NEP-2020 Aligned Curriculum for

Three Year (Six Semesters) Diploma Programme in

PAINT TECHNOLOGY

(3rd to 4th Semester)

==========

Semester System

==========

(Effective From Session 2025 - 26)

Prepared By:

Institute Of Research, Development & Training, U.P., Kanpur

CONTENTS

THIRD SEMESTER

FOURTH SEMESTER

PREFACE

An important issue generally debated amongst the planners and educators world over is how technical education can contribute to sustainable development of the societies struggling hard to come in the same bracket as that of the developed nations. The rapid industrialization and globalization has created an environment for free flow of information and technology through fast and efficient means. This has led to shrinking of the world, bringing people from different culture and environment together and giving rise to the concept of world turning into a global village. In India, a shift has taken place from the forgettable years of closed economy to knowledge based and opens economy in the last few decades. In order to cope with the challenges of handling new technologies, materials and methods, we have to develop human resources having appropriate professional knowledge, skills and attitude. Technical education system is one of the significant components of the human resource development and has grown phenomenally during all these years. Now it is time to consolidate and infuse quality aspect through developing human resources, in the delivery system. Polytechnics play an important role in meeting the requirements of trained technical manpower for industries and field organizations. The initiatives being taken by the State Board of Technical Education, UP to revise the existing curricula of 42 diploma programmes as per the needs of the industry and making them NEP-2020/AICTE compliant, are laudable.

In order to meet the requirements of future technical manpower, we will have to revamp our existing technical education system and one of the most important requirements is to develop outcome-based curricula of diploma programmes. The curricula for diploma programmes have been revised by adopting time-tested and nationally acclaimed scientific method, laying emphasis on the identification of learning outcomes of diploma programme.

The real success of the diploma programme depends upon its effective implementation. However best the curriculum document is designed, if that is not implemented properly, the output will not be as expected. In addition to acquisition of appropriate physical resources, the availability of motivated, competent and qualified faculty is essential for effective implementation of the curricula.

It is expected of the polytechnics to carry out job market research on a continuous basis to identify the new skill requirements, reduce or remove outdated and redundant courses, develop innovative methods of course offering and thereby infuse the much needed dynamism in the system.

Director
Institute of Research Development & Training

ACKNOWLEDGEMENTS

We gratefully acknowledge the guidance and contribution received from the following Persons

1. Sh. Narendra Bhooshan, IAS, Additional Chief Secretary, Department of Technical Education, Govt. of UP, for his exemplary vision & approach.

2. Sh. Avinash Krishna Singh, IAS, Secretary, Directorate General, Department of Technical Education, Govt. of U.P.

3. Sh. F.R. Khan, Director, I.R.D.T. Kanpur for continually motivating, guiding and taking keen interest in the review of curriculum..

4. All the participants from industries, Polytechnics and other technical institutions for their professional inputs during curriculum workshops.

5. CDC Officer and other concerning staff of IRDT for their support and assistance in conducting curriculum workshops.

6. In the last but not least would like to thanks management of the industries who spare not only their precious time but also allowed the visit of their industries to the team making the curriculum

Shyam Lal
Text Book Officer/Course Coordinator
IRDT Kanpur

1 SALIENT FEATURES

.

1)	Name of the Programme	:	Diploma in Paint Technology
2)	Duration of the Programme	:	Three years (Six Semesters)
3)	Entry Qualification	:	Matriculation or equivalent NSQF Level as Prescribed by State Board of Technical Education, UP
4)	Pattern of the Programme	:	Semester Pattern
5)	NSQF Level	:	Level - 5
6)	Ratio between theory and Practical	:	40: 60 (Approx.)

7) **Industrial Training**

Four and six weeks of industrial training is made mandatory after the II and IV semesters during summer vacation.Total marks allotted to industrial training will be respectively 50 & 100.

In the last (6^{th} Semester) we have made the one semester Industrial training/Internship as optional along with usual classroom training.

8) **Ecology and Environment**

As per Govt. of India directives a subject on Environmental Science has been incorporated in the curriculum.

9) **Entrepreneurship and Start-ups**

A full subject Entrepreneurship & Start-ups has been incorporated in the curriculum.

10) **Student Centred Activities**

A provision of 4-8 hrs per week has been made for organizing Student Centered Activities for overall personality development of students. Such activities will comprise of co–curricular activities such as expert lectures, self-study, games, hobby classes like photography, painting, singing etc. seminars, declamation contests, educational field visits, NCC, NSS, library and other cultural activities.

11) **Project work**

A project work has been included in the curriculum to enable the student get familiarize with the practices and procedures being followed in the industries and provide an opportunity to work on some live projects in the industry.

2- PROGRAM OUTCOMES (POs)

PO1: Basics and Discipline specific Knowledge
Assimilate knowledge of basic mathematics, science, engineering fundamentals.

PO2: Problem's Analysis and solution
Identify, analyse and solve problems using standard methods and established techniques.

PO3: Design and Development
Design solutions for technical problems.
Assist in designing components, systems, or processes to meet specific requirements.

PO4: Engineering Tools, Experimentation, and Testing
Use modern engineering tools and appropriate techniques to conduct experiments as per BIS standard.

PO5: Socio/ Economic /Environmental impact assessment/remedy.

Apply relevant technologies while considering societal needs, environmental impact keeping in view sustainable and ethical responsibilities.

PO6: Project Management and Communication
Apply engineering management principles, work effectively as an individual or in a team, and communicate clearly on activities.

PO7: Lifelong Learning
Recognize the importance of continuous learning and actively pursue self-improvement to keep pace with technological developments.

3- **Employment Opportunities -**

Chemical and Allied Industries like

- Paint & Allied Industries
- Paint Manufacturing Indutries

- Pulp and Paper industry
- Polymer industry
- Pharmaceutical industry
- Paint and dye industry
- Rubber industry
- General processing industries
- Glass industry
- Ceramics industry
- Automobile industry (paint shop and electroplating shop)\
- Test Equipment : Manufacturing and repairing
- Paint Applications industries. Etc.

In various functional areas like erection and commissioning of plant, plant operation, energy conservation, plant utilities, production, water treatment, maintenance and safety, quality control, inspection and testing, marketing and sales, consultancy services and areas concerning environmental protection.

(ii) Research Organizations like CSIR laboratories, Defence laboratories, Atomic energy establishments etc.
(iii) Boards and Corporations.
(iv) Entrepreneurs to small/tiny units especially food, agro and chemical industries such as paints, soap, detergents, equipment repairing etc.
v) Academic Institutions (as technicians/instructors at all levels

4. LEARNING OUTCOMES

Sr.	Learning Outcomes
After undergoing this programme, students will be able to:	
1	Prepare and interpret drawings of engineering components and plants
2	Read and interpret drawings related to plant layout, process equipment and components, process flow sheets and product manufacturing.
3	Apply concepts of mechanics to solve chemical engineering problems
4	Apply basic principles of mathematics, science and engineering to solve chemical engineering problems
5	Select various materials used in chemical processes, their properties and specifications
6	Understand various unit operations, unit processes and process instrumentation in process industry
7	Calculate the quantity of raw materials, energy inputs, manpower requirement and output from the process
8	Control the process and quality of the products commensurating with laid specifications
9	Recognise the need for and have the ability to engage in life long learning
10	Conduct experiments, analyse, interpret data and synthesise valid conclusions
11	Operate conventional machine for machining of components as per specifications as an aid to function effectively in the process industry.
12	Use electrical and electronic instruments to measure various engineering parameters
13	Use various measuring and gauging instruments
14	Select material as per desired application
15	Understand the general design of process equipments and testing
16	Operate different utility plants
17	Understand different renewable sources of energy and their applications.
18	Understand different plants utilities and their generation and maintenance
19	Use various software tools for automation and process development.
20	Interpret factory acts, laws and taxes
21	Develop communication and interpersonal skills for effective functioning in the world of work.
22	Communicate effectively in English and local language in oral and written form with others
23	Manage resources effectively at work place
24	Plan and execute given task/project as a team member or leader
25	Prepare detailed project proposal and report.
26	Use computer and IT tools for creating documents, making spread sheet and making presentation
27	Solve real life problems by application of acquired knowledge and skills
28	Use energy conservation methods to manage energy efficiency
29	Use appropriate practices for conservation and prevention of environment pollution and safety in process industries.

5- ABSTRACT OF CURRICULUM AREAS

HUMANITIES & SOCIAL SCIENCES COURSES [HS]	
	• Communication Skills in English
	• Sports and Yoga
	• Entrepreneurship and Start-ups
BASIC SCIENCES COURSE [BS]	
	• Mathematics
	• Applied Physics
	• Applied Chemistry
ENGINEERING SCIENCE COURSES [ES]	
	• Engineering Graphics
	• Engineering Workshop Practice
	• Introduction to IT Systems
	• Fundamentals of Electrical & Electronics Engineering
	• Engineering Mechanics
PROGRAM CORE COURSES [PC]	
	• Introduction to Paint and Polymer Technology
	• Pigment and Extender
	• Resin and Paint Media
	• Resin and Paint Media
	• Drying Oils , Driers , Solvents & Paint Additives
	• Chemical process Calculation
	• Fluid Mechanics and solid Handling
	• Heat & Mass Transfer
	• Chemical Reaction • Engineering & Thermodynamics
	• Formulation and Manufacturing of Paint
	• Formulation and Manufacturing of Paint
	• Surface Preparation and Paint Application

PROGRAM ELECTIVE COURSES [PE]	
	Program Elective -1 • Material science and Technology • Energy Engineering **Program Elective-2** • Plant Utilities • Waste Management
OPEN ELECTIVE COURSES [OE]	
	Open Elective -1 ● Renewable Energy Technologies ● Internet Of Things ● Disaster Management

PROJECT WORK, SEMINAR AND INTERNSHIP IN INDUSTRY OR ELSEWHERE

- Summer Internship – I (3-4 weeks) after IInd Sem
- Summer Internship – II (4-6 weeks) after IVth Sem
- Major Project(In-House) / Internship / Industrial Training

AUDIT COURSES [AU]

- Environmental Science
- Essence of Indian Knowledge and Tradition
- Indian Constitution

6-STUDY AND EVALUATION SCHEME FOR PAINT TECHNOLOGY

NOTE: I & II Sem. is common to all Engineering & Technology branches and implemented from the session 2024-2025

THIRD SEMESTER

SR. NO.	SUBJECTS	COURSE TYPE AND CATEGORY	STUDY SCHEME PERIODS/WEEK			CREDITS	MARKS IN EVALUATION SCHEME								TOTAL MARKS OF INTERNAL & EXTERNAL
							INTERNAL ASSESSMENT			EXTERNAL ASSESSMENT					
			L	T	P		TH	PR	TOT	TH	HRS	PR	HRS	TOT	
3.1	Introduction to Paint and Polymer Technology	Program Core (Practicum)	2	-	2	2+1=3	40	-	40	60	3	-	-	60	100
3.2	Pigment and Extender	Program Core (Practicum)	2	-	2	2+1=3	40	-	40	60	3	-	-	60	100
3.3	Resin and Paint Media	Program Core (Theory)	2	-	-	2+0=2	40	-	40	60	3	-	-	60	100
3.4	Resin and Paint Media	Program Core (Practical)	-	-	4	0+2=2	-	60	60	-	-	40	3	40	100
3.5	Drying Oils , Driers , Solvents & Paint Additives	Program Core (Practicum)	2	-	2	2+1=3	40	-	40	60	3	-	-	60	100
3.6	Chemical process Calculation	Program Core (Theory)	2	-	-	2+0=2	40	-	40	60	3	-	-	60	100
3.7	Fluid Mechanics and solid Handling	Program Core (Practicum)	2	-	2	2+1=3	40	-	40	60	3	-	-	60	100
3.8	Summer Internship **(4 Weeks)		-	-	-	0+2=2	-	50	50	-	-	-	-	-	50
#Student Centered Activities			-	-	12	-	-	50	50	-	-	-	-	-	50
TOTAL			**12**	**-**	**16**	**20**	**240**	**160**	**400**	**360**		**40**		**400**	**800**

****** Students will present a seminar on their summer internship along with certificate, project and report.

Student Centered Activities will comprise of co-curricular activities like extension lectures, games, hobby clubs e.g. Photography etc., Seminars, Declamation Contests, voluntary contribution in physical activities, Educational Field Visits, NCC, NSS, Cultural Activities and Self-Study etc.

Note- 1) Each period will be 60 minutes duration.
2) Each session will be of 16 weeks.
3) Effective teaching will be at least 14 weeks.

STUDY AND EVALUATION SCHEME FOR PAINT TECHNOLOGY

FOURTH SEMESTER

SR. NO.	SUBJECTS	COURSE TYPE AND CATEGORY	STUDY SCHEME PERIODS/WEEK			CREDITS	MARKS IN EVALUATION SCHEME								TOTAL MARKS OF INTERNAL & EXTERNAL
							INTERNAL ASSESSMENT			EXTERNAL ASSESSMENT					
			L	T	P		TH	PR	TOT	TH	HRS	PR	HRS	TOT	
4.1	Heat & Mass Transfer	Program Core (Practicum)	2	-	2	2+1=3	40	-	40	60	3	-	-	60	100
4.2	Chemical Reaction Engineering & Thermodynamics	Program Core (Practicum)	2	-	2	2+1=3	40	-	40	60	3	-	-	60	100
4.3	Formulation and Manufacturing of Paint	Program Core (Theory	2	-	-	2+0=2	40	-	40	60	3	-	-	60	100
4.4	Formulation and Manufacturing of Paint	Program Core (Practical)	-	-	4	0+2=2	-	60	60	-	-	40	-	40	100
4.5	Surface Preparation and Paint Application	Program Core (Practicum)	2	-	4	2+2=4	40	-	40	60	3	-	-	60	100
4.6	Program Elective - 1	Program Core (Theory)	2	-	-	2+0=2	40	-	40	60	3	-	-	60	100
4.7	Program Elective - 2	Program Core (Theory)	2	-	-	2+0=2	40	-	40	60	3	-	-	60	100
4.8	(Q) Open Elective-1 **OR**	Open Elective	2	-	-	2	50*	-	-	-	-	-	-	-	-
	*Advance Skill Development	Certification Course	-	-	-		-	-	-	-	-	-	-	-	-
4.9	(Q) Essence Of Indian Knowledge and Tradition	Audit Course	2	-	-	-	50*	-	-	-	-	-	-	-	-
# Student Centered Activities			-	-	8	-	-	50	50	-	-	-	-	-	50
TOTAL			**16**	**-**	**20**	**20**	**240**	**110**	**350**	**360**		**40**	**-**	**400**	**750**

*Students will submit the certificate.

(Q) This Course is Qualifying only, Exam marks will not be added in obtained marks.

Advance Skill Development:

To fulfill the requirements for Advanced Skill Development, a minimum of 20 hours of skill certification is necessary. This certification must be obtained from a recognized national or international agency or institute. The assessment and certification process will be conducted by the respective agency or institute. Students must present their certificate to earn 02 credits for this subject.

Student Centered Activities will comprise of co-curricular activities like extension lectures, games, hobby clubs e.g. Photography etc., Seminars, Declamation Contests, voluntary contribution in physical activities, Educational Field Visits, NCC, NSS, Cultural Activities and Self-Study etc.

-Industrial Training (Summer Internship-II) of 4-6 Weeks after 4th Semester, Evaluation will be in 5th Semester.

PROGRAM ELECTIVE-1

SR. NO.	SUBJECT NAME
1	Material science and Technology
2	Energy Engineering

PROGRAM ELECTIVE-2

SR. NO.	SUBJECT NAME
1	Plant Utilities
2	Waste Management

OPEN ELECTIVE-1

SR. NO.	SUBJECT NAME
1	Renewable Energy Technologies
2	Internet Of Things (IoT)
3	Disaster Management
4	Any Course of Minimum 02 Credit From NPTEL MOOCS Through SWAYAM AICTE-ELIS And Centrally Funded Technical Institutes C-Dac Certificates Conducted by The Institute of National Importance (IIT, NIT, IIT Etc.) ISRO E-Learning Other Relevant Government, International/National Platforms of Repute, NIT, IIT

Note- 1) Each period will be 60 minutes duration.
2) Each session will be of 16 weeks.
3) Effective teaching will be at least 14 weeks.

DETAILED CONTENTS OF VARIOUS SUBJETS

		L	T	P
PRACTICUM	**3.1 INTRODUCTION TO PAINT & POLYMER TECHNOLOGY**	**2**	**-**	**2**

COURSE OBJECTIVES

In this subject Students will get to know the basic knowledge of Paint as material , and different types of polymers and polymerization techniques to get the film formers.

COURSE OUTCOME:

After undergoing this Subject, the students will be able to:

CO1: Understand the Fundamentals of Paints

CO2: Understand the Fundamentals of Oils

CO3: Understand the Fundamentals of Polymers.

CO4: Analysis of Polymerization techniques

CO5: Understanding Application of Synthetic Film Formers.

COURSE CONTENTS

UNIT 1- BASICS OF PAINT: (07 Periods)

General Introduction of Paint Industry, general classification of coatings, definition of Paints, Varnishes and Lacquers, their constituents and functions, sources and composition of oils, type of oils, extraction and refining of oils, mechanism of film formation,

Experiment:

1. To prepare oil varnish.

UNIT 2- FUNDAMENTAL OF POLYMERS: (07 Periods)

Introduction of polymers, macro-molecular concept, monomers & polymers nomenclature, applications of a polymer, definition of polymerization, rate of polymerization, average degree of polymerization, functionality and polymerization, oligomers and high polymers, scope of elastomeric, plastic materials, concept of glass transition temperature.

UNIT 3- CLASSIFICATION OF POLYMERIZATION: (07 Periods)

Types of polymerizations, addition (chain) polymerization, condensation polymerization, Comparison between addition and condensation polymerization. Bulk, suspension, solution & emulsion polymerization.

Experiment:

1. Preparation of Acrylic Emulsions.
2. Preparation of Polystyrene by bulk polymerization.

UNIT 4- FUNDAMENTAL OF SYNTHETIC FILM FORMERS: (07 Periods)

Fundamental of film formers, chemical structure of monomers, functionality and its determination, polymerization and molecular weight, convertible, non-convertible film formers, linear, branched and cross-linked film formers and co polymers.

Experiment:

1. Preparation of polyacrylate by solution polymerization

INSTRUCTIONAL STRATEGY

As the subject involves manufacturing of polymers used in paint industry, It can be made more interacting by showing various paint samples.

It enables students to get awareness on convertible and non-convertible film formers used in the paint industry.

MEANS OF ASSESSMENT

- Assignments and quiz/class tests
- Mid-term and end-term written tests
- Execution of practical work
- Practical file submission

RECOMMENDED BOOKS

1 Basics of Paint Technology- Part- 1 By V.C.Malshe, Meenal. A.Sikchi

2 Organic Coating Technology vol-1 By Henry Fleming, Payne Publisher John Wiley & Sons.

3 Surface Coatings: Raw materials & their usage Volume-1 By OCCA-Australia Publisher Champas & Hall

4 Outlines of Paint Technology By W.M.Morgan Publisher Edward Arnold.

5 Introduction To Paint Chemistry By G.P.A.Turner Publisher champan & Hall

6 Polymer Science By V.R.Gowariker Publisher New Age International

WEBSITES FOR REFERENCE:

1. http://swayam.gov.in

SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time Allotted (Periods)	Marks Allotted (%)
1	07	25
2	07	25
3	07	25
4	07	25
Total	28	100

PRACTICUM	3.2 PIGMENT AND EXTENDER	L	T	P
		2	-	2

COURSE OBJECTIVES

In this subject, the concept of colors is discussed, Various types of Pigments and Extenders are discussed in this paper which are responsible for colors and other properties in Paints and Coatings.

COURSE OUTCOMES

After the completion of this course, the students will be able to:

CO1: Understand the color phenomena and its application.

CO2:Determine the difference between Pigments & Dyes.

CO3:Understand the Extenders and Pigments, and their manufacturing Processes.

CO4:Learn about Inorganic and organic & Special effect Pigments.

CO5:Evaluation of pigments and extenders properties

COURSE CONTENTS

UNIT 1- INTRODUCTION: (06 Periods)

Definition of pigment, dyes, dyes stuffs, toners and lake pigment etc., classification of pigments, properties & testing of pigments e.g. oil absorption value, bulking value, sp. Gravity, refractive index, mass tone, reducing power, tinting strength, resistance to heat, Concept of color phenomena, hue, value and chroma, delta E.

Experiment:

1. To measure oil absorption value, refractive index, specific gravity of pigment/extenders.
2. To measure color, tinting strength, reducing power, mass tone and undertone of pigment.

UNIT 2- INORGANIC PIGMENTS: (06 Periods)

(A)- White pigment such as titanium dioxide, zinc oxide, Zinc Sulphate, Lithopone etc.

(B)- Color pigments natural and synthetic iron oxide, silico chromates and molybdates, chrome green, chromium oxide, cadmium pigments, Prussian and ultramarine-blue, black, mercuric sulfide, synthetic inorganic complexes etc.

(C)- Metallic pigments such as alloys of aluminium, zinc, copper, stainless steel etc., anti-corrosive pigments such red lead, silicon chromate, zinc and strontium chromate white molybdates, calcium plumbate etc. Functional and miscellaneous pigments such as cuprous and mercuric oxides, barium meta borate, nacreous luminescent, etc.

UNIT 3- EXTENDERS: (06 Periods)

Sources, manufacture, properties and uses of extenders pigments such as carbonates, silicates, sulphates, oxides, aluminates etc. Lead carbonate, Sulphate, silicate etc., antimony oxides, zirconium oxide and silicate, potassium titanate etc.

UNIT 4- ORGANIC PIGMENTS: (06 Periods)

Natural organic pigments, comparison of organic pigments and inorganic pigments,

Classification of synthetic organic pigments and azo pigments, Basic and acid dye pigment.

Testing and identification of organic pigments.

UNIT 5- MISCELLANEOUS PIGMENTS: (04 Periods)

Phthalocyanine blue and green, hansa yellows rubine, toners, para red, toluedene red, metallic, phosphorescent, fluorescent, pearl thermochromic pigments, polymeric pigments, invisible piments, etc., treated pigments.

INSTRUCTIONAL STRATEGY

Lot of emphasis given to students to understand and compare the difference between organic and inorganic pigments visually and by using certain properties. Also enables the student to determine L,a,b values and also get to know the awareness of color matching by visual and by delta E value. This will make the subject interesting and improve student involvement in the subject.

MEANS OF ASSESSMENT

- Assignments and quiz/class tests
- Mid-term and end-term written tests
- Execution of practical work
- Practical file submission

RECOMMENDED BOOKS

1. Organic Coating Technology vol-2 By Henry Fleming, Payne Publisher John Wiley & Sons.
2. Surface Coatings : Raw materials & their usage Volume-1 By OCCA-Australia Publisher Champas & Hall
3. Outlines of Paint Technology by W M Morgans Publisher Edward Arnold.
4. Pigment Handbook vol-1 By T.C.Patton
5. Surface Coatings: Science & Technology by Swaraj Paul Publisher John Wiley & Sons.
6. The Chemistry and Physics of Organic Pigments by L.S.Pratt.
7. Basics of Paint Technology, Part I & II, by V.C.Malshe &Meenal Sikchi
8. Pigments, dyestuffs and lakes, part six, Paint Technology Manuals.
9. Industrial Organic Pigments by Dr. Willy Hurbst

Lab references

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

SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time Allotted (Periods)	Marks Allotted (%)
1.	06	20
2.	06	20
3.	06	20
4.	06	20
5.	04	20
Total	**28**	**100**

THEORY	3.3 RESIN AND PAINT MEDIA	L	T	P
		2	-	-

COURSE OBJECTIVES

In this subject various types of resins are discussed which are used as film former or binder in the Paints & Coating, Synthetic resins for different application area are discussed along with properties and manufacturing.

COURSE OUTCOMES

After studying this course, the students will be able to:

CO1: Understand about Natural and Synthetic Resins

CO2: Understanding the Manufacturing Process of Resins.

CO3: Understanding of resin chemistry and mechanism of its polymerization.

CO3: Understand the Structure-Property Relationship of each Resin.

CO4: Knowledge on properties and application of various resin

COURSE CONTENTS

UNIT 1- INTRODUCTION TO NATURAL RESINS : (5 Periods)

Classification and properties of natural resins etc., various sources of natural resin, oleoresin and its composition, properties of natural resin,

Deficiencies of rosin film, modification of rosin: Calcium rosinate and maleoprimaric rosin etc.

Shellac: origin, different kinds of lac and their properties, chemical modification of shellac for use in coatings ,oleo-resinous varnishes etc. from shellac.

Cellulose source, properties, modification of cellulose for use in surface coatings like cellulose esters, ethers.

UNIT 2- ALKYD RESIN,POLYESTER AND PHENOLIC RESINS: (8 Periods)

Alkyd resin, raw material, chemistry and formulation of various alkyds, manufacturing process classification, properties and application of various types of alkyds, water soluble alkyds, Saturated & Unsaturated polyester resins.

Phenolic resins, classification, types of phenols used, reaction of phenol and formaldehyde (P/F ratio), novolac and resoles, production of phenolic resin, properties and application of various phenolics, water soluble phenolics.

UNIT 3- AMINO RESINS, EPOXY RESINS AND POLYAMIDE RESIN: (7 Periods)

Amino resin: urea formaldehyde and melamine formaldehyde resins, formulation of methylol products, alkylation and curing reaction, properties and application in surface coating, water soluble and other amino resins.

Epoxy resin manufacture, formulation of two pack systems like solvent-based coatings, solvent less coating, high solids coating, single pack epoxies like epoxy ester, thermoplastic epoxy etc., Polyamide resins, polyamines and acids used, dimerized fatty acids, properties and application of various polyamides.

UNIT 4- POLYURETHANE AND SILICONE RESINS: (4 Periods)

Poly urethanes: various isocyanates used, reaction of the isocyanate group, hazards associated, classification of poly urethanes, properties and application of various single and two pack systems, concept of blocked isocyanates and curing mechanism.

Silicone resin; synthesis of silicone resin, structure and properties relationship, properties and application of silicone resins.

UNIT 5- VINYL, ACRYLIC(ETHYLENIC) AND OTHER RESINS: (4 Periods)

A. Vinyl: vinyl monomers, type of vinyl resin used in surface coating, PVC, PVC- PVAc copolymers and their properties.
B. Acrylic resin: 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
C. Miscellaneous resins-Hydro carbon resin, coumarone and indene resins, fluoro polymers, ketone resins, poly carbonate resin etc.

INSTRUCTIONAL STRATEGY

Teacher should explain each process of resin manufacturing. An industrial visit can be organized in various chemical and process industries for better understanding and for practical approach. Audio-visuals should be used to teach.

MEANS OF ASSESSMENT

- Assignments and quiz/class tests
- Mid-term and end-term written tests

RECOMMENDED BOOKS

1. Basics of Paint Technology- Part- 1 and 2 b y V.C.Malshe, Meenal. A.Sikchi
2. Organic Coating Technology, Volume I; by Henry Fleming Payne, John Wiley & Sons.
3. Surface Coatings : Raw materials & their usage Volume-1 By OCCA-Australia Publisher Champas & Hall
4. Outlines of Paint Technology By W.M.Morgan Publisher Edward Arnold.
5. The Chemistry of Organic film formers by D.H.Solomon , R.E.Kriegar
6. A manual for Resin for surface coatings By P.K.Oldring Publisher SITA Technology
7. Polymer Science By V.R.Gowariker Publisher New Age International
8. 4Modern Surface Coatings, by P.Nylen and E. Sunderland.
9. Organic Coatings: Science and Technology, Volume I; by Z.W.Wicks, F.N.Jones and S.P.Pappas, Wiley
10. Handbook of coatings additives, by L.J. Calbo (Ed.), Marcel Dekker Inc.
11. Protective and decorative coatings; by J.J. Mattiello.
12. Technology of Paints, Varnishes and Lacquers by C.R.Martin.

SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time allotted (Periods)	Marks Allotted (%)
1.	5	15
2.	8	20
3.	7	25
4.	4	15
5.	4	15
Total	**28**	**100**

PRACTICAL	3.4 RESIN AND PAINT MEDIA (Lab)	L	T	P
		-	-	4

COURSE OBJECTIVES

In This subject, Various Types of Resins are discussed which are used as Film former or binder in the Paints & Coating Synthetic Resins for different application area are discussed along with properties and manufacturing of each.

COURSE OUTCOMES

After studying this course, the students will be able to:

CO1:Understand about modification of natural resin.

CO2:Understanding the manufacturing process of resins.

CO3:Understanding of resin chemistry and mechanism of its polymerization.

CO4:Determination and evaluation of resin properties of resin

CO5:Preparation and testing of various resins

PRACTICAL CONTENTS

UNIT 1- INTRODUCTION TO NATURAL RESINS :

1. Preparation and testing of rosin modification such as ester gum/maleic resins.
2. Determination of acid value of resin.

UNIT 2- ALKYD RESIN AND PHENOLIC RESINS:

1. Preparation and testing of synthetic alkyd resins.
2. Preparation and testing of phenolic resins.

UNIT 3- AMINO RESINS AND EPOXY RESINS:

1. Preparation and testing of Urea formaldehyde resins
2. Preparation and testing of epoxy resins
3. Preparation and testing of polyamide resins

UNIT 4- POLYURETHANE AND SILICONE RESINS:

1. Preparation and testing of polyurethane resins

UNIT 5- VINYL AND ACRYLIC RESINS:

1. Preparation and testing of acrylic resins

INSTRUCTIONAL STRATEGY

Teacher should explain each process of resin manufacturing. An industrial visit can be organized in various chemical and process industries for practical approach generation among students. Audio-visuals should be used to teach.

MEANS OF ASSESSMENT

- Execution of practical work
- Practical file submission

LAB REFERENCES:

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

PRACTICUM	3.5 DRYING OILS , DRIERS , SOLVENTS & PAINT ADDITIVES	L	T	P
		2	-	2

Course Objective:

This Subject equips the students with the knowledge of the oils used in surface Coating as film formers. It also gives basic knowledge about driers , solvents, plasticizers and additives.

Course Outcomes:

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

CO1: Understand the oils used in Paint.

CO2: Understand the Solvents used in Paint.

CO3: Understand the driers and Plasticizer .

CO4: Understand characteristics of driers, and additives for special function.

CO5: Understand the composition and properties of various raw materials for paints.

COURSE CONTENTS

UNIT 1- INTRODUCTION TO OILS: (08 Periods)

Properties and uses of some commonly used drying, semi drying & nondrying oils, yellowing of oils, Chemical reactions of oils, like oxidation, hydrolysis, glycerolysis, acid value, Iodine value, saponification value etc., Evaluation & characterization of oils, modified oils like heat treated oils, maleinised oils, co-polymerized oils, dehydrated castor oils, isomerized oils, reconstituted oils etc.

Experiment:

1. Physical testing of drying oils/Semidrying oil and non-drying oil for Colour,Specific Gravity, Refractive Index, Drying time etc.
2. Preparation & testing of dehydrated castor oils (DCO).
3. Preparation & testing of stand oils.
4. Determination of acid value of oils.

UNIT 2- DRIERS: (06 Periods)

Definition of driers, types of driers like primary, secondary and auxiliary. Function of metals as well as acid part of driers, driers mechanisms, manufacture of driers, their evaluation and recommendation for water based and solvent based coatings, combination and dosage of driers, properties of different metal as well as organic radical of driers.

UNIT 3- SOLVENTS: (06 Periods)

Types of volatile solvents, general properties of solvents like solvent power, toxicity rate of evaporation, boiling point & aromatic content, etc classification like true solvents, latent solvents and diluents, effect of solvent on film properties, classes of solvents with their sources, properties, evaluation of solvents, solubility parameters.

Experiment:

1. Determination of Flash & Fire Point of volatile solvent.
2. Boiling range determination of solvents.

UNIT 4- PLASTICIZERS & ADDITIVES: (08 Periods)

Definition, importance, mechanism of plasticization, types of plasticizers with their properties, evaluation of plasticizers. Function of additives, additives for solvent-thinned coating like wetting, and dispersing agents, anti-settling and bodying agents, anti skinning agents, anti flooding agents etc., additives for latex paints like surface – active agents, antifoam agents, emulsifier, thickening agents, preservatives & coalescing agents etc.

INSTRUCTIONAL STRATEGY

Teacher should explain basic raw material used in paint. An industrial visit can be organized in paint manufacturing industries for visual demonstration and practical approach generation among students. This will help students to connect with the subject more closely.

MEANS OF ASSESSMENT

- Assignments and quiz/class tests
- Mid-term and end-term written tests
- Execution of practical work
- Practical file submission

RECOMMENDED BOOKS AND RESOURCES

1 Basics of Paint Technology by V.C.Malshe, Meenal. A.Sikchi

2 Organic Coating Technology by Henry Fleming, Payne Publisher John Wiley & Sons.

3 Surface Coatings : Raw materials & their usage Volume-1 By OCCA-Australia Publisher Champas & Hall

4 Outlines of Paint Technology by W M Margans Publisher Edward Arnold., London

5 Surface Coatings: Science & Technology by Swaraj Paul Publisher John Wiley & Sons.

WEBSITES FOR REFERENCE:

http://swayam.gov.in

SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time allotted (Periods)	Marks Allotted (%)
1.	08	30
2.	06	20
3.	06	25
4.	08	25
Total	28	100

THEORY	3.6 CHEMICAL PROCESS CALCULATION	L	T	P
		2	-	-

COURSE OBJECTIVES

This subject explains the basic chemical engineering calculations. It is one of the core subjects. In this subject, students learn the fundamental concepts on which chemical engineering design is based. This subject helps the student to prepare the material and energy balance of a process. It also helps them to calculate the quantity of material and energy input and output of a process plant.

COURSE OUTCOMES

After studying this course, the students will be able to:

CO 1: To understand the scope of material and energy balance in chemical industries and conversion of basic fundamental units

CO 2: To understand the ideal gas law and various units of concentration.

CO 3: To understand the various types of unit operation involving material balance without chemical reaction

CO 4: To understand the various types of unit operation involving material balance with chemical reaction

CO 5: To understand the fundamental concept of energy balance and combustion behavior.

COURSE CONTENTS

UNIT-1: INTRODUCTION (03 Periods)

1. Introduction to material and energy balance in chemical industries
2. Unit conversion, S.I. system, M.K.S. system, C.G.S. system.

UNIT-2: GASES AND GAS MIXTURE (06 Periods)

1. Boyle's law, Charle's law, Ideal Gas law, value of universal gas constant, Amagat's Law
2. Average molecular weight, density and composition (by weight and by mole) of gas mixture.
3. Various units of concentration: PPM (parts per million), PPB (parts per billion) molarity, molality, normality.

UNIT-3: MATERIAL BALANCE WITHOUT CHEMICAL REACTION (06 Periods)

1. Steps for solving simple material balance problems.
2. Solving simple problems on various unit operations like drying, evaporation, crystallization, distillation, mixing and absorption.
3. Concept of: Bypass streams.

UNIT-4: MATERIAL BALANCE WITH CHEMICAL REACTION (04 Periods)

4. Limiting component, excess component, percent excess, yield, conversion, and selectivity recycle, and purge related simple problems.

UNIT-5: ENERGY BALANCE & COMBUSTION (09 Periods)

1. Definitions of Specific heat (Cp & Cv)/sensible heat, latent heat.
2. Hess's law and associated basic problems.
3. Concept of Heat of reaction, heat of combustion & heat of formation.
4. Adiabatic reaction and adiabatic flame temperature
5. Calorific Value: Net and gross and its basic numerical problems.
6. Combustion: proximate and ultimate analysis, air fuel ratio in Boiler/Furnaces, Theoretical oxygen/air

required.

7. Problems of fuel analysis.
8. Oxidation of Sulphur and its compounds.

INSTRUCTIONAL STRATEGY

Teacher should give small assignments to the students. Give industrial based practical problems for material and energy calculations.

MEANS OF ASSESSMENT

Assignments and quiz/class tests
Mid-term and end-term written tests

RECOMMENDED BOOKS

1. Stoichiometry by B. I. Bhatt &S. M. Vora; McGraw Hill Publication
2. Chemical Process Principles Part-1 by O.A. Hougen and K.M. Watson.
3. Chemical Process Principles Part-1 by R.A. Rastogi
4. Solved Examples in Chemical Engineering by G.K. Ray

SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time allotted (Periods)	Marks Allotted (%)
1.	03	10
2.	06	22
3.	06	23
4.	04	15
5.	09	30
Total	28	100

PRACTICUM	3.7 FLUID MECHANICS & SOLID HANDLING	L	T	P
		2	-	2

COURSE OBJECTIVES

The subject gives knowledge of measurement of fluid flow and various fluid transportation machinery. The knowledge gained by this subject is directly used in different subjects studied in Chemical Engineering. Knowledge of this subject helps in installation of different fluid flow and transportation machinery. Solid handling is the fundamental of different machine and equipment's used in the chemical industries such as grinding, crushing, ball mills etc. chain belts and screw conveyor, filtration & mixing equipment's. Theoretical and experimental work will inculcate their interest in learning and teaching among the students and teachers.

COURSE OUTCOMES

After studying this subject, the students will be able to:

CO 1: To understand the different types of fluid and its flow pattern with its associated property

CO 2: To understand the various pressure difference measuring instruments and analyses the flow rate through Bernoulli's theorem application.

CO 3: To understand the basic knowledge the pipe, fitting, valves and various types of pumps.

CO 4: Understand the different characterizations of particulate solids and knowledge of screening.

CO 5: To study the basic knowledge for the filtration and mixing operation and its associated equipment.

COURSE CONTENTS

Unit-1: Introduction to fluids (05 Periods)

1. Properties of fluids- Density and viscosity, Vapor pressure and surface tension, cohesion and adhesion, Hydrostatic Pressure.
2. Types of Fluids- Ideal and Real fluids, Compressible and Incompressible Fluids (liquid), Newtonian and Non-Newtonian fluids (rheology of fluids) and Newton's Law of Viscosity.
3. Types of Fluid flow: Streamline flow, steady and unsteady state flow, uniform and non- uniform flow, Reynolds Number, Elementary knowledge of laminar and turbulent flow.

Experiment:

Ex 1. Determination of Density using Density Bottle and Hydrometer.

Ex 2. To measure the viscosity of different liquids (Ford cup)

Unit-2: Pressure Measurements and Flow meters (05 Periods)

1. Pressure: Types of Pressure, Atmospheric, Gauge & Absolute Pressure, Barometric Leg
   List of Pressure measuring devices: U-Tube Manometer –computation of Pressure difference using U-Tube manometer - Inclined Manometer –Simple Problems in U-Tube manometer. Basic law of Bernoulli theorem and its application: Orifice meter, venturimeter, pitot tube, rotameter. Definition:- Cofficient of contraction, Coefficient of velocity, coefficient of discharge.

Experiment:

Ex3. Study Sketch and Demonstration of U-Tube Manometer.

Ex4. To determine the co-efficient of discharge of orifice-meter.

Ex5. To determine the co-efficient of discharge of venturimeter

Unit-3: Pipe, fitting and valves & **Transportation of Fluids** (08 Periods)

Type of Pipes, Standard sizes of pipes on the basis of Wall thickness, Difference between Tube and Pipe Joints and fittings, Gate valve, Globe valve, Ball valve, Needle valve, Non return value, Butterfly valve, Diaphragm valve, Control Valves, Solenoid Operating Valves.
Pumps- Classification of Pumps, Centrifugal Pump: Parts of centrifugal pump, working of Centrifugal pump, riming, Cavitation, Net Positive Suction Head (NPSH). (derivation excluded).
Positive displacement Pump: Reciprocating pumps based on Fluid Handling and based on action of piston/plunger, Construction & working of Gear pump, Rotary Pump, Diaphragm pump, Screw pump.

Experiment:

Ex 6. Study Sketch and Demonstration of centrifugal pump.
Ex 7.Study-Sketch or Demonstration of Reciprocating Pumps/gear pump

Unit-4: CHARACTERIZATION OF SOLID PARTICLES AND SCREENING (04 Periods)

Concept and role of unit operation in Industries, Characterization of solid particles, screening equipment, standard screens.

Ex 8. To analyze the given sample on a set of screens and report the analysis

Unit-5: FILTRATION AND MIXING EQUIPMENTS: (06 Periods)

Types of filtration equipment, their application and operation, sand filters, filter-press, leaf-filters, rotary filters, filter aids. Centrifugal filtration, Classifiers ,Cyclones and cyclone separators
Mixing equipment's used for liquid-liquid, liquid-solid and liquid-gas system.

Experiments:

Ex.9 To find the rate of filtration with the help of filter press.
Ex.10 To perform an experiment on rotary vacuum filter and find rate of filtration.
Ex.11 To perform an experiment on cyclone separator.

INSTRUCTIONAL STRATEGY

Teacher should give small assignments to the student. Give industrial based practical problems for material and energy calculations.

MEANS OF ASSESSMENT

- Assignments and quiz/class tests
- Mid-term and end-term written tests
- Execution of practical work
- Practical file submission

RECOMMENDED BOOKS

1. Unit Operations of Chemical Engineering by McCabe, Smith; McGraw Hill
2. Introduction to Chemical Engineering by Badger & Banchero; McGraw Hill
3. Chemical Engineering Volume-1 by Richardson & Coulson; Pergamon Press
4. Mechanical Operations by Swain Palra, G.K. Roy, Tata McGraw Hill Publication
5. Mechanical Operations by Kiran D. Patil, Nirali Publication
6. Chemical Engineering, Vol. I and II by Coulson and Richardson, Pergamon Press Publication
7. Unit Operation of Chemical Engineering by McCabe and Smith; McGraw Hill Publication
8. Introduction to Chemical Technology by Badger and Banchero, McGraw Hill Publication

SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time Allotted (Periods)	Marks Allotted (%)
1	05	20
2	05	20
3	08	30
4	04	10
5	06	20
Total	**28**	**100**

PRACTICUM	4.1 HEAT AND MASS TRANSFER	L	T	P
		2	-	2

COURSE OBJECTIVES

Most of the Chemical Engineering operations will involve heat and mass addition or heat and mass removal in one way or the other. It is, therefore, extremely necessary to have good understanding about the heat and mass transfer mechanisms. This subject enables the students to apply this knowledge for understanding the performances of various heat transfer and mass equipment such as heat exchangers, condensers, evaporators, distillation, boiling point diagrams, extraction operation, humidification and drying processes etc. used in almost all chemical and related industries. The subject have experiments as well, to be aware of the facts involved in actual process.

COURSE OUTCOMES

After the completion of this course, the students will be able to:

CO 1:To understand different modes of heat transfer, conduction, convection and radiation
CO 2: Analyze heat exchanger performance using LMTD and use it for parallel or counter flow Recognizer various types of heat exchanger working principle, and basic geometries of heat exchanger.
CO 3; Understand the concept of boiling, condensation and evaporation
CO 4: To know the concept of rate of mass transfer diffusion and distillation
CO 5: To know the concept of Humidification, extraction and drying.

COURSE CONTENTS

UNIT 1- MODE OF HEAT TRANSFER: 06 PERIODS

Conduction, Convection and Radiation, Fourier's Law, Thermal conductivity, one dimensional steady state heat conduction through a plane wall and composite wall, Insulation and insulating materials, critical thickness of insulation, physical properties of insulating materials
Natural and Forced convection, Individual heat transfer coefficients and overall heat transfer coefficients. dimensional analysis and significance of various dimensional groups such as Reynolds number, Prandtl number, Nusselt number, Grasshof number.
Reflection, absorption and transmission of radiation, Emissive power, Wein's displacement law, Stefan Boltzmann Law, Planck's law, Kirchhoff's law, Concept of black body, Grey body.

Experiment:

1. To determine the thermal conductivity of metal rod.
2. To determine thermal conductivity (insulating powder) by measuring apparatus.
3. To determine heat transfer coefficient, laboratory scale set up- Natural and forced convection apparatus

UNIT 2- HEAT EXCHANGERS: 02 PERIODS

Introduction, classification, individual and overall heat transfer coefficient, fouling factor, LMTD for parallel and counter current heat exchangers, construction and description of:- Concentric double pipe, Shell and tube (1-1 heat exchanger and 1-2 heat exchanger), Plate type heat exchanger, Basic of extended surface equipment (fins) and its application.

Experiment:

4. Laboratory- scale shell and tube heat exchangers apparatus setup.
5. Laboratory- scale double pipe heat exchanger for heat transfers coefficient apparatus setup.

UNIT 3- BOILING & CONDENSATION, EVAPORATORS: 04 PERIODS

Interface, bubble and film boiling, boiling regime (boiling curve), Concept of condensation, types of condensation i.e. drop wise and film wise condensation

Evaporation Capacity, Evaporation Economy (steam economy), construction and description of open pan, long type vertical evaporator, and agitated thin film evaporator, multiple effect evaporator, feeding arrangements- forward, backward, mixed and parallel feed.

Experiment:

6. To study and the construction of an open pan evaporator.
7. Laboratory scale single effect evaporator setup

UNIT 4- DIFFUSION AND DISTILLATION: 08 PERIODS

Definition of diffusion, Rate of diffusion in Mass Transfer, Fick's law, diffusion in the gas phase- Equimolecular counter diffusion, diffusion through a stationary gas (Stefan's Law), Mass. Transfer Coefficient.

DISTILLATION:

Various distillation methods:-

Equilibrium or flash distillation, Differential distillation, Batch distillation, Vacuum and Steam distillation, Azeotropic and Extractive distillation.

Bubble cap plate column Vapor liquid equilibrium diagram, Raoult's law; Relative volatility, constant boiling mixtures, equilibrium diagram and construction of equilibrium diagram, Fractionating column calculation- Heat & material balance, Reflux ratio, equilibrium plate, Location of feed plate. Sub cooled reflux; effect of reflux ratio, Total reflux, Minimum reflux ratio Entrainment; Mc-Cable Thiele diagram-section above and below feed plate; Intersection of operating line. Location of q-line, optimum reflux ratio, calculation of no. of equilibrium plate by Mc-Cable Thiele diagram.

Experiment:

8: Solid and liquid diffusion apparatus

9: Distillation packed column apparatus setup

UNIT 5- HUMIDIFICATION, EXTRACTION AND DRYING 08 PERIODS

Determination of (1) Humidity (2) Percentage humidity (3)Relative humidity (4) Humid volume (5) Humid heat (6) bulb and wet bulb temperature (7) Adiabatic saturation temperature (8) Use of Humidity chart (9) Dew point temperature. Construction and description of cooling towers. (Natural and induced draft}

EXTRACTION :

Applications of extraction, Choice of solvent, Steps of extraction operation, Solid Liquid extraction, construction and description of Moving Bed type oil seed extractor.

Liquid extractor; description and construction of Mixer settler extraction system.

Drying :

General drying behavior- Critical moisture content, equilibrium moisture content: Description and construction of dryer: Tray & Rotary dryer.

Experiment:

10.To measure humidity and temperature using wet bulb thermometer.

11. Liquid liquid extractor laboratory-scale setup.

12. Laboratory scale tray dryer setup

13. Laboratory scale cooling tower setup.

INSTRUCTIONAL STRATEGY

Field visit will make the students familiar with different types of heat exchangers and different types of evaporators. This will also make the students aware of auxiliary equipment/models/supports used in paint industries. Along with the theoretical part, emphasis should be given to problem solving and practices.

MEANS OF ASSESSMENT

- Assignments and quiz/class tests
- Mid-term and end-term written tests
- Execution of practical work
- Practical file submission

RECOMMENDED BOOKS

1. Mass Transfer Operations by Treybal, Kogakusha Publication
2. Introduction to Chemical Engineering by Badger and Banchero, McGraw Hill Publication
3. Unit Operation of Chemical Engineering by McCabe and Smith; McGraw Hill Publication
4. Chemical Engineers Handbook by Perry and Chilton, McGraw Hill Publication
5. Mass Transfer Operations by Kiran D. Patil, Nirali Publication
6. Heat Transfer by Chapman, MacMillan Publication.
7. Process Heat Transfer by Kern, McGraw Hill Publication.
8. Heat Transfer by McAdams, McGraw Hill Publication.
9. Heat Transfer by KA Gavahane, Nirali Publications.
10. Process Heat Transfer by Kern DQ, McGraw Hill Book, New York
11. Heat Transfer Principles and Applications by K Dutta; Prentice Hall, India.

SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time Allotted (Periods)	Marks Allotted (%)
1	06	10
2	02	20
3	04	20
4	08	25
5	08	25
Total	**28**	**100**

PRACTICUM	4.2 CHEMICAL REACTION ENGINEERING AND THERMODYNAMICS	L	T	P
		2	-	2

COURSE OBJECTIVES

This subject outlines the basic principles of Kinetics. These principles which are useful in developing new concept and operating the plant. It enables the students to have an idea about the different types of rectors and it's design also gives knowledge about the importance of catalyst in various chemical processes in the industries. understanding basic concepts, thermodynamic properties of fluid and performance of thermal systems used in industry.

COURSE OUTCOMES

After Studying this subject, the students will be able to:
CO1: Know about rate of chemical reaction and theories associated its kinetic parameters
CO2: Understand interpretation of batch reactor data.
CO3: Know the performance of reactor design.
CO4: Know about basic concepts of thermodynamics
CO5: Understand the laws of thermodynamics and its application.

COURSE CONTENTS

UNIT 1-INTRODUCTION TO CHEMICAL KINETICS (06 PERIODS)

1. Concept of rate of reaction, rate equation, rate constant, order of reaction, Molecularity of reaction.
2. Single reaction multiple reaction, non-elementary reaction.
3. Theories of reaction (Collision & Transition State Theory) rates constant- Arrhenius law and problems based on it.
4. Activation Energy.
5. Definition, Important Classification and desired properties of catalysts.

Experiments:

Ex.1 Demonstration of heterogeneous Catalytic reaction

UNIT 2-INTERPRETATION OF BATCH REACTOR DATA. (06 PERIODS)

1. Concept of batch & semi-Batch reactor.
2. Integral and Differential method of analysis of batch reactor data.

Half-life concept for the overall order of irreversible reactions and problems based on that.

Ex.1 Study, Sketch and Demonstration of Batch Reactor

Ex.2 To determine the rate constant for Saponification reaction of Sodium Hydroxide and Ethyl Acetate through a batch reactor.

UNIT 3-INTRODUCTION TO REACTOR DESIGN (06 PERIODS)

1. Type of reactor (Batch reactor, Continuous reactor, Plug flow reactor, Mixed flow reactor, biological reactor, Fixed (packed) bed reactor, fluidized bed reactor.
2. Concept of space-time, space velocity and holding time.

UNIT 4-INTRODUCTION & CONCEPT OF THERMODYNAMICS (04 PERIODS)

Systems, Scope & importance of Thermodynamics, surroundings & Processes open, closed and isolated systems intensive and extensive properties, state and path functions/ Concept of internal energy, enthalpy, entropy, free energy and equilibrium equation of state, ideal gas law, Vander Waals equation. Dalton's law, Henry's law, Zeroth law of thermodynamics.

Experiment:-

Ex.1 Study, Sketch and Demonstration of CSTR
Ex.2 Study, Sketch and Demonstration of PFR

UNIT 5- LAW OF THERMODYNAMICS (06 PERIODS)

- Statement of first law of thermodynamics, calculation of internal energy, enthalpy, heat and work for ideal gas undergoing reversible, isothermal, Isobaric, adiabatic and polytrophic process. T-V, P-V and P-T diagrams.
- Statement of second law of thermodynamics: Kelvin Plank statement and Classius statement, Carnot cycle and its efficiency,
- Statement of third law of thermodynamics. Heat pump and heat engine (coefficient of performance and efficiency),

Applications of Second Law of Thermodynamics

Refrigeration, The Carnot Refrigeration cycle, vapor compression and absorption refrigeration cycle, air refrigeration cycle, coefficient of performance(COP), liquefaction process, latest refrigerants

INSTRUCTIONAL STRATEGY

Teachers should give small assignments to the students related to subject and transfer industrial knowledge to students.

MEANS OF ASSESSMENT

- Assignments and quiz/class tests
- Mid-term and end-term written tests
- Execution of practical work
- Practical file submission

RECOMMENDED BOOKS

1. Chemical Reaction Engineering by Octave Levenspiel; Wiley Eastern Ltd.
2. Chemical Engineering Kinetics by J.M Smith; McGraw Hill Publication
3. Chemical Engineering Thermodynamics by J.M Smith, H.C. Vanness; McGraw Hill
4. Thermodynamics for Chemists by Samuel Glasstone; Krieger Publication Company.
5. Introduction to Chemical Engineering Thermodynamics by Smith and Vanness; McGraw Hill.
6. Chemical Engineering Thermodynamics by K.V. Narayanan; Prentice Hall India.
7. Chemical Engineering Thermodynamics by YVC Rao
8. Engineering Thermodynamics by PK Nag
9. Chemical Engineering Thermodynamics by K.A. Gavhane, Nirali Publication.

SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time Allotted (Periods)	Marks Allotted (%)
1	06	15
2	06	20
3	06	25
4	04	15
5	06	25
Total	**28**	**100**

THEORY	4.3 FORMULATION AND MANUFACTURING OF PAINTS	L	T	P
		2	-	-

COURSE OBJECTIVES

In this Subject there is discussion of Formulation of the Coating for different applications. Various parameters, and steps during formulation is discussed, there is also discussion on the machinery for manufacturing of Coating and health, hazards and safety principles during the same.

COURSE OUTCOMES

After studying this course, the students will be able to:

CO1: To understand the manufacturing steps for paint.
CO2: Learning principles and concepts of formulation techniques.
CO3: Study machinery and equipment used in paint manufacture, their selection for efficient operation, economic considerations, etc.
CO4: Study safe environment during manufacturing.
CO5: Study plant layout for paint manufacturing process and its implications.

COURSE CONTENTS

UNIT 1-INTRODUCTION: (5 Periods)

- Principles of paint formulation, formulation elements, mathematics & steps involved in paint
- Pigment Volume Concentration (PVC) and CPVC
- Relation between PVC and various film properties
- Pigment to Binder (P/B) ratio
- Formulation of primers, under coats, base coats and finish coats for steel surfaces.

UNIT 2-STEPS IN PAINT MANUFACTURING: (5 Periods)

- Rheology and rheological considerations (Pseudoplasticity, dilatancy and thixotropy).
- Steps in paint manufacture- Premixing, grinding, letdown, thinning, tinting (shade matching), straining,
- Phenomenon of Soaking, wetting, grinding, dispersion and stabilization,
- Important considerations in pigment dispersion.

UNIT 3-MACHINERY USED IN PAINT MANUFACTURING: (7 Periods)

3.1 High Speed Dispersion Equipment

High speed disperser: Description and working principle, Twin shaft disperser, Cowles dissolvers, mill base composition and premixing parameters.

3.2. Ball Mills, Attritors, Sand Mills

Ball and pebble mills: Description and working principle, cascading & factors affecting effectiveness of milling, physical factors affecting the performance of ball mill, advantages and disadvantages.

Attritors and Bead Mills, Sand Mills: Description and working principle, Vertical and Horizontal type of sand mills (Dyno mill, Eco mill, etc), types of sand, selection of grinding media, mill base composition, advantages & disadvantages of Bead mill, attritor, sand mill.

3.3 Heavy Duty Machines

Heavy duty mixtures, double blade mixers, sigma kneaders, pug mills, edge runner roller mills. New industrial grinding equipment's such as jet mills, Rotostator Roll mills: Triple roll mills; mill base compositions.

UNIT 4-GENERAL HAZARDS ,ENVIRONMENT AND SAFETY: (6 Periods)

- General industrial hazards, Fire and health hazards, prime cause and mitigation for fire and explosion, electro-static charges precautionary measures.
- Eco-friendly, waste minimization & waste disposal.
- Safety precautions in paint operation and application, use of PPE`S(Personal protective equipment) in paint industries, safety considerations in storage of hazardous and inflammable raw materials.

UNIT 5- SIMULATION,ARTIFICIAL INTELLIGENCE IN PAINTS AND FACTORY LAYOUTS (5 Periods)

Introduction to artificial intelligence (AI) and its application in Paint Technology.

Factory layout principles and general considerations, typical flow diagram, single & multi storied building, sections of paint factory and their location.

INSTRUCTIONAL STRATEGY

Teacher should explain each process, types of industry and use of each and every equipment used in paint formulation and manufacturing. An industrial visit can be organized in various chemical and process industries. Audio-visuals should be used to teach.

MEANS OF ASSESSMENT

- Assignments and quiz/class tests
- Mid-term and end-term written tests

RECOMMENDED BOOKS

1. Basics of Paint Technology- Part- 2 By V.C.Malshe, Meenal. A.Sikchi
2. Organic Coating Technology vol-2 By Henry Fleming, Payne Publisher John Wiley & Sons.
3. Surface Coatings : Raw materials & their usage Volume-2 By OCCA-Australia Publisher Champas & Hall
4. Outlines of Paint Technology By W.M.Morgan Publisher Edward Arnold.
5. Surface Coatings: Science & Technology By Swaraj Paul Publisher John Wiley & Sons.
6. Organic Coatings: Science & Technology By Z.W.WICKS, F.N.JONES, S.P.PAPPAS Publisher Wiley & Sons
7. Paint Formulation : Principles and Practice By J Boxall & J.A.Fraunhofer

SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time Allotted (Periods)	Marks Allotted (%)
1.	5	15
2.	5	25
3.	7	25
4.	6	20
5.	5	15
Total	**28**	**100**

PRACTICAL	4.4 FORMULATION AND MANUFACTURING OF PAINTS (Lab)	L	T	P
		-	-	4

COURSE OBJECTIVES

In this Subject there is discussion of Formulation of the Coating for different applications. Various parameters, and steps during formulation is discussed, there is also discussion on the machinery for manufacturing of Coating and health, hazards and safety principles during the same.

COURSE OUTCOMES

After studying this course, the students will be able to:

CO1: To understand the manufacturing steps for paint.
CO2: Learning principles and concepts of formulation techniques.
CO3: Study machinery and equipment used in paint manufacturing
CO4:Evaluation and study of P/B ratio and its applicability in paint
CO5:Study of manufacturing paint by different machines and comparison

COURSE CONTENTS

UNIT 1-INTRODUCTION:

Experiment:

1. To determine pigment binder ratio.
2. Preparation of oleo-resinous based paint.
3. Preparation of mill base for ball mill.

UNIT 2-STEPS IN PAINT MANUFACTURING:

Experiment:

1. To prepare mill base and grinding of paint to get desired dispersion using hegman gauge.
2. To check and compare the Tinting and shade matching against given shade panel during processing.

UNIT 3-MACHINERY USED IN PAINT MANUFACTURING:

Experiment:

1. Ball mill equipment study and manufacturing of primer, base and topcoat.
2. Bead mill/Attritor equipment study and manufacturing of primer, base and topcoat.
3. High speed disperser equipment study and manufacturing of primer, base and topcoat.
4. Sand mill(Dyno mill) equipment study and manufacturing of primer, base and topcoat.

INSTRUCTIONAL STRATEGY

Teacher should explain each process industry and use of each, and every equipment used. An industrial visit can be organized in various chemical and process industries.

Audio-visuals should be used to teach.

MEANS OF ASSESSMENT

- Execution of practical work
- Practical file submission

RECOMMENDED BOOKS

- Basics of Paint Technology- Part- 2 By V.C.Malshe, Meenal. A.Sikchi
- Organic Coating Technology vol-2 By Henry Fleming, Payne Publisher John Wiley & Sons.
- Surface Coatings : Raw materials & their usage Volume-2 By OCCA-Australia Publisher Champan & Hall
- Outlines of Paint Technology By W.M.Morgan Publisher Edward Arnold.
- Surface Coatings: Science & Technology by Swaraj Paul Publisher John Wiley & Sons.
- Organic Coatings: Science & Technology By Z.W.WICKS, F.N.JONES, S.P.PAPPAS Publisher Wiley & Sons
- Paint Formulation : Principles and Practice by J Boxall & J.A.Fraunhofer

PRACTICUM	4.5 SURFACE PREPARATION AND PAINT APPLICATION	L	T	P
		2	-	4

COURSE OBJECTIVES

In this Subject Students will know the importance of surface preparation. Different techniques of surface preparation along with various application techniques are also discussed. The curing mechanism and different types of defects in coating is discussed here.

COURSE OUTCOMES

After completion of this course, the students will be able to:

CO1: Understand the importance of surface preparation.

CO2: Understand different methods and types of surface preparation.

CO3: Apply the knowledge of paint application using atomization.

CO4: Apply the knowledge of paint application without using atomization.

CO5: Understand Types, Causes & Remedies of defects in Coatings.

COURSE CONTENTS

UNIT 1-SURFACE PREPARATION: (06 Periods)

Importance of surface preparation, types of substrates : Substrate, Degreasing, rust & oxide removal, blast cleaning, degreasing mild steel, Preparation of samples of wood by a sequence of staining, filling and sealing.

Experiment:

1. Preparation of surfaces on following substrates:

i) Wood

ii) Metal

iii) Plastic

iv) Concrete/cement/brick

2. Removal of paints from different substrates using:

i. Sandpaper

ii.Solvent

iii.Orbital Sander

iv.Chemicals

UNIT 2-PRE-TREATMENT: (04 Periods)

Steps of surface pretreatment process – degreasing, derusting, activation, phosphating (di and tricationic system), coating weight, P-ratio, passivation, water rinses(RO and DI).

Experiment:

1.Preparation of Panels by pretreatment method using Degreasing, derusting , activation , phosphating and passivation

2.To determine coating weight and film thickness of phosphating

UNIT 3-PAINT APPLICATION INVOLVING ATOMIZATION (06 Periods)

Selection criteria for application techniques, Paint application involving atomization air assisted spraying, airless spraying, electro state spraying, compare hot and cold spraying. Disc and bell application and robotics in spraying, powder coating involving atomization.

Experiment:

Painting on the substrates using various application techniques:

1. Preparing coated panels through conventional Spray gun application for liquid paint and varnishes
2. Preparing coated panels through electrostatic Spray gun application and robotic application for solvent-based paint
3. To prepare coated panel through electrostatic Spray gun application for powder coating

UNIT 4-PAINT APPLICATION NOT INVOLVING ATOMIZATION: (06 Periods)

Paint application not involving atomization: Dipping, roller coating, coil & curtaing coating , other application methods- brushing, hand rolling trowelling , silk screening tumbling, flow coating, electro deposition, anodic vs cathodic electro deposition – merit and demerits, throwing powder, CED process and plant lay out, powder coating not involving atomization.

Experiment:

Painting on the substrates using various application techniques:

1. Brush (Wall/wood/metal etc.)
2. Roller (Wall/wood/metal etc.)
3. Dip coating (Metal)
4. Knife coating (Wall/wood/metal etc.)
5. Cathodic electro-deposition(Metal)
6. Fluidized bed powder coating (Metal)

UNIT 5-DRYING, CURING AND PAINT DEFECTS: (06 Periods)

Drying and curing process: air drying, forced drying and stoving, radiation curing (ultraviolet and electron beam), hybrid curing, selection of curing techniques .

Defects:rundown,dust,sagging,mottling,thinpaint,craters,blistering,popping.overspray,scratch,floating,foaming, skinning, orange peels, peel off,chalking,crocodiling,alligatoring, pin hole, brush mark, oil patch, ooze out(oozing) etc.

Experiment:

1.Preparation of sample and analyze defects for rundown, dust, sagging, thin paint, overspray, scratch, brush mark, oil patch through visual observation.

2.To determine drying time of paint/varnish

INSTRUCTIONAL STRATEGY

This subject is of great importance; therefore the teachers are expected to lay considerable stress on renewable sources, their importance, production, utilization and storage system. As far as possible, the teaching of the subject must be supplemented by showing the videos on the working principle of various renewable energy equipment and also visits to nearby places where such equipment is installed.

MEANS OF ASSESSMENT

- Assignments and quiz/class tests
- Mid-term and end-term written tests
- Execution of practical work
- Practical file submission

RECOMMENDED BOOKS

1. Basics of Paint Technology- Part- 2 By V.C.Malshe, Meenal. A.Sikchi
2. Organic Coating Technology vol-2 By Henry Fleming, Payne Publisher John Wiley & Sons.
3. Outlines of Paint Technology By W.M.Morgan Publisher Edward Arnold.
4. Failure Analysis of Paints & Coatings by D Wight G. Weldon Publisher John Wiley & Sons
5. Good painting practices vol. 1 by Joseph Bigos
6. Surface Coatings, Vol. I & II; by: OCCA, Australia
7. Surface Coating Technology; by Swaraj Paul
8. Phosphating of metals by Warner Rausch
9. Blasting Technology by Momber

SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time Allotted (Periods)	Marks Allotted (%)
1	06	20
2	04	20
3	06	20
4	06	20
5	06	20
Total	**28**	**100**

Program Elective -1

		L	T	P
THEORY	**4.6 (a) MATERIAL SCIENCE AND TECHNOLOGY**	**2**	**-**	**-**

COURSE OBJECTIVES

Lot of developments has taken place in the field of materials. New materials are being developed and it has become possible to change the properties of materials to suit the requirements. Diploma holders in this course are required to make use of different materials for various applications. For this purpose, it is necessary to teach them basics of metal structure, properties, usage and testing of various ferrous and non-ferrous materials and various heat treatment processes. This subject aims at developing knowledge about the characteristics, testing and usage of various types of materials used in industries.

LEARNING OUTCOMES

After the completion of this course, the students will be able to:

CO1: To Understand the different types of bonding in materials.

CO2: To understand the characterize engineering materials.

CO3: To Understand phase and equilibrium diagram.

CO4: Distinguish between various engineering materials based on mechanical, magnetic and electrical properties.

CO5: Identify materials for applications in chemical process industry.

COURSE CONTENTS

Unit-1: Introduction (04 Periods)

- Introduction: Importance of materials, Periodic table, Chemical bonding.
- Crystallography and imperfections: Concept of unit cell, space lattice, Bravais lattices, common crystal structures. X-ray crystallography techniques, Imperfections, Defects &Dislocations in solids.

Unit-2: Properties of Materials (08 Periods)

1. Mechanical Properties and Testing: Stress strain diagram, Ductile and brittle materials, stress vs strength, toughness, hardness, fracture, fatigue and creep. Testing, such as Strength testing, Hardness testing, Impact testing, Fatigue testing Creep testing, Non-destructive testing (NDT)
2. Magnetic Properties: Concept of magnetism-Dia, para, ferro magnetic materials, Soft and hard magnetic materials.
3. Electric Properties: Concept of conductor, insulator and semiconductor. Intrinsic and extrinsic semi-conductors, Diffusion of Solid, Super conductivity, Type I & II superconductors. High temperature superconductors.

Unit-3: Phase Diagram and Equilibrium Diagram (04 Periods)

Unitary and Binary diagrams, Phase rules, Types of equilibrium diagrams: solid solution type, Iron-carbon equilibrium diagram.

Unit-4: Ferrous and Non-ferrous Materials and Alloys (06 Periods)

1. Ferrous materials: Types of iron and steel, Manufacture of steel, its properties and uses.
2. Heat Treatment: Annealing, Normalizing, Quenching, Tempering and Case hardening, Time Temperature Transformation (TTT) diagrams
3. Non-Ferrous Materials and Alloys: Non-ferrous metals- Cu, Al, Zn, Cr, Ni and its applications. Various types of brass, bronze, their properties and uses. Aluminum alloys such as Duralumin.

Unit-5: Ceramics and Other Advanced Materials **(06 Periods)**

1. Ceramics: Structure, types, properties and applications of ceramics.
2. Introduction to glass and refractories.
3. Introduction to advanced material (Biomaterials, Nano Materials, Green Building Materials and composites)

INSTRUCTIONAL STRATEGY

Audio-visuals can be used as teaching aid. Processes of Heat-treatment can be shown to students in workshop.

MEANS OF ASSESSMENT

1. Assignments and quiz/class tests
2. Mid-term and end-term written tests

LIST OF REFERENCE BOOKS

1. Material Science & Engineering by William D. Callisster Jr.; John Wiley and Sons Inc
2. Elements of Material Science & Engineering by Van Vlack; John Wiley &Sons.
3. Material Science by V. Raghvan; Prentice Hall of India.
4. Material Science by Narula; Tata McGrawHill.
5. Science of Materials Engineering by Srivastava, Srinivasan; New Age International

SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time Allotted (Periods)	Marks Allotted (%)
1	04	15
2	08	20
3	04	15
4	06	25
5	06	25
Total	**28**	**100**

Program Elective -1

THEORY	4.6 (b) ENERGY ENGINEERING	L	T	P
		2	-	-

COURSE OBJECTIVES:

1. To identify different types of fuel sources for energy production.
2. To appreciate the advantages of energy production from renewable energy resources.

COURSE OUTCOMES:

After completion of this course, the students will be able to:

CO1: To understand energy production from conventional fuels and renewable energy resources.

CO2: To understand the process of energy generation by conventional as well as renewable resources such as Liquid fuels.

CO3: To understand the gases fuel

CO4: To understand the combustion with the use of various energy sources.

CO5: Familiar with information on renewable energy technologies as a basis for further analysis and evaluation.

COURSE CONTENT

UNIT-I **(05 periods)**

Fuels - Classification, Properties, tests and analysis. Solid Fuels - Coal, origin, classification, storage and handling, carbonization, gasification and briquetting - gasification of biomass.

UNIT-II **(05 periods)**

Liquid fuels - Petroleum based fuels, synthetic fuels, alcohol and blended fuels, storage and handling.

UNIT-III **(06 periods)**

Gaseous fuels - Water gas, Carbureted water gas, producer gas, coal gas and natural gas.

UNIT-IV **(06 periods)**

Combustion - Air requirement for solid, liquid and gaseous fuels, Combustion equipment

UNIT-V **(06 periods)**

Introduction to Solar energy, Wind energy, Tidal energy, Hydro power, Geothermal energy, Nuclear energy.

REFERENCE BOOKS

1. Gupta, “Energy Technology”, Khanna Publishing House, New Delhi
2. G.D.Rai, “Non-conventional energy sources”, Khanna Publishers, IV edition, New Delhi,

SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time Allotted (Periods)	Marks Allotted (%)
1	05	20
2	05	20
3	06	20
4	06	20
5	06	20
Total	**28**	**100**

Program Elective -2

		L	T	P
THEORY	**4.7 (a) PLANT UTILITIES**	**2**	**-**	**-**

COURSE OBJECTIVES

The objective of this subject is to teach the students about requirement of different utilities for the process plant and effective utilization. Main utilities required for process plants are water, steam, air and refrigerants. Steam and non-steam heating media is used for conversion of raw material to products in reactors and to elevate the temperature in the chemical processes. Similarly, refrigeration is important to maintain the temperature in the process plant. Compressed air and process air is used in processes and instrument air is used in pneumatic devices and controls.

COURSE OUTCOMES

After studying this course, the students will be able to:
CO1: To understand the selection of different utilities.
CO2: Understand basic calculations involved in steam generation, psychometric operation and refrigeration.
CO3: Describe the different equipment used to run the process plant with different utilities.
CO4: State the principles involved during water treatment
CO5: Know different fuels used in boilers

COURSE CONTENTS

Unit-1: Importance and Classification of utilities: (04 Periods)
Hard and soft water, requisites of industrial water and its uses.
Methods of water treatment such as chemical softening and demineralization, resins used for water Softening and reverse osmosis. Effects of impure boiler feed water.

Unit-2: Fuel and waste disposal: (04 Periods)
Fuels used in boilers- coal, fuel oil, rice husk, natural and biogas, liquid petroleum fuels etc.
Waste disposal of fuel residue.

Unit-3: Steam and steam generation: (06 Periods)
Properties of steam, types of steam generator such as fire tube boiler, water tube boiler and fluidized bed boiler. Scaling and trouble shooting. Steam traps and accessories.

Unit4: Refrigeration: (06 Periods)
Refrigeration cycles, methods of refrigeration used in industry and different types of refrigerants such as mono Chlorodifluoromethane, Chlorofluorocarbons and brine. Refrigerating effects and liquefaction processes.

Unit-5: Compressed air: (08 Periods)
1. Classification of compressor, reciprocating compressor, centrifugal compressor, impellers, Properties of air –water vapors and use of humidity chart.
2. Equipments used for humidification, Dehumidification and cooling towers.

INSTRUCTIONAL STRATEGY

Teacher should focus on conceptual clarity.

An industrial visit can be organized in relevant industries. Audio-visuals aids should be used to teach.

RECOMMENDED BOOKS

1. Thermal Engineering by P.L. Ballaney; Khanna Publisher New Delhi
2. Industrial water treatment by S.T. Powel; McGraw Hill New York
3. Boiler Operations by Chattopadhyay; Tata McGraw Hill, New Delhi
4. Perry's chemical Engineer's Handbook by Perry R.H. Green D.W; McGraw Hill, New York
5. Elements of Heat Engines Vol. II,III by R.C. Patel C.J.Karmchandani; Acharya Book Depot Vadodara
6. Refrigeration & Air conditioning by P.N. Ananthanarayan; Tata McGraw Hill
7. Industrial chemistry by Jain & Jain; Tata McGraw Hill

SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time allotted (Periods)	Marks Allotted (%)
1.	04	15
2.	04	15
3.	06	20
4.	06	20
5.	08	30
Total	**28**	**100**

Program Elective -2

THEORY	4.7 (b) WASTE MANAGEMENT	L	T	P
		2	-	-

COURSE OBJECTIVES:

1. To recognize and learn about waste management, waste treatment and recycling
2. To understand the impacts on our environment.
3. To learn about pollution, pollutants, waste disposal processes

COURSE OUTCOMES:

At the end of the course student will be able

CO1: To understand the solid and Hazardous wastes

CO2: To understand the reduction and recycling of solid waste.

CO3: To prepare concept design for the common functional elements of the wastemanagement systems.

CO4: To understand the Disposal in Landfills and Site Selection.

CO5: To understand the Legislation on waste Management.

COURSE CONTENT

UNIT- I **(05 Periods)**

Types and Sources of Solid and Hazardous Wastes - Need for Solid and Hazardous Waste Management, Waste Generation Rates – Composition – Hazardous Characteristics,

UNIT-II **(06 Periods)**

Waste Sampling - Source Reduction of Wastes - Recycling and Reuse - Handling and Segregation of Wastes at Source - Storage and Collection of Municipal Solid Wastes - Analysis of CollectionSystems - Need for Transfer and Transport - Transfer Stations - Labeling and Handling of HazardousWastes.

UNIT-III **(06 Periods)**

Waste Processing - Processing Technologies - Biological and Chemical Conversion Technologies - Composting - Thermal Conversion Technologies - Energy Recovery - Incineration - Solidification and Stabilization of Hazardous Wastes - Treatment of Biomedical Wastes -

UNIT-IV **(06 Periods)**

Disposal in Landfills - Site Selection - Design and Operation of Sanitary Landfills - Secure Landfills and Landfill Bioreactors - Leachate and Landfill Gas Management - Landfill Closure and Environmental Monitoring - Closure of Landfills - Landfill Remediation –

UNIT-V **(05 Periods)**

Legislations on Management and Handling of Municipal Solid Wastes, Hazardous Wastes, and Biomedical Wastes - Elements of Integrated Waste Management.

REFERENCE BOOKS:

1. O.P. Gupta, “Elements of Solid Waste Hazardous Management”, Khanna Publishing House, New

Delhi, 2018

2. George Tchobanoglous, Hilary Theisen and Samuel A, Vigil, Integrated Solid Waste Management, McGraw-Hill, New York, 19932.

3. CPHEEO, Manual on Municipal Solid waste management, Central Public Health and Environmental Engineering Organization, Government of India, New Delhi.

SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time allotted (Periods)	Marks Allotted (%)
1.	05	20
2.	06	20
3.	06	20
4.	06	20
5.	05	20
Total	**28**	**100**

OPEN ELECTIVE -1

Open Elective	4.8 (a) Renewable Energy Technologies	L	T	P
		2	-	-

COURSE OBJECTIVES

- To understand present and future scenario of world energy use.
- To understand fundamentals of solar energy systems.
- To understand basics of wind energy.
- To understand bio energy and its usage in different ways.
- To identify different available non-conventional energy sources.

COURSE OUTCOMES:

At the end of the course, the student will be able to:

CO1	Understand present and future energy scenario of the world.
CO2	Understand various methods of solar energy harvesting.
CO3	Identify various wind energy systems.
CO4	Evaluate appropriate methods for Bio energy generations from various Bio wastes.
CO5	Identify suitable energy sources for a location.

COURSE CONTENT

UNIT-I: Introduction: (06 Periods)

World Energy Use; Reserves of Energy Resources; Environmental Aspects of Energy Utilisation; Renewable Energy Scenario in India and around the World; Potentials; Achievements / Applications; Economics of renewable energy systems.

Unit-II: Solar energy: (06 Periods)

Solar Radiation; Measurements of Solar Radiation; Flat Plate and Concentrating Collectors; Solar direct Thermal Applications; Solar thermal Power Generation Fundamentals of Solar Photo Voltaic Conversion; Solar Cells; Solar PV Power Generation; Solar PV Applications.

Unit-III: Wind Energy: (05 Periods)

Wind Data and Energy Estimation; Types of Wind Energy Systems; Performance; Site Selection; Details of Wind Turbine Generator; Safety and Environmental Aspects.

Unit-IV: Bio-Energy: (05 Periods)

Biomass direct combustion; Biomass gasifies; Biogas plants; Digesters; Ethanol production; Bio diesel; Cogeneration; Biomass Applications.

Unit-V: Other Renewable Energy Sources: (06 Periods)

Tidal energy; Wave Energy; Open and Closed OTEC Cycles; Small Hydro-Geothermal Energy; Hydrogen and Storage; Fuel Cell Systems; Hybrid Systems.

REFERENCE BOOKS:

1. O.P. Gupta, Energy Technology, Khanna Publishing House, Delhi (ed. 2018)
2. Renewable Energy Sources, Twidell, J.W. & Weir, A., EFN Spon Ltd., UK, 2006.
3. Solar Energy, Sukhatme. S.P., Tata McGraw Hill Publishing Company Ltd., New Delhi, 1997.
4. Renewable Energy, Power for a Sustainable Future, Godfrey Boyle, Oxford University Press, U.K., 1996.
5. Fundamental of Renewable Energy Sources, GN Tiwari and MK Ghoshal, Narosa, New Delhi,2007.
6. Renewable Energy and Environment-A Policy Analysis for India, NH Ravindranath, UK Rao, BNatarajan, P Monga, Tata McGraw Hill.
7. Energy and The Environment, RA Ristinen and J J Kraushaar, Second Edition, John Willey &Sons, New York, 2006.
8. Renewable Energy Resources, JW Twidell and AD Weir, ELBS, 2006.

SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time allotted (Periods)	Marks Allotted (%)
1.	06	20
2.	06	20
3.	05	20
4.	05	20
5.	06	20
Total	**28**	**100**

OR

OPEN ELECTIVE -1

Open Elective	4.8 (b) Internet of Things	L	T	P
		2	-	-

COURSE CONTENT

Unit I - Introduction to Internet of Things

- Define the term "Internet of Things"
- State the technological trends which have led to IoT.
- Describe the impact of IoT on society.

Unit II - Design consideration of IoT

- Enumerate and describe the components of an embedded system.
- Describe the interactions of embedded systems with the physical world.
- Name the core hardware components most commonly used in IoT devices.

Unit III-Interfacing by IoT devices

- Describe the interaction between software and hardware in an IoT device.
- Explain the use of networking and basic networking hardware.
- Describe the structure of the Internet.

SUGGESTED SOFTWARE/LEARNING WEBSITES:

1. https://www.raspberrypi.org/blog/getting-started-with-iot/
2. https://www.arduino.cc/en/IoT/HomePage
3. https://www.microchip.com/design-centers/internet-of-things
4. https://learn.adafruit.com/category/internet-of-things-iot
5. http://esp32.net/

SUGGESTED LEARNING RESOURCES

1- Internet of Things by Raj Kamal, McGraw Hill Education; First edition (10March 2017)

2- internet of Things: AHands-On Approach by Arsheep Bahge andVijay Madisetti, Orient Blackswan Private Limited - New Del-hi; First edition (2015) ISBN : 978-8173719547

OR

OPEN ELECTIVE -1

Open Elective	4.8 (c) Disaster Management	L	T	P
		2	-	-

COURSE OBJECTIVES:

Following are the objectives of this course:

- To learn about various types of natural and man-made disasters.
- To know pre- and post-disaster management for some of the disasters.
- To know about various information and organizations in disaster management in India.
- To get exposed to technological tools and their role in disaster management.

COURSE OUTCOMES:

After competing this course, student will be:

- Acquainted with basic information on various types of disasters
- Knowing the precautions and awareness regarding various disasters
- Decide first action to be taken under various disasters
- Familiarized with organization in India which are dealing with disasters
- Able to select IT tools to help in disaster management

COURSE CONTENT:

Unit – I: Understanding Disaster

Understanding the Concepts and definitions of Disaster, Hazard, Vulnerability, Risk, Capacity – Disaster and Development, and disaster management.

Unit – II: Types, Trends, Causes, Consequences and Control of Disasters

Geological Disasters (earthquakes, landslides, tsunami, mining); Hydro-Meteorological Disasters (floods, cyclones, lightning, thunder-storms, hail storms, avalanches, droughts, cold and heat waves) Biological Disasters (epidemics, pest attacks, forest fire);

Technological Disasters (chemical, industrial, radiological, nuclear) and Manmade Disasters (building collapse, rural and urban fire, road and rail accidents, nuclear, radiological, chemicals and biological disasters) Global Disaster Trends – Emerging Risks of Disasters – ClimateChange and Urban Disasters.

Unit- III: Disaster Management Cycle and Framework

Disaster Management Cycle – Paradigm Shift in Disaster Management.

Pre-Disaster – Risk Assessment and Analysis, Risk Mapping, zonation and Micro zonation, Prevention and Mitigation of Disasters, Early Warning System; Preparedness, Capacity De- velopment; Awareness.

During Disaster – Evacuation – Disaster Communication – Search and Rescue – Emergency Operation Centre – Incident Command System – Relief and Rehabilitation –

Post-disaster – Damage and Needs Assessment, Restoration of Critical Infrastructure – Early Recovery – Reconstruction and Redevelopment; IDNDR, Yokohama Stretegy, Hyogo Frame- work of Action.

Unit– IV: Disaster Management in India

Disaster Profile of India – Mega Disasters of India and Lessons Learnt.

Disaster Management Act 2005 – Institutional and Financial Mechanism,

National Policy on Disaster Management, National Guidelines and Plans on Disaster Management; Role of Government (local, state and national), Non-Government and Inter Governmental Agencies

Unit– V: Applications of Science and Technology for Disaster Management

Geo-informatics in Disaster Management (RS, GIS, GPS and RS).

Disaster Communication System (Early Warning and Its Dissemination).

Land Use Planning and Development Regulations, Disaster Safe Designs and Constructions, Structural and Non Structural Mitigation of Disasters

S&T Institutions for Disaster Management in India

RECOMMENDED BOOKS

2. Publications of National Disaster Management Authority (NDMA) on Various Templates andGuide-lines for Disaster Management
3. Bhandani, R. K., An overview on natural & man-made disasters and their reduction, CSIR,New Delhi
4. Srivastava, H. N., and Gupta G. D., Management of Natural Disasters in developing countries,Daya Publishers, Delhi
5. Alexander, David, Natural Disasters, Kluwer Academic London
6. Ghosh, G. K., Disaster Management, A P H Publishing Corporation
7. Murthy, D. B. N., Disaster Management: Text & Case Studies, Deep & Deep Pvt. Ltd.

AUDIT COURSE	4.9 ESSENCE OF INDIAN KNOWLEDGE AND TRADITION	L	T	P
		2	-	-

COURSE OBJECTIVES:

Understand the fundamental aspects of the Indian Knowledge System, its integration with modern science, principles of Yoga and holistic healthcare, and practical applications in contemporary contexts.

COURSE OUTCOMES

Upon completion of the course, the student will be able to demonstrate knowledge of the following topics:

1. Overview, importance, and relevance of the Indian Knowledge System, including Vedas, Upavedas, Vedangas, and Upangas.
2. Relevance of science and spirituality, and contributions of ancient Indian science and technology.
3. Basic principles of Yoga, benefits of holistic healthcare, and integration with modern healthcare.
4. Practical applications and case studies of the Indian Knowledge System's relevance today.

COURSE CONTENTS

UNIT 1: INTRODUCTION TO INDIAN KNOWLEDGE SYSTEM (16 Periods)

Overview of Indian Knowledge System

Importance and relevance

1. Introduction to the Vedas
2. Upavedas
3. Vedangas
4. Upangas

UNIT 2: MODERN SCIENCE AND INDIAN KNOWLEDGE SYSTEM (06 Periods)

1. Relevance of Science and Spirituality,

2. Science and Technology in Ancient India,

UNIT 3: YOGA AND HOLISTIC HEALTHCARE (04 Periods)

1. Basic principles of Yoga
2. Benefits of holistic healthcare practices
3. Integration with modern healthcare

UNIT 4: CASE STUDIES / ASSIGNMENT (02 Periods)

Practical Applications / Case studies demonstrating the relevance of Indian Knowledge System in modern times

MEANS OF ASSESSMENT

Viva -Voce Exam

ANNEXURE- 1

Evaluation method for Practicum Based Course Paper (End Exam: PRACTICAL)

Internal Assessment (60 Marks)					**External Assessment (40 Marks)**
Mode	Sessional Exam (02 Best of 03)	Practical Test	Practical Documentation	Attendance and Assignment	Practical Exam
Portion	2 Units	100% Practical	All Practical	All Units	All Practical
Duration	1 Hr.	3 Hrs.	Regularly Monitored by Faculty	Regularly	4 Hrs.
Exam Marks	20	20	10	10	40
Tentative Schedule	6^{th} Week	12^{th} Week	13^{th} Week	$14^{th} – 15^{th}$ Week	Semester End Exam

NOTE:

1. Complete all exercises/experiments as outlined above and keep them for the practical test. The practical test should be conducted in accordance with the evaluation scheme. The best of the two practical tests will be evaluated internally for a total of 20 marks.

2. Maintain a practical file for each exercise. Submit the document for the practical file with a valid certificate (Progress Card) and Lab/classroom attendance and evaluate it for 10 marks.

3. Submit a micro project report along with the fabrication model/analysis report. The performance of each student in the group will be evaluated by the laboratory supervisor and an internal examiner evaluate it for 10 marks.

Evaluation method for Practical Based Course Paper (End Exam: PRACTICAL)

Internal Assessment (60 Marks)					**External Assessment (40 Marks)**
Mode	Practical Test	Practical Test	Attendance and Practical Documentation	Micro Project	Practical Exam
Portion	50% Practical	50% Practical	All Practical	All Practical	All Practical
Duration	3 Hr.	3 hrs.	Regularly	Regularly	4 hrs.
Exam Marks	20	20	20	20	40
Tentative Schedule	6^{th} Week	12^{th} Week	13^{th} Week	$14^{th} – 15^{th}$ Week	Semester End Exam

NOTE:

1. Complete all exercises/experiments as outlined above and keep them for the practical test. The practical test should be conducted in accordance with the evaluation scheme. The best of the two practical tests will be evaluated internally for a total of 20 marks.

2. Maintain a practical file for each exercise. Submit the document for the practical file with a valid certificate (Progress Card) and Lab/classroom attendance and evaluate it for 20 marks.

3. Submit a micro project report along with the fabrication model/analysis report. The performance of each student in the group will be evaluated by the laboratory supervisor and an internal examiner evaluate it for 20 marks.

Evaluation method for THEORY Based Course Paper

Internal Assessment (40 Marks)					**External Assessment**
Mode	Sessional Exam-1	Sessional Exam-2	Sessional Exam-3	Attendance and Assignment	Written Exam
Portion	2 Units	2 Units	All Units	Regularly	All Units
Duration	1 Hr.	1 Hr.	1 Hr.	1 Hr.	3 Hrs.
Exam Marks	10	10	10	10	60
Tentative Schedule	4^{th} Week	8^{th} Week	$12\text{-}14^{th}$ Week	Regularly	Semester End Exam

Evaluation method for Practicum Based Course Paper (End Exam: THEORY)

Internal Assessment (40 Marks)					**External Assessment (60 Marks)**
Mode	Sessional Exam (02 Best of 03)	Practical Test	Practical Documentation	Attendance and Assignment	Written Exam
Portion	2 Units	100% Practical	All Practical	All Units	All Units
Duration	1 Hr.	3 Hrs.	Regularly Monitored by Faculty	Regularly	3 Hrs.
Exam Marks	10	10	10	10	60
Tentative Schedule	6^{th} Week	12^{th} Week	13^{th} Week	$14^{th} – 15^{th}$ Week	Semester End Exam

8- GUIDELINES FOR ASSESSMENT OF STUDENT-CENTRED ACTIVITIES (SCA)

It was discussed and decided that the maximum marks for SCA should be 50 as it involves a lot of subjectivity in the evaluation. The marks may be distributed as follows-

15 Marks for general behaviour and discipline
(by HODs in consultation with all the teachers of the department)

10 Marks for attendance as per following:
(by HODs in consultation with all the teachers of the department)

a) 75 - 80% 06 Marks

b) 80 - 85% 08 Marks

c) Above 85% 10 Marks

25 Marks maximum for Sports/NCC/Cultural/Co-curricular/NSS activities as per following:
(by In-charge Sports/NCC/Cultural/Co-curricular/NSS)

a) 25 - State/National Level participation

b) 20 - Participation in two of above activities

c) 15 - Inter-Polytechnic level participation

9- List Of Instruments/Resource requirement

Paint Lab 1: IPPT, PE, RPM & DDSA				
S. N.	**Equipment Name**	**Qty**	**Approx Cost (In Rs/Unit)**	**Total cost**
1	Beaker 1000 ml	4	550	2200
2	Beaker 200 ml	5	250	1250
3	Beaker 500 ml	5	380	1900
4	BK Drying recorder(Digital)	1	42550	42550
5	Brush (small) for cleaning various type of material	6	180	1080
6	Burette	9	455	4095
7	Burette stand	6	200	1200
8	Burette stand with clips	5	879	4395
9	BYK Gardner tube viscosity apparatus (A-Z6)	1	250000	250000
10	Colorimeter	1	18879	18879
11	Condenser with Tube and Heating Material	1	9885	9885
12	Conical flask 500 ml	5	550	2750
13	Digital electronic balance	1	18000	18000
14	Digital PH meter	1	8500	8500
15	Digital weighing balance	1	18000	18000
16	Distillation Boiling range apparatus	1	39450	39450
17	Drawdown card	10	45	450
18	Empty bubble tubes	5	800	4000
19	Filter paper	24	120	2880
20	Flash point apparatus	1	15890	15890
21	Flask 500 ml	6	1200	7200
22	Ford Cup	1	5300	5300
23	Funnel stand	6	550	3300
24	Glass plate 4 cm Diameter	10	100	1000
25	Glass plate 6*6 inch	10	200	2000
26	Heating mental	2	5600	11200
27	High speed disperser	1	45800	45800
28	Hot Oven	1	16000	16000
29	Hot plate	2	5500	11000
30	Hot Plate 7-1/22" ,3" Diameter	2	4750	9500
31	Iron plate 6*6 inch	10	150	1500
32	Lab Stirrer	2	9800	19600
33	Measuring Cylinder (1000ml)	5	750	3750
34	Measuring Cylinder (250ml)	5	310	1550
35	Measuring Cylinder (500ml)	5	520	2600
36	Measuring flask 250ml with cap(Stopper)	5	800	4000
37	Pipette	9	250	2250
38	Pipette stand	4	200	800
39	RD bottle	10	325	3250
40	Reagents Bottle 250ml,500ml,1000ml	10	2250	22500
41	Refractometer	1	11500	11500

42	Spatula	5	120	600
43	Specific gravity bottle	10	200	2000
44	Spectrophotometer	1	125000	125000
45	Sprit lamp	6	379	2274
46	SS Test tube stand	2	1200	2400
47	Steel polymerisation vessel of 5 ltr	1	26512	26512
48	Stirrer blade (Teflon)	4	110	440
49	Stirrer rod	4	150	600
50	Stirrer with speed Regulator	1	9800	9800
51	Test tube	20	25	500
52	Test tube stand	6	520	3120
53	Thermometer	2	600	1200
54	Three neck flasks	4	750	3000
			Grand Total	810400

Paint Lab 2: FMP & SPPA				
S. N.	**Equipment Name**	**Qty**	**Approx Cost (In Rs/Unit)**	**Total cost**
1	Digital weighing balance	1	18000	18000
2	Glass plate 6*6 inch	6	200	1200
3	Iron plate 6*6 inch	6	200	1200
4	Petri dish	10	250	2500
5	Spatula	5	120	600
6	Stirrer rod	5	100	500
7	Lab High speed disperser	1	45800	45800
8	Lab Dyno mill 1.4 L(Sand mill)	1	135000	135000
9	Hegman gauge (0-8 scale)	1	5800	5800
10	Lab Ball mill	1	36000	36000
11	Lab Bead mill/Attritor	1	55800	55800
12	Beaker 500 ml	5	600	3000
13	Beaker 1000 ml	5	1100	5500
14	Steel vessels 10 Litre	2	1800	3600
15	Steel vessels 5 Litre	4	1100	4400
16	Spray booth	1	55800	55800
17	Gravity feed Spray gun	1	5500	5500
18	Metal panel	200	20	4000
19	Cylindrical flask of 1 lit .	10	900	9000
20	Orbital sander	1	9500	9500
21	Compressed air unit	1	35800	35800
22	Steel vessels 10 Litre (PT Tanks)	12	1800	21600
23	Digital electronic balance	1	18000	18000
24	Conventional spray gun with accessories	1	9600	9600
25	Electrostatic spray gun accessories	1	15800	15800
26	Lab painting robots with accessories	1	42500	42500

27	Electrostatic spray gun unit for powder coating with accessories	1	65800	65800
28	Lab oven	1	18999	18999
29	UV curing cabinet and accessories	1	31800	31800
30	E-beam curing cabinet and accessories	1	98000	98000
31	Lab fluidised bed for powder coating application	1	78000	78000
32	B.K drying recorder	2	28500	57000
33	Powder coating booth	1	68000	68000
34	CED Lab unit((Tank, agitation system, electrode set up, temperature control, filter pump, rectifier (DC Power supply), magnetic stirrer))	1	325000	325000
35	Conductivity meter	1	15500	15500
36	Digital pH meter	1	8500	8500
37	Muffle furnace (1000-1200 Deg C)	1	12600	12600
			Total cost	**1006299**

Fluid mechanics and solid handling

S. N.	Equipment Name	Qty	Approx Cost (In Rs/Unit)	Total cost
1	Density Bottles (5 ml)	6	600	3600
2	Density Bottles (10 ml)	6	800	4800
3	Density Bottles (100 ml)	6	1000	6000
4	Hydrometer	1	790	790
5	Ostwald Viscometer /Digital Viscometer	1	10000	10000
6	Redwood Viscometer /Digital Viscometer	1	17584	17584
7	U-Tube manometer (For Demonstration Purposes)	1	1580	1580
8	Reynolds Experiment set-up	1	50000	50000
9	Bernoulli’s Theorem Experiment Set-up	1	30000	30000
10	Venturi Meter & Orifice Meter Experiment Set-up	1	35000	35000
11	Vacuum pump with experiment set-up	1	20000	20000
12	Determination of Frictional losses through pipe	1	55000	55000
13	Centrifugal pumps and reciprocating pump(For Demonstration Purposes)	1	30000	30000
14	Rota-meter, Venturi meter, Orifice meter, pitot tube	1	80000	80000
15	Globe valve, check valves, Butterfly valve, Needle valve, Gate Valve, Diaphragm Valve	1	18000	18000
16	Experiments related raw materials	1	50000	50000
17	Ball Mill	1	75000	75000
18	Jaw Crusher	1	70000	70000

19	Sieve shaker with sieves	1	30000	30000
20	Roller mill/Roll crusher	1	50000	50000
21	Cyclone Separator	1	40000	40000
22	Plate and frame filter press	1	80000	80000
23	Mixer: Liquid-Liquid Mixer	1	40000	40000
24	Solid-Liquid Mixer	1	40000	40000
25	Centrifuge experimental set-up	1	50000	50000
26	Ribbon Mixer	1	35000	35000
27	Laboratory slurry mixture	1	80000	80000
28	Experiments related raw materials.	1	50000	50000
			Total	**375000**

Heat and mass transfer

S. N.	Equipment Name	Qty	Approx Cost (In Rs/Unit)	Total cost
1	Equipment to measure thermal conductivity of metal rod.	1	57550	57550
2	Heat transfer through compound wall equipment.	1	57200	57200
3	Thermal conductivity (Insulating powder) Apparatus	1	58600	58600
4	Forced convection apparatus	1	57800	57800
5	Natural convection apparatus	1	54100	54100
6	Open pen evaporator	1	56800	56800
7	Drop and film wise condensation apparatus	2	65200	130400
8	Parallel and counter flow apparatus for heat exchanger	1	60100	60100
9	Shell and tube heat exchanger	1	63690	63690
10	Double pipe heat exchanger for heat transfer coefficient	1	63686	63686
11	Single effect evaporator	1	125339	125339
12	Liquid Diffusion Apparatus	1	111000	111000
13	Solid Diffusion Apparatus	1	114000	114000
14	Wetted Wall Column Apparatus	1	102000	102000
15	Tray Dryer	1	60000	60000
16	Rotary Dryer	1	60000	60000
17	Laboratory Batch Distillation Apparatus	1	130551	130551
18	Absorption Packed Column Apparatus	1	99958	99958
19	Electrical Oven	1	30952	30952
20	Bubble Cap Distillation Column(5 litter)	1	90000	90000
21	Liquid-Liquid Extractor Setup	1	50000	50000
22	Cooling Tower	1	112609	112609
23	Laboratory Crystallizer	1	105975	105975
24	Digital Hygrometer	1	12875	12875

			Total	**3292539**

Chemical reaction engineering and thermodynamics

S. N.	Equipment Name	Qty	Approx Cost (In Rs/Unit)	Total cost
1	Batch Reactor with 5 litter tank capacity, SS material	1	120000	120000
2	Isothermal Plug Flow Reactor	1	120000	120000
3	Isothermal Mixed Flow Reactor/Continuous Stirred Tank Reactor(2 litter)	1	120000	120000
4	PFR and CSTR in series	1	125000	125000
6	Reigerator(280 lt)	1	40000	40000
7	Electronic Weighing Balance	1	25000	25000
8	Experiments related raw materials.	1	25000	25000
			Total	**575000**

10 - List of Participants / Experts

The following experts participated in various workshop for Developing the Curriculum's Structure and Contents of **Paint Technology** at I.R.D.T. Kanpur.

1. Mr. Rakesh Kumar, Head of Department (Chemical), Government Polytechnic, Kanpur
2. Mr. Ashwani Kumar Mishra, HOD, (Chemical), Government Polytechnic, Kotwan, Mathura
3. Mr. Abhinav Jain, Head of Department (Chemical), Government Polytechnic, Mankeda, Agra
4. Dr. Shivcharan Prajapati, Lecturer (Paint Technology), Government Polytechnic, Bindki, Fatehpur
5. Mr. Vinod Prasad Sharma, Lecturer (Paint Technology), Government Polytechnic, Kanpur
6. Mr. Satyaveer Singh, Lecturer (Chemical), Government Polytechnic, Kotwan, Mathura
7. Dr. Shashi Bala Gautam, Lecturer (Chemical), Government Polytechnic, Kanpur
8. Mr. Mausam Kumar, Lecturer (P.M.T.), Government Polytechnic, Kanpur
9. Mr. Devesh Srivastava, Lecturer (Chemical), Government Polytechnic, Bindki, Fatehpur
10. Mrs. Kanchan Kushwaha, Lecturer (Petro-Chemical), Government Polytechnic, Kotwan, Mathura

11 . EVALUATION SCHEME

a. For Theory Courses:

(The weightage of Internal assessment is 40% and for End Semester Exam is 60%) The student has to obtain at least 40% marks individually both in internal assessment and end semester exams to pass.

b. For Practical Courses:

(The weightage of Internal assessment is 60% and for End Semester Exam is 40%) The student has to obtain at least 40% marks individually both in internal assessment and end semester exams to pass.

c. For Summer Internship / Projects / Seminar etc.

Evaluation is based on work done, quality of report, performance in viva-voce, presentation etc.

Note: The internal assessment is based on the student's performance in mid semester tests (two best out of three), quizzes, assignments, class performance, attendance, viva-voce in practical, lab record etc.