classification of volatile solvents.

2. Various characteristics of solvents and their determination.
3. Preparation of thinners: Conventional and eco-friendly.

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 board 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 (e) Colour in industrial 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, Electrocoating (EC), Sealing and Underbody Protection, Paint Application, Function Layer and Primerless 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

TPT - 461: NANOTECHNOLOGY IN SURFACE COATINGS

L	T	P	C
3	0	0	3

OBJECTIVE: The objective of this course is to enable the students understand:
The physics of the solid state
The manufacturing of Nano particles
The methods of measuring the properties of nanoparticle
The properties of individual nanoparticle and carbon nanostructures
Bulk Nano structured materials
Application of Nano technology in surface coating.

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

CO1	Understand the crystal structure, lattice vibration, energy band and gaps of semiconductors.	Understand
CO2	Determine the particle size and surface structureusing microscopy and spectroscopy techniques.	Analyze
CO3	Understand the various properties of individual Nano particles and methods of their synthesis	Understand, Apply
CO4	Understand the mechanical properties and application of carbon Nanotubes.	Apply
CO5	Understand the methods of synthesis, failure mechanisms and mechanical properties of bulk Nano-structured materials	Apply

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	-	-	-	-	-	1	1	2
CO2	3	2	1	2	2	1	-	-	2	1	2	2
CO3	3	2	3	2	2	2	1	-	2	2	2	2
CO4	3	2	2	1	1	1	2	-	2	1	2	2
CO5	3	2	2	3	2	1	2	2	3	2	3	3
Avg	3.0	2.0	1.6	1.6	1.4	1.0	1.0	0.4	1.8	1.4	2.0	2.2

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

Course Level Assessment Questions

Course Outcome 1(CO1)
1. Crystal structures, face-centered cubic Nanoparticles,tetrahedrally bonded semiconductor structures of nano particles.
2. Insulators, semi-conductors and conductors.
3. Donors, acceptors, and deep traps.

Course Outcome 2(CO2)
1. Structures, crystallography and particle size determination.
2. Transmission electron microscopy, field ion microscopy and scanning microscopy.
3. Magnetic resonance, infrared and Raman spectroscopy, photoemission and X-ray spectroscopy , magnetic resonance

Course Outcome 3(CO3)
1. Magic numbers, geometric structure, electronic structure, reactivity and fluctuations of metal nanoclusters.
2. Optical properties, photo fragmentation and columbic explosion of semiconducting nanoparticle.
3. Theoretical modeling of nanoparticles.

Course Outcome 4(CO4)
1. Structure and superconductivity of C_{60}.
2. Electrical, vibrational and mechanical properties of carbon nanotubes.
3. Applications of carbon nanotubes.

Course Outcome 5(CO5)
1. Synthesis of solid disordered nanostructures.

2. Computational prediction of cluster lattice.
3. Polymer based nanoparticles.

SYLLABUS

Module-I: Introduction to physics of the solid state structure; size dependence of properties, crystal structures , face-centered cubic nanoparticles , tetrahedrally bonded semiconductor structures , lattice vibrations , size dependence of properties , energy bands ; insulators, sermi-conductors and conductors, reciprocal space , energy bonds and gaps of semiconductors , effective masses , fermi surfaces , localized particles ; donors, acceptors, and deep traps, mobility , excitons,

Module-II: Methods of measuring properties introduction , structure ; atomic structures , crystallography , particle size determination , surface structure , microscopy; transmission electron microscopy , field ion microscopy , scanning microscopy , spectroscopy ; magnetic resonance ,infrared and raman spectroscopy , photoemission and x-ray spectroscopy , magnetic resonance

Module-III: Properties of individual nano particles metal nano-clusters; magic numbers , geometric structure , electronic structure , reactivity ,fluctuations , magnetic clusters , bulk to nano-transition , semiconducting nanoparticles; optical properties, photo-fragmentation , coulombic explosion , rare gas and molecular clusters ; inert-gas clusters , superfluid clusters , molecular clusters , theoretical modeling of nanoparticles ,methods of synthesis; rf plasma , chemical methods , thermolysis , pulsed laser methods

Module-IV: Carbon nano structures carbon molecules; nature of the carbon bond,, new carbon structures carbon clusters; small carbon clusters, , structure of c_{60} and its crystal alkali-doped c_{60}, superconductivity in c_{60}, larger and smaller fullerenes other buckyballs, carbon nanotubes; (cnt) fabrication, structure, electrical properties, vibrational properties , mechanical properties ,applications of carbon nanotubes ; field emission and shielding, computers, fuel cells , chemical sensors , catalysis , mechanical reinforcement

Module-V: Bulk nanostructured materials solid disordered nanostructures; methods of synthesis, failure mechanisms of conventional grain-sized materials, mechanical properties, nanostructured multilayers, electrical properties, other properties , porous silicon , metal nanocluster composite glasses , nanostructured crystals; natural nano crystals , computational prediction of cluster lattices, arrays of nanoparticles in zeolites , crystals of metal nanoparticles , nanoparticle lattices in colloidal suspensions , photonic crystals, organic compounds and polymers; forming and characterizing polymers, polymerization , sizes of polymers , nano silica, nano titanium, nano zinc, nano silver nano crystals;, polydiacetylene types , condensed ring types , polymers; conductive polymers , block copolymers , supra-molecular structures ; transition-metal-mediated types , dendritic molecules , supra-molecular dendrimers , micelles.

Course contents and lecture schedule

Module No.	Topic	No. of lectures
1.	Introduction to physics of the solid state	
1.1	Structure; size dependence of properties, crystal structures	01
1.2	Face-centered cubic nanoparticles	01
1.3	Tetrahedrally bonded semiconductor structures , lattice vibrations , size dependence of properties	02
1.4	Energy bands ; insulators, semi-conductors and conductors	01
1.5	Reciprocal space , energy bonds and gaps of semiconductors	01
1.6	Effective masses , fermi surfaces , localized particles ; donors, acceptors, and deep traps, mobility , excitons	01
2.	Methods of measuring properties	
2.1	Introduction , structure ; atomic structures , crystallography , particle size determination, surface structure	01
2.2	Microscopy; transmission electron microscopy ,	02
2.3	Field ion microscopy , scanning microscopy	02
2.4	Types of co-polymerization	02
2.5	Spectroscopy ; magnetic resonance ,infrared and raman spectroscopy	01
2.6	Photoemission and x-ray spectroscopy	02
2.7	Magnetic resonance	02
3.	Properties of individual Nanoparticles	
3.1	Metal nanoclusters; magic numbers , geometric structure , electronic structure	02
3.2	Reactivity ,fluctuations , magnetic clusters, bulk to nanotransition	01
3.3	Semiconducting nanoparticles; optical properties, photofragmentation , coulombic explosion	02
3.5	Rare gas and molecular clusters ; inert-gas clusters , superfluid clusters , molecular clusters , theoretical modeling of Nanoparticles	01
3.7	Methods of synthesis; rf plasma , chemical methods , thermolysis , pulsed laser methods	01
4.	Carbon nanostructures	
4.1	Carbon molecules; nature of the carbon bond,, new carbon	02
4.2	Carbon clusters; small carbon clusters c_{60} structure ofc_{60} and its crystal alkali-doped c_{60}, superconductivity in c_{60}	02
4.3	Larger and smaller fullerenes other buckyballs, carbon nanotubes; fabrication, structure, electrical properties, vibrational properties , mechanical properties	02
4.4	Applications of carbon nanotubes ; fieldemission and shielding, computers, fuel cells , chemical sensors , catalysis , mechanical reinforcement	01
5.	Bulk Nanostructured materials	
5.1	Solid disordered nanostructures; methods of synthesis, failure mechanisms of conventional grain-sized materials, mechanical properties, nanostructured multilayers, electrical properties, other properties, porous silicon, metal nanocluster composite glasses	02
5.2	Nanostructured crystals; natural nanocrystals, computational prediction of cluster lattices, arrays of nanoparticles in zeolites ,crystals of metal nanoparticles, nanoparticle lattices in colloidal suspensions , photonic crystals	01
5.3	Organic compounds and polymers; forming and characterizing polymers, polymerization , sizes of polymers	02
5.4	Nanocrystals;, polydiacetylene types , condensed ring types	01
5.5	Polymers; conductive polymers , block copolymers, supramolecular structures; transition-metal-mediated types, dendritic molecules , supramoleculardendrimers , micelles	01
Total Hours		**40**

OPT433: BASIC PAINT TECHNOLOGY

L	T	P	C
3	0	0	3

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 "-"*

Course Level Assessment Questions

Course Outcome 1(CO1)

1. Definition of paints & their general ingredients
2. Classification of Paints
3. Film Formers

Course Outcome 2(CO2)

1. Extenders & Prime Pigments
2. Solvents & thinners
3. Driers, Plasticizers & Additives

Course Outcome 3(CO3)

1. Formulation Principals of Organic coatings
2. Calculations involved in formulation of surface coatings
3. Paint manufacturing

Course Outcome 4(CO4)

1. Testing of pigment/resins/Oils
2. Testing of Liquid paints & Evaluation of coatings.
3. Chemical resistance & corrosion resistance.

Course Outcome 5(CO5)

1. Surface Preparation
2. Application Techniques for paints

3. Paint Defects, safety & Health Hazards.

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 Paints and coatings raw materials
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 involved in paint formulations, steps in paint manufacture dispersion equipment & machinery used in paint manufacture

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

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

References:
1. Organic Coating Technology, Vol. I & II; by HF Payne.
2. Outlines of Paint Technology; by WM Morgan.
3. Surface Coatings, Vol. I & II; by OCCA, Australia.
4. Basics of Paint Technology (Part I & II); by Malshe&Sikchi.
5. IS:33-.1992, IS:3493.1978, IS:74.1979, IS:104.1964, IS:2932, IS:2074

Course content and lecture schedule

Module No.	Topic	No. of Lectures
1.	Basics aspects and concepts	
1.1	Paints and their general ingredients	02
1.2	Functions of ingredients	
1.3	Classifications of paints	02
1.4	Drying oils, modified drying oils	02
1.5	Natural resins, synthetic resins	06
2	Other raw materials	01
2.1	Extenders & prime pigments, inorganic & organic pigments	01
2.2	True solvents, latent solvents	01
2.3	Drying catalysts	02
2.4	Plasticizers, additives	
3	Formulation & manufacture of coatings	
3.1	Formulation principal for organic coating (paint, varnishes & lacquers)	02
3.2	Calculations involved in paint formulations	
3.3	Dispersion equipment & machinery	02
4	Testing of raw materials & paints	
4.1	Testing of pigments, extenders, oils, resins, solvents	02
4.2	Testing of liquid paints	02
4.3	Evaluation of paint films for physical, mechanical, optical properties chemical & corrosion resistance	02
5	Surface preparation & paint application	
5.2	Different steps involved in preparation	01
5.3	Application techniques	03
5.4	Paint defects	02
5.5	Safety & health hazards	01
	Total hours	**34**

TPT – 493: INDUSTRIAL TRAINING PRESENTATION

L	T	P	C
0	0	4	2

The students offer summer internship of 6 to 8 weeks would be giving presentation on the work they performed or learned during training

OBJECTIVE: The objective of this course is to enable the students
To expose to industrial environment
To acquaint with the various machines for the manufacturing of paints
For testing of raw materials and finished products
Handle the research project.
To improve professional attitude

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

CO1	Understand the plant layout, work culture and human relationship.	Understand
CO2	Apply the theoretical knowledge in understanding the working of various machines and manufacturing processes	Apply
CO3	Understand the process sequence and optimization of process parameters.	Apply, Analyze
CO4	To get exposure to various conventional and modern tools and equipment for testing of raw materials and finished products	Apply
CO5	To analyze the research problem and devise methodology/ steps to solve it and development of products	Analyze, Create

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

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	3	2	-	-	2	1	3	3	2	3	3
CO2	3	2	2	1	2	2	-	1	2	-	2	3
CO3	3	3	3	2	3	2	1	2	2	2	2	3
CO4	3	3	2	3	3	-	-	-	-	-	1	3
CO5	3	3	3	3	3	3	2	1	3	2	3	3
Avg	2.6	2.8	2.4	1.8	2.2	1.8	0.8	1.4	2.0	1.2	2.2	3.0

TPT - 495: SEMINAR

L	T	P	C
0	0	4	2

OBJECTIVE:The objective of this course is to enable the students
Study a topic of latest developments/innovative technology on their own and to prepare a dissertation report on this topic.
Present a lecture on the topic on power point format.
Improve the communication skill of the students.

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

CO1	Review, collect and study literature on a topic of interest	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 and answer questions from audience, if any	Apply
CO4	While being in the audience listen to the lectures delivered by other participants evaluate the same and comment on the same	Evaluate
CO5	Analyze own shortcomings as well as that of other participants and improve upon the same	Analyze, Evaluate

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	3	3	2	2	-	2	-	2	3
CO2	3	3	2	2	3	2	3	2	2	3	2	2
CO3	3	-	-	-	2	2	2	-	2	3	2	2
CO4	3	-	-	-	-	1	1	2	3	3	1	2
CO5	2	-	1	2	1	2	3	1	3	3	2	3
Avg	2.2	1.2	1.0	1.4	1.8	1.8	2.2	1.0	2.8	2.4	1.8	2.4

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

TPT – 497: PROJECT

L	T	P	C
0	0	8	4

OBJECTIVE:The objective of this course is to enable the students
To identify a paint product 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	Review, collect and study literature on a project topic	Understand
CO2	Apply the knowledge to prepare a dissertation report on the same	Apply
CO3	Evaluate the collected literature and formulate a product	Apply, Evaluate
CO4	Define a process/method for manufacture of the same	Apply
CO5	Analyze environment and sustainability of related technology	Analyze

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	3	-	2	1	-	1	-	2	3
CO2	3	2	2	2	1	2	3	-	2	3	3	2
CO3	3	3	3	2	3	1	2	2	3	3	3	3
CO4	3	3	2	-	2	2	2	3	3	3	3	3
CO5	3	3	3	-	1	2	3	3	2	1	2	3
Avg	3.0	2.2	2.0	1.4	1.4	1.8	2.0	1.6	2.2	2.0	2.6	2.8

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

TPT – 452: HIGH POLYMERIC ENGINEERING

L	T	P	C
3	1	0	4

OBJECTIVE: The objective of this course is to enable the students understand:
The polymerization techniques and their kinetics
The mechanism of homopolymerization and copolymerization
The polymer characterization by various techniques
Glass transition temperature and special properties of polymers

Course Outcome

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

CO1	Understand the polymerization techniques and their kinetics	Understand
CO2	Understand the mechanism of homo and co-polymerization.	Understand
CO3	Determine the Molecular weight of polymers by various analytical methods	Apply, Analyze
CO4	Studypolymer degradation and biodegradability of polymers.	Apply
CO5	Study and determine various physical, mechanical and optical properties of polymers by testing.	Apply

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	1	2	-	-	-	-	-	2	2
CO2	3	2	1	1	2	-	-	-	-	-	2	2
CO3	3	2	3	2	3	-	-	-	-	-	2	2
CO4	3	2	-	-	1	2	2	2	-	-	2	2
CO5	3	2	2	3	3	1	2	1	-	-	2	2
Avg	3.0	2.0	1.2	1.4	2.2	0.6	0.8	0.6	0.0	0.0	2.0	2.0

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

Course level assessment questions

Course Outcome 1(CO1)

1. Classification of polymers.
2. Techniques of polymerization.
3. Anionic and cationic polymerizations.

Course Outcome 2(CO2)

1. Kinetics and mechanism of polymerization.
2. Co-polymerization and co-polymeric equation.
3. Instantaneous composition feed and polymer.

Course Outcome 3(CO3)

1. Number, weight, viscosity and Z- average molecular weights of polymers.
2. Determination of average molecular weights by various techniques.
3. Fractionation of polymers.

Course Outcome 4(CO4)

1. Thermal and mechanical degradation of polymers.
2. Photo degradation and degradation of polymers by ultrasonic waves and high energy radiations .
3. Oxidative and Chemical degradation.

Course Outcome 5(CO5)

1. Physical and chemical properties, glass transition temperature of polymers.
2. Mechanical and Thermal properties of polymers.
3. Optical and Electrical properties of polymers.

SYLLABUS

Module-I:Techniques and kinetics of polymerization
Basic concept of polymeric engineering, classification of polymers; polymerisation techniques such as bulk, solution, emulsion and suspension; mechanism and kinetics of chain polymerisation, effect of temperature, pressure, initiator Concentration monomer concentration; mechanism and kinetics of step growth polymerization molecular weight control; ionic polymerisation anionic polymerisation and cationic polymerisation coordination polymerization.

Module-II: Copolymerization mechanism
Copolymerization mechanism and kinetics, copolymer equation monomer reactivity ratios and their determination, types of co-polymerization, instantaneous composition of feed and polymer, azeotropic: copolymerisation, study state kinetics.

Module-III: Degree of polymerization and molecular weight
Molecular weight of polymer, molecular weight average and degree of polymerisation, polydispersity and molecular weight distribution practical significance of polymer molecular weight determination of molecular weight by cryoscopy ebulliometry, isometry, end group analysis, viscometry, light scattering and ultra-centrifugation fractionation of polymers precipitation extraction gradients elution gel permeation chromatographic technique.

Module-IV: Degradation of polymers
Polymer degradation, types of degradation thermal, mechanical ultrasonic waves photodegradation, high energy radiation, oxidative and chemical degradation.

Module-V: Properties of polymers
Physical and mechanical properties of polymers glass transition temperature its importance, amorphous and crystalline polymers and their properties and influence on surface coatings. Optical properties, colour properties, thermal and radiation stability, electrical resistivity, electrical conductivity, fibre forming properties, orientation and its effect on the properties of polymers, chemical reactivity and products derived from polymers, oxidation stability of polymers.

References :
1. Organic Coating Technology, Vol. I & II by HF Payne
2. Principles of Polymer Chemistry by P. J. Flory
3. Text Book of Polymer Science by F. W. Billmeyer
4. Polymer Science by Gowariker

Course contents and lecture schedule

Module No.	Topic	No. of Lectures
1.	Techniques and kinetics of polymerization	
1.1	Basic concept of polymeric engineering, classification of polymers; polymerisation techniques such as bulk, solution, emulsion and suspension;;	01
1.2	Mechanism and kinetics of chain polymerisation,	01
1.3	Effect of temperature, pressure, initiator Concentration monomer concentration	02
1.4	Mechanism and kinetics of step growth polymerization	01
1.5	Molecular weight control	01
1.6	Ionic polymerisation anionic polymerisation and cationic polymerisation coordination polymerization	01
2.	Copolymerization mechanism	
2.1	What is Copolymerization, ,	01
2.2	Mechanism and kinetics, copolymer equation	02
2.3	Monomer reactivity ratios and their determination	02
2.4	Types of co-polymerization	02
2.5	Instantaneous composition of feed and polymer,	01
2.6	Azeotropic: copolymerization, study state kinetics	02
2.7	Different modes of initiation	02
3.	Degree of polymerization and molecular weight	
3.1	Molecular weight of polymer, ,	02
3.2	Molecular weight average and degree of polymerisation	01
3.3	Polydispersity and molecular weight distribution	02
3.5	Practical significance of polymer molecular weight determination of molecular weight by cryoscopy ebulliometry, isometry, end group analysis, viscometry	01
3.7	Light scattering and ultra-centrifugation fractionation of polymers precipitation extraction gradients elution gel permeation chromatographic technique	01
4.	Degradation of polymers	
4.1	Polymer degradation	02
4.2	Types of degradation	01
4.3	Thermal, mechanical ultrasonic waves photo-degradation,	01
4.4	High energy radiation, oxidative degradation	02
4.5	Chemical degradation	01
5.	Properties of polymers	
5.1	Physical and mechanical properties of polymers.	02
5.2	Glass transition temperature its importance, amorphous and crystalline polymers and their properties and influence on surface coatings	01
5.3	Optical properties, colour properties, thermal and radiation stability	02
5.4	Electrical resistivity, electrical conductivity, fiber forming properties	01
5.5	Orientation and its effect on the properties of polymers, chemical reactivity and products derived from polymers, oxidation stability of polymers.	01
	Total hours	**40**

TPT – 454: TECHNOLOGY OF PACKAGING AND WASTE MANAGEMENT

L	T	P	C
3	1	0	4

OBJECTIVE: **The objective of this course is t**o 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 "-"*

Course Level Assessment Questions

Course Outcome 1(CO1)

1.1 Requirements of packing materials for various products.
1.2 Labeling, coding and holograms.
1.3 Eco-friendly packaging.

Course Outcome 2(CO2)

1.1 Design and developments of packages.
1.2 Printing of different types of packages.
1.3 Packaging machineries.

Course Outcome 3(CO3)

1.1 Tin plate cans and Aluminum cans; Coatings and lining.
1.2 Collapsible tubes and fiber tubes.
1.3 Aerosols and closures & applicators.

Course Outcome 4(CO4)

1.1 Gas and diesel waste.
1.2 Paint waste and paint booth filters, as waste.
1.3 Grease-bearing waste, contaminated cloths and rags, waste solvents.

Course Outcome 5(CO5)

1.1 Waste management in painting, reduction of over spray.
1.2 Air pollution control, aqueous cleaning, recovery and disposal of solvents.

1.3 Global and Indian policies and regulations towards environmental challenges

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. Coatings and lamination, paper films and foils for lamination, adhesives, labels and labeling, heat transfer labels, coding and holograms etc. cushioning, strapes, clips, nuts, nails, laws and regulations, Test methods, quality control, machinery and equipment. Package printing importance, Package disposal, Eco-Friendly packaging, Innovations in packaging: Active packaging, anti-microbial containers, RFID technologies

Module - II Fundamentals of Packaging Technology

Package Development & Design; Package Development Process, **Package Printing & Decorating;** Color Perception, Introduction to Printing, Printing Methods, Electronic Product Coding, Labels & Labeling **Paperboard & Corrugated ;** Paper & Paperboard, Folding Cartons, Corrugated Fiberboard, Corrugated Boxes, Compression Strength Workshop, **Distribution & Transportation Packaging;** Distribution Environment, Protective Packaging, Pre-Shipment Testing, Industrial Packaging, Wood Packaging, **Packaging Plastics;** Introduction to Polymers, Polymer Chemistry, Packaging Polymers, Polymer Property Comparisons, **Plastic Processing;** Extruded Films, Flexible Packaging, Thermoforming, Injection Molding, Blow Molding, **Containers & Closures;** Bottle Design Criteria, Metal Containers, Aerosols, **Packaging Machinery ;** Packaging Machinery, Filling Systems

Module-III: Packaging materials

Metal containers, tin plate cans, tin free steel cans and tempers, coatings and linings, aluminum cans, collapsible tubes, fiber tubes, Aerosols-principle, valves, spray pattern, metering valves. Closures, applicators, fasteners.
Ecology, safety, degradability and recyclability

Module-IVAutomotive Waste Services

Gas and waste diesel, Paint waste and paint booth filters, Waste bearing grease, Brake fluid, Contaminated cloths and rags, Waste solvents, Paint sludge, Paint Booth additives

Module-VWaste management

Waste management in Painting, Management Attitudes for Painting, Waste During Painting, General Recommendations To Reduce Overspray, Waste during General Recommendations
To Reduce Overspray, Solvents/ Thinners; Waste Reduction Techniques in Painting, Air Pollution Control, Aqueous Cleaning: An Effective Strategy, Solvent Recycling Techniques, Recovery and Disposal of Solvents, Improve efficiency and productivity, Characteristics of Hazardous Industrial Wastes;
Global policies and regulations. Social and environmental challenges of paint waste in India. paint and environment. Salient features of the paint waste management (PWM) rules. Waste treatment of various paint plants, estimation of power requirement and efficiency of size reduction operation of paints

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

Course contents and lecture schedule

Module No.	Topic	No. of lectures
1.	Elements of packaging	
1.1	Elements of packaging, concepts, function, entities, status, scope, biotic and abiotic	01
1.2	Natural packaging, packaging values	01
1.3	Professional approach to development of package for food products	02
1.4	General consumables, cosmetics, pharmaceuticals	01
1.5	Engineering materials and other utilities	01
1.6	Degree of polymerization and mot. Wt. Calculation with examples	01
2.	Fundamentals of packaging technology	
2.1	**Package development & design;** package development process, **package printing & decorating**	01
2.2	Color perception, introduction to printing, printing methods, electronic product coding,labels& labeling,	02
2.3	**Paperboard & corrugated ;** paper & paperboard, folding cartons, corrugated fiberboard, corrugated boxes, compression strength workshop,	02
2.4	**Distribution & transportation packaging;** distribution environment, protective packaging, pre-shipment testing, industrial packaging, wood packaging	02
2.5	**Packaging plastics;** introduction to polymers,polymer chemistry, packaging polymers, polymer property comparisons, **plastic processing;** extruded films, flexible packaging,thermoforming, injection molding, blow molding	01
2.6	**Containers & closures;** bottle design criteria, metal containers, aerosols	02
2.7	**Packaging machinery ;** packaging machinery, filling systems	02
3.	Packing materials	
3.1	Metalcontainers, tin plate cans	02
3.2	Tin free steel cans and tempers	01
3.3	Coatings and linings	02
3.5	Aluminum cans, collapsible tubes, fiber tubes, aerosols-principle	01
3.7	Valves, spray pattern, metering valves. Closures, applicators, fasteners	01
4.	Automotive waste services	
4.1	Gas and waste diesel	02
4.2	Paint waste and paint booth filters	01
4.3	Waste bearing grease	01
4.4	Brake fluid	02
4.5	Contaminated cloths and rags, waste solvents,	01
5.	Waste management	
5.1	Waste management in painting, management attitudes for painting, waste during painting, general recommendations to reduce overspray	02
5.2	Waste during general recommendations to reduce overspray, solvents/ thinners; waste reduction techniques in painting	01
5.3	Air pollution control, aqueous cleaning: an effective strategy, solvent recycling techniques, recovery and disposal of solvents, improve efficiency and productivity	02
5.4	Characteristics of hazardous industrial wastes; Global policies and regulations. Social and environmental challenges of paint waste in India.	01
5.5	Paint and environment. Salient features of the paint waste management (pwm) rules. Waste treatment of various paint plants, estimation of power requirement and efficiency of size reduction operation of paints	01
	Total hours	**40**

PROGRAMME ELECTIVE COURSE I V

TPT 456: PROCESS MODELING AND SIMULATION

L	T	P	C
2	1	0	3

Assessment:
Sessional: 50 marks
End Semester: 50 marks

Course Objectives:
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:
Students completing the course will be able to

CO 1	Model deterministic systems and differentiate between nonlinear and linear models	Remember, Apply, Analyze
CO 2	Numerically simulate linear and non linear ordinary differential equations for deterministic systems	Apply, Analyze, Evaluate
CO 3	Estimate and validate a model based upon input and output data.	Apply, Analyze, Evaluate
CO 4	Create a model prediction based upon new input and validate the output data	Understand, Apply, Analyze, Evaluate, Create
CO 5	Develop steady state models for flash vessels, equilibrium staged processes, distillation columns, absorbers, strippers, CSTR, heat exchangers and packed bed reactors.	Remember, Apply, Analyze, Evaluate

	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	3	3	2	-	-	1	-	1	1	2	**1**	**1**
CO2	3	3	3	3	3	1	-	1	-	1	1	2	3	3
CO3	3	3	3	2	3	1	-	1	-	1	1	2	3	3
CO4	3	3	3	2	2	1	-	1	-	1	1	2	3	3
CO5	3	3	3	3	3	1	1	1	-	1	2	3	3	3
Avg.	3	3	3	2.6	2.6	0.8	0.2	1	-	1	1.2	2.2	3	3

Syllabus

Module1 (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.

Module2 (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.

Module3 (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 procedures and available numerical software libraries.

Module4 (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 beds; Packed bed reactors; Modeling of reactive separation processes; Review of solution strategies for Differential Algebraic Equations (DAEs), Partial Differential Equations (PDEs), and available numerical software libraries.

Module5 (6 hours)

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

Suggested Text Books

1. Luyben W.L., “Process Modeling, Simulation, and Control for Chemical Engineering”, Mc Graw Hill.
2. D. F. Rudd and C. C. Watson, “ Strategy of Process Engineering”, Wiley international.
3. M.M. Denn, “Process Modelling”, Wiley, New York, (1990).

Suggested Reference Books

1. A. K. Jana, “Chemical Process Modelling and Computer Simulation”, PHI,(2011)
2. C.D. Holland, “Fundamentals of Modelling Separation Processes”, Prentice Hall, (1975)
3. Hussain Asghar, “Chemical Process Simulation”, Wiley Eastern Ltd., New Delhi, (1986)

PROGRAMME ELECTIVE COURSE IV

TPT 458: COMPUTER AIDED EQUIPMENT DESIGN

L	T	P	C
2	1	0	3

Assessment:
Sessional: 50 marks
End Semester: 50 marks

Course Objectives:

The objective of this course is to acquire basic understanding of design parameters, complete knowledge of design procedures for commonly used process equipment and their attachments (e.g. internal and external pressure vessels, tall vessels, high pressure vessels, supports etc.), and different types of equipment testing methods.

Course outcomes: Students completing the course will be able to

CO1	Understand the basics of process equipment design and important parameters of equipment design	Understand
CO2	Understand the basics of process equipment design and important parameters of equipment design	Understand
CO3	Design special vessels such as tall vessels, self-supporting vessels, and skirt (and other support for vertical vessels).	Apply
CO4	Design liquid and gas storage tanks with and without floating roof	Apply
CO5	Select standard piping, flanges, gaskets and bolts associated with the vessels and storage tanks.	Analyze

Syllabus

Module 1 (6 hours)
Introduction: Classification of engineering materials, properties of Ferrous metals, Non ferrous metals, alloys & Ceramic materials Structure-Property relationship in materials. Deformation of Materials Fracture: Elastic deformation, Plastic deformation, Creep, Visco-elastic deformation, Different types of fracture, 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 techniques (bending, Rolling, Forming) & Metal joining techniques, welding – such as Butt, Lap, fillet, corner. Inspection and testing of process vessel.

Module 2 (6 hours)
Pressure Vessels: 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 closures and heads such as Flat, hemispherical, tori-spherical, elliptical & conical.; Introduction to compensation for opening such as nozzles & manholes etc.

Module 3 (6 hours)
Flanges: Selection of gaskets, selection of standard flanges, optimum selection of bolts for flanges, design of flanges. Inspection and testing of vessels, heads, and flanges; as per code specifications. Piping: Pipe thickness calculation under internal and external pressure, introduction to flexibility analysis of piping system.

Module 4 (6 hours)

Tall Tower Design: Design of shell, skirt, bearing plate and anchor bolts for tall tower used at high wind and seismic conditions. Supports: Design of lug support and saddle support including bearing plates and anchor bolts.

Module 5 (6 hours)

Storage Tanks: Introduction to Indian standards, filling and breathing losses; classification of storage tanks; Design of liquid and gas storage tanks with and without floating roof. High-pressure vessels, Fundamental equations, Compound vessels, Liquid storage tanks, Mechanical design of centrifuges, Centrifugal pressure, Bowl and spindle motion: critical speed.

Suggested Text Books

1. Brownell L. E. and Young H. E., "Process Equipment Design", John Wiley and Sons. 2009.
2. Bhattacharya B. C., "Introduction of Chemical Equipment Design", 1st Edition, CBS Publisher. 2008.
3. I.S.:2825-1969, "Code for Unfired Pressure Vessels", Bureau of Indian Standards.1969.
4. I.S.:803-1962, "Code of Practice for Design, Fabrication and Erection of Vertical Mild Steel Cylindrical Welded Oil Storage Tanks", Bureau of Indian Standards.1962.

Suggested Reference Books

1. Moss D. R., "Pressure Vessel Design Manual", 3rd Edition, Gulf Publishers, 2004.
2. Annartone D., "Pressure Vessel Design", 3rd Edition, Springer 2007.
3. Joshi M.V., and Mahajani, V.V., "Process Equipment Design", 3rd Edition, Macmillan India, 2000.
4. Coulson, J.M., Richardson, J.F., and Sinnott, R.H., "Chemical Engineering Volume 6, 3rd revised Edition, Butterworth-Heinemann Ltd., 1999.

OPEN ELECTIVE COURSE IV

OCH 444 TRANSPORT PHENOMENA

L	T	P	C
2	1	0	3

Assessment:
Sessional: 50 marks
End Semester: 50 marks

Course Objectives:
This course will highlight coupling between three transport phenomena with applications in various disciplines in engineering and science, and will demonstrate to the students the common mathematical structure of transport problems. The course will deal with flow problems involving Newtonian and non-Newtonian fluids, solid-state heat conduction, forced and free convection, binary diffusion with or without chemical reaction.

Course Outcomes:

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CO1	Perform basic vector and tensor analysis	Understand, Apply,
CO2	Solve transport problems using shell balances	Apply, Evaluate
CO3	Formulate and solve one-dimensional transport problems by using the conservation equations	Analyse, Evaluate
CO4	Formulate simple multi-dimensional transport problems	Apply, Evaluate, Create
CO5	Understand and apply the shell balance and boundary conditions on various types of system	Understand, Evaluate

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	**PSOs**	
CO1	3	3	3	2	1	-	-	-	-	-	-	1	**1**	**2**
CO2	3	3	3	2	2	1	-	-	-	1	1	1	3	3
CO3	3	2	2	2	2	1	-	-	-	1	1	1	3	3
CO4	3	3	1	2	2	1	-	-	-	1	1	1	3	3
CO5	3	3	1	2	2	1	-	-	-	1	1	1	3	3
Avg	3	2.8	2	2	1.8	0.8	-	-	-	0.8	0.8	1	3	3
													3	**3**

Syllabus

Module1 (7 hours)
Introduction to Newton's law of viscosity, non –Newtonian fluids, pressure & temperature dependence of viscosity, estimation of viscosity from critical properties. Shell momentum balances, boundary conditions, flow of a falling film, flow through a circular tube, flow through annular, creeping flow along a solid sphere.

Module2 (7 hours)
The equation of continuity, the equation of motion, use of the equations of change to set up steady flow problems and applications.

Module3 (4 hours)
Flow near a wall suddenly set in motion, Boundary layer theory and applications.

Module4 (6 hours)
Shell energy balances, temperature profiles, average temperature, energy fluxes at surfaces, Equations of change, equation of motion for forced and free convection and applications.

Module5 (6 hours)
Definitions of concentrations, velocities & mass fluxes, Fick's law of diffusion, Temperature & pressure dependence of mass diffusivity, Maxwell's law of diffusion. shell mass balance, boundary conditions, diffusion through a stagnant gas film and applications.

Suggested Text books
1. Bird, R. B., Stewart, W. E. and Lightfoot, E. N., "Transport Phenomena", 2nd edition John Wiley (1960).
2. Bannet, C. O. and Myers J. E., "Momentum Heat and Mass Transfer" Tata McGraw Hill, (1973).

Suggested Reference Books
1. RS Brodkey and HC Hersey, "Transport Phenomena: AUnified approach", McGraw-Hill Book,(1988).

TPT – 498: PROJECT

L	T	P	C
0	0	16	8

OBJECTIVE:The objective of this course is to enable the students
To identify the project, product ideas may emerge mainly from survey of raw materials
To prepare a detailed project report on fabrication of a product/equipment/process of a plant for production of paints product with complete lay-out or a research problem and conduct experiment.
To assess the economic analysis and to prepare a feasibility report for a project based on manufacturing of product/equipment/process.
To prepare the students for entrepreneurship. .
To develop marketing skill in the students.

Course Outcome

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

CO1	Study the principles of project management and finance and apply the same for making project related calculations	Apply
CO2	Apply the knowledge to prepare a report of the project selected in previous semester	Apply
CO3	Calculate the cost of product based on the formulation decided	Apply
CO4	Evaluate various methods/processes of production available and select the one which is most suitable and cost-effective	Evaluate
CO5	Calculate the feasibility of the project selected	Apply

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	3	2	1	2	3	3	2	3
CO2	2	3	2	1	2	2	3	2	2	3	3	3
CO3	3	3	3	3	3	1	2	2	3	3	3	3
CO4	3	3	3	2	3	2	2	2	3	3	3	3
CO5	3	3	3	3	3	2	3	2	2	3	3	3
Avg	2.8	2.8	2.6	2.0	2.8	1.8	2.2	2.0	2.6	3.0	2.8	3.0

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