

Shroff S.R. Rotary Institute of Chemical Technology

Teaching Scheme for Fourth Year Bachelor of Chemical Technology

Semester-VII (Chemical Technology) Proposed Structure

Category of Course	Code No.	Course Title	Hours Per Week			Total contact hrs/ week	Total Credits	E	M	I	V	Total marks
			L	T	P							
Professional Core Course	CT2401	Principles of Process Equipment Design	3	0	2	5	4	70	30	20	30	150
	CT2402	Chemical Engineering Thermodynamics	3	0	0	3	3	70	30	0	0	100
Professional Elective Course	CT2403-06	Specialized Subjects-I	3	0	2	5	4	70	30	20	30	150
	CT2407-10	Specialized Subjects-II	3	0	0	3	3	70	30	0	0	100
Open Subject	CT2411-12	Open Elective-I	3	0	0	3	3	70	30	0	0	100
Project work, seminar and internship in industry	MH2401	Summer Internship	0	0	0	0	3	0	0	20	80	100
Total						19	20	350	150	60	140	700

Specialized Subjects-I		
Category of Course	Code No.	Course Title
Pharma. Tech	CT2403	Pharmaceutical Formulation Technology-II
Dyes & Pig. Tech	CT2404	Evaluation & Testing of Dyes & Pigments
Pol & Rub. Tech	CT2405	Testing of Polymer & Rubber
Glass Tech	CT2406	Physical Ceramics
Specialized Subjects-II		
Pharma. Tech	CT2407	Pharmaceutical Drug Delivery and Biotechnology
Dyes & Pig. Tech	CT2408	Industrial Applications of Pigments
Pol & Rub. Tech	CT2409	Polymer Characterization Concepts
Glass Tech	CT2410	Advanced Ceramics
Open Elective-I	CT2411	Renewable Energy Sources
	CT2412	NPTEL Course

Semester-VIII (Chemical Technology) Proposed Structure

Category of Course	Code No.	Course Title	Hours Per Week			Total contact hrs/ week	Total Credits	E	M	I	V	Total marks
			L	T	P							
Professional Core Course	CT2413	Process Modelling and Simulation	3	0	2	5	4	70	30	20	30	150
Professional Elective Course	CT2414-17	Specialized Subjects-III	3	0	0	3	3	70	30	0	0	100
Open Subject	CT2418-19	Open Elective-II	3	0	0	3	3	70	30	0	0	100
Project work, seminar and internship in industry	MH2402	Project	0	0	18	18	9	0	0	100	100	200
Total						29	19	210	90	120	130	550

Specialized Subjects-III		
Category of Course	Code No.	Course Title
Pharma. Tech	CT2414	Validation and Regulatory Requirements
Dyes & Pig. Tech	CT2415	Nanotechnology in Colorant Industry
Pol & Rub. Tech	CT2416	Recycling of Polymer & Rubber
Glass Tech	CT2417	Refractories-II
Open Elective-II	CT2418	Process Optimization
	CT2419	Introduction to Sustainable Engineering

A. Course Code and Definition

Course Code	Definitions
L	Lecture
T	Tutorial
P	Practical
E	Theory External Examination Marks
M	Theory Internal Examination Marks
I	Practical Internal Examination Marks
V	Practical External Examination Marks

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Bachelor of Engineering

Subject Code: CT2401

Subject Name: Principles of Process Equipment Design

Shroff S.R. Rotary Institute of Chemical Technology

Semester: VII

Type of course: Professional Core Courses

Prerequisite: The student should have basic understanding of Unit Operations of Chemical Engineering and also knowledge of various subjects like fluid mechanics, heat transfer and mass transfer & mathematics.

Rationale: Equipment design involves modifications and additions to existing plants or creating design layouts of plant / equipment. It has been observed conclusively that practice in using the reference literature and software has helped the students to secure jobs and also to perform better in profession.

Teaching and Examination Scheme:

Teaching Scheme			Credits C	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs.
SECTION-A		
1	Introduction to Process Equipment Design Criteria and factors for design, need for design, basic considerations in equipment design, nature of design, types of process, codes and standards, factor of safety, degree of freedom and design variables.	03
2	Process design of piping, Fluid moving devices: Introduction, Process design of piping, $NPSH_A$ & $NPSH_R$, Power required by pump, Evaluation of Centrifugal pump performance when handling viscous liquids, Power required in Fan, Blower and adiabatic compressor.	07
3	Process design of Heat exchangers: Shell & Tube heat exchangers, Functions of various parts of shell & Tube Heat exchanger, General design method of shell & tube heat exchanger, Process design of without phase change heat exchanger, Process design of condenser, Criteria of selection for Horizontal and vertical condenser, Process design of Reboilers	10

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Bachelor of Engineering

Subject Code: CT2401

Subject Name: Principles of Process Equipment Design

SECTION-B		
4	Process design of Distillation Column: Introduction, Criteria of selection, Selection of equipment for distillation, Distillation column design, Selection of key components for multi-component distillation, Determination of operating pressure for distillation column, Determination of nos. of theoretical stages for multi-component distillation by Fenskey- Underwood-Gilliland's method.	10
5	Process design of Reactors: Introduction, Different types of reactors, Batch Reactor, Advantages and disadvantages of batch reactors over continuous flow reactors, Continuous flow reactors, Advantages and disadvantages of PFR over MFR, Ideal MFR, Degree of completion of reaction, mixing for the different type of reaction systems, Bubble column reactor, various factors affecting performance of Bubble column reactor, process design of Bubble column reactor.	07
6	Process design Absorber: Selection criteria from different available types of absorption equipment, amount of solvent utilized, determination of tower diameter, pressure drop calculation, NtoG, HtoG and height of packing.	08

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
07	21	21	7	7	7

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Recommended Books:

1. Ray Sinnott, Gavin Towler, Chemical Engineering Design - Principles, Practice and Economics of Plant and Process Design, Butterworth - Heinemann, 2008.
2. Introduction to Process Engineering and Design by S B Thakore and B I Bhatt, Tata McGraw Hill, 1st Edition, 2007.
3. M. S. Peters and K. D. Timmerhaus, Plant Design and Economics for Chemical Engineers, a. 4th ed., McGraw - Hill, New York, 1991.
4. Ludwig, E. E., Applied process design for chemical and petrochemical plants , volume 1,2 & 3, Third Edition, Butterworth- Heinemam,1997
5. TEMA Standards.
6. Don W. Green, Robert H. Perry, Perry's Chemical Engineers' Handbook, 8th Edn., McGraw -Hill, New York, 2008
7. James R. Couper, James R. Fair & W. Roy Penney, Chemical Process Equipment - Selection and Design, 2nd Edn., Butterworth - Heinemann, 2010.

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Bachelor of Engineering

Subject Code: CT2401

Subject Name: Principles of Process Equipment Design

List of Practical:

1. Symbols of Equipment & Piping
2. Types of Shell & Tube Heat Exchanger.
3. TEMA Designation.
4. Types of Distillation Column.
5. Types of Reactor.

Course Outcomes:

After learning this course, students will be able to:

CO No.	CO statement
CO-1	Build a bridge between theoretical and practical concepts used for designing the equipment in any process industry.
CO-2	Create understanding of equipment design.
CO-3	Review the importance of design concepts in process industry.
CO-4	Interpret the basic fundamentals of process plant and equipment design.
CO-5	Build a skill to evaluate design parameters of equipment.
CO-6	Solve various problem of designing of equipment.

List of Open-Source Software/learning website:

Reference to NPTEL lectures can be made for a better understanding regarding Process design of equipment under different conditions.

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Bachelor of Engineering

Subject Code: CT2402

Subject Name: Chemical Engineering Thermodynamics

Shroff S.R. Rotary Institute of Chemical Technology

Semester: VII

Type of course: Professional Core Courses

Prerequisite: Studied previous semesters subjects and should have knowledge of basic properties and law of conservation of energy

Rationale: The main objective of this subject is to understand the laws of thermodynamics and its application in different domain of chemical technology.

Teaching and Examination Scheme:

Teaching Scheme			Credits C	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	0	3	70	30	00	00	100

Content:

Sr. No.	Content	Total Hrs.
SECTION-A		
1	Introduction And First Law Of Thermodynamics: Systems and variables, Work, Heat, Internal Energy, Thermodynamic Equilibrium, Reversible and Irreversible Processes; Phase-Rule; Significance of Chemical Engineering Thermodynamics, Closed and Open Systems, Application of first law of thermodynamics to steady state flow process.	06
2	Properties Of Pure Substances: PVT behavior of pure substances, Ideal and non-ideal gases, Equation of states, Virial, Van der waals, Redlich/Kwong (RK), RKS Equation, PR Equation etc., Calculation of constants in terms of Pc, Tc, Vc, Principles of corresponding states.	06
3	Second Law Of Thermodynamics: Statements of second law of thermodynamics, Heat engines, Thermodynamic Temperature Scales, Concept of entropy, Entropy changes of an Ideal Gas, Third law of thermodynamics.	05
SECTION-B		
4	Thermodynamic Properties of Fluids and Solution Thermodynamics: The fundamental property relations for homogeneous phases, Maxwell's equations, Residual properties, Mathematical relations among thermodynamic properties, Two phase systems, Thermodynamic	13

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Bachelor of Engineering

Subject Code: CT2402

Subject Name: Chemical Engineering Thermodynamics

	diagrams. Ideal Solutions; Partial molar quantities; Gibbs-Duhem Equation; Criteria for Thermodynamic Equilibrium; Phase Equilibrium Criteria, Non ideal Solutions; Residual and Excess Properties; Fugacity and Activity Coefficient models.	
5	Phase Equilibria: Introduction, The Nature of Equilibrium, The Phase Rule; Duhem's Theorem, VLE- Qualitative Behavior, P-x-y, T-x-y, x-y diagram, Azeotropic Mixtures, Raoult's Law, Dew point and Bubble point Calculations with Raoult's Law, Henry's law, VLE by Modified Raoult's Law, Flash Calculations.	07
6	Chemical Reaction Equilibria: Criteria of chemical reaction equilibrium, Equilibrium extent of reaction, Equilibrium constant, Effect of temperature and pressure on K, Evaluation of K by various methods, Evaluation of equilibrium extent of reaction for exothermic, endothermic, reversible, irreversible reactions and various combinations. Thermodynamic analysis of some important industrial reactions	08

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
20	30	20	15	15	-

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Recommended Books:

1. Smith J.M, Van Ness H.C., Abbott M. M, "Introduction to Chemical Engineering Thermodynamics", the McGraw Hill Companies, Inc., USA, 7th Ed., 2005.
2. K. V. Narayanan "A Text book of chemical Engineering thermodynamics", Prentice-Hall of India Pvt. Ltd.
3. B.G. Kyle, "Chemical Process Thermodynamics", 2nd Edn. Prentice Hall of India Pvt. Ltd., New Delhi, 2000.
4. Y.V.C. Rao, "Introduction to Thermodynamics"; 2nd Edition, Wiley Eastern Limited.
5. Elliot J. R. and Lira C.T., "Introductory Chemical Engineering Thermodynamics", Prentice Hall, 1999.
6. Perry's chemical engineer's handbook, 7th edition, McGraw Hill, USA, 2000.
7. Stanley I. Sandler, "Chemical, Biochemical and Engineering Thermodynamics", Wiley India Pvt. Ltd., 4th ed., 2007.
8. Stanley M. Walas, "Phase-Equilibria in Chemical Engineering", Wiley India Private Limited

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Bachelor of Engineering

Subject Code: CT2402

Subject Name: Chemical Engineering Thermodynamics

Course Outcomes:

After learning this course, students will be able to:

CO No.	CO statement
CO-1	Develop fundamental understanding of the basic principles of thermodynamics and related calculations.
CO-2	Demonstrate the use and applications of the first and second laws of Thermodynamics.
CO-3	Evaluate changes in different thermodynamic properties for pure fluids using Equations of state (EOS).
CO-4	Apply fundamental property relations to find thermodynamic properties of solutions.
CO-5	Analyze phase equilibria and application of Raoult's law and its variation to obtain VLE for binary systems.
CO-6	Determine equilibrium conversions of reaction systems and its dependence on various operating parameters.

List of Open-Source Software/learning website:

Reference to NPTEL lectures can be made for a better understanding regarding thermodynamics under different conditions.

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Bachelor of Engineering

Subject Code: CT2403

Subject Name: Pharmaceutical Formulation Technology-II

Shroff S.R. Rotary Institute of Chemical Technology

Semester: - VII

Type of course: Professional Elective Course

Prerequisite: Needs basic knowledge of Pharmaceutics

Rationale: The course is designed to train the students with respect to basics and application of technology of sterile pharmaceuticals, ophthalmic products, blood products and substitutes and sutures and ligatures.

Teaching and Examination Scheme:

Teaching Scheme			Credits C	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs.
SECTION-A		
1	Parenteral Pharmaceuticals <ul style="list-style-type: none"> • Introduction to sterile dosage forms, routes of parenteral administration • Preformulation considerations for sterile dosage forms: small-volume parenterals, large volume parenterals Formulation of Small-volume Parenterals and Large Volume Parenterals (discuss various dosage forms like solutions, suspensions, emulsions, dry powders) <ul style="list-style-type: none"> • Quality control 	10
2	Facility Design for parenteral manufacture with focus on air systems HEPA filters, environmental classes for manufacture of parenterals Methods of sterilization	5
3	Containers and Closures for Parenteral Formulations: Glass and plastic as a container material; ampoules, vials, bottles, rubber closures manufacturing, sterilization, quality control	5
SECTION-B		
4	Water for Injection: Monograph IP, methods of preparation, quality control tests, storage	5
5	Ophthalmics: <ul style="list-style-type: none"> • Introduction to Ophthalmic dosage form • Anatomy of eye, factors affecting ophthalmic drug absorption 	10

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Bachelor of Engineering

Subject Code: CT2403

Subject Name: Pharmaceutical Formulation Technology-II

	<ul style="list-style-type: none"> • Preformulation considerations for ophthalmic dosage forms • Dosage forms: discuss various dosage forms like solutions suspensions, ointments, gels, films, inserts, lenses etc. w.r.t advantages and limitations, excipients, methods, equipments, advances, problems and solutions thereof • Quality control of ophthalmics • Large scale manufacture and packaging with focus on equipment • Layout design and Unit operations 	
6	<p>Blood Products and Glandular Products:</p> <p>Blood products</p> <ul style="list-style-type: none"> • Introduction, advantages and limitations • Collections and storage techniques for whole blood • Methods of blood and plasma fractionation into individual components • Quality control <p>Plasma substitutes</p> <ul style="list-style-type: none"> • Introduction, advantages and limitations • Methods of preparation • Quality control <p>Insulin and insulin products</p> <p>Medical Sutures and Ligatures</p>	10

Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
40	25	15	10	5	5

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Reference Books:

1. Remington's Pharmaceutical Sciences, A. R. Gennaro Mac Pub. Co. Easton, Pennsylvania (1990)
2. Theory & Practice of Industrial Pharmacy. L. Lachman, Herbert A. Lieberman & J. Kanig, Lea & Febiger, Philadelphia (1987)
3. Novel drug delivery systems D.K.Tripathi and Amit Alexander
4. Pharmaceutical Dosage Form: Dispersed Systems (Vol.1 & 2) Herber A. Lieberman, Martin A. Rieger, G. S. Ban, Marcel Dekker Inc. (1993)
5. Pharmaceutical Dosage forms: Parenteral Medications in Three volumes, Kenneth E. Avis, Herbert A. Lieberman, Leon Lachman, Marcel Dekker Inc. (1993)
6. Drug Delivery Device: Fundamentals & Applications, Tyle ,New York , Marcel Dekker 1988
7. Pharmaceutical production Facilities Design & Application , G.C.Cole New York EIIis Horwood 1990
8. Indian Pharmacopoeia, British Pharmacopoeia, United States Pharmacopoeia.

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Bachelor of Engineering

Subject Code: CT2403

Subject Name: Pharmaceutical Formulation Technology-II

9. Aulton's *Pharmaceutics, The design and manufacture of medicines.*, Michael E. Aulton; Kevin M. G. Taylor
10. Martin's *Physical Pharmacy and Pharmaceutical Sciences.*, Patrick J. Sinko

List of Experiments:

1. Preparation and study of ascorbic acid parenteral preparation
2. Preparation and study of Calcium Gluconate parenteral preparation
3. Preparation of Atropine Sulphate Eyedrops
4. Preparation of Hydrocortisone eye ointment
5. To study the preparation of ophthalmic ointments
6. Overview of blood components and their preparations
7. To study the techniques involved in collection and storage of whole blood
8. To study of Pharmaceutical Manufacturing Facility design

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	To describe the Preformulation, formulation techniques involved in sterile, ophthalmic preparations and blood products	15
CO-2	To apply concepts of different dosage forms of sterile, ophthalmic and blood products	15
CO-3	To be able to understand the various facility parameters	20
CO-4	To be able to analyze quality parameters for sterile, water, ophthalmic and blood preparations	15
CO-5	To remember the principles of dosage form design to various formulations of different dosage forms and their advantages and limitations.	15
CO-6	To evaluate importance of facility requirements, stringent testing norms and extreme care during manufacturing to ensure safety and efficacy of the parenteral and ophthalmic dosage forms.	20

List of Open Source Software/learning website:

- Literature available on internet
- www.iri.net.in
- www.ipiindia.org
- Delnet

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Bachelor of Engineering
Subject Code: CT2404
Subject Name: Evaluation & Testing of Dyes & Pigments

Shroff S.R. Rotary Institute of Chemical Technology
Semester: - VII

Type of course: Professional Elective Course

Prerequisite: Basic Knowledge of Dyes & Pigment is required.

Rationale: The main objective of this subject is to study the basic knowledge of dyes and pigment analysis. This is applied in of various types of dyes, pigments and allied industries. This subject provides fundamental knowledge of various types of Dyes & Pigments analysis to be performed in industries.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs.
SECTION-A		
1	Basic Concepts and Advancements in Testing: Specifications and standards, Purpose of specifications	08
2	Gravimetric analysis of Pigments: Hiding power, oil absorption, specific gravity, bulking value, reducing power, tinting strength, fastness properties such as resistance to light, heat, water, chemicals, bleeding etc. corrosion resistance, toxicity of pigments etc.	10
3	Sophisticated Instrumental analysis of Pigments: Crystal structure, particle size, shape and distribution, refractive index, thermal stability etc.	10
SECTION-B		
4	Analysis of Dyes & Inter-mediate: Colour fastness, Light fastness, sublimation fastness, Paper Chromatography, Thin Layer Chromatography, Column Chromatography etc.	08
5	Sophisticated Instrumental analysis of Pigments: Colour Matching Spectrophotometer, UV-visible Spectrophotometer etc.	08
6	Health and Safety Aspects: Introduction, Toxicology and Toxicity Assessments; Acute Toxicity, Sensitization, Mutagenicity, Carcinogenicity, Metabolism of Dyes.	08

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Bachelor of Engineering

Subject Code: CT2404

Subject Name: Evaluation & Testing of Dyes & Pigments

Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
20	30	30	10	10	-

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

List of Experiments:

1. To determine colour value by using UV-visible Spectrophotometer
2. To determine colour strength by using colour matching spectrophotometer.
3. To determine stain resistance of pigmented coating
4. To determine solvent resistance of pigmented coating
5. To determine particle size of pigment by Particle Size Analyzer
6. To determine the R_f value by using paper chromatography method.
7. To determine the R_f value by using thin layer chromatography method.
8. To determine the R_f value by using column chromatography method.

Reference Books:

1. Chemistry of Synthetic Dyes – Vol II, Venkataraman K., Academic Press, New York, 1952
2. Industrial Organic Pigments – Production, Properties, Applications, Herbst W. and Hunger K., VCH Verlag, Weinheim, 1997.
3. High Performance Pigments, Smith H. M.
4. Industrial Dyes: Chemistry, Properties, Applications Klaus Hunger- WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim
5. Chemistry of Synthetic Dyes Lubs H.A. - Robert E Krieger Publishing Company New York - 1st Ed., 1995

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	To recognize the knowledge of basic concepts and advancements in testing of dyes & pigment materials.	20
CO-2	To get the basic knowledge of gravimetric analysis of pigments	20
CO-3	To get the basic knowledge of instrumental analysis of pigments	20
CO-4	To get the basic knowledge of gravimetric analysis of dyes	20
CO-5	To get the basic knowledge of instrumental analysis of dyes	10
CO-6	To know the various health & safety aspects of dyes & pigments	10



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Bachelor of Engineering

Subject Code: CT2404

Subject Name: Evaluation & Testing of Dyes & Pigments

List of Open Source Software/learning website:

- Literature available on internet
- Dyes dictionaries
- Delnet
- Literature available under R&D in Pigments & Paints industries
- Dyes & Pigments, Pigments & Resin & Paint India journals

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Bachelor of Engineering
Subject Code: CT2405
Subject Name: Testing of Polymer & Rubber

Shroff S.R. Rotary Institute of Chemical Technology

Semester: - VII

Type of course: Professional Elective Course

Prerequisite: Student should know the basics of polymer and rubber material and its properties and structures.

Rationale: The main objective of this subject is to provide the knowledge about the different polymer and rubber testing methods.

Teaching and Examination Scheme:

Teaching Scheme			Credits C	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs.
SECTION-A		
1	Introduction: Basic Concepts and Advancements in Testing, Specifications and standards, Purpose of specifications.	08
2	Structural Evaluation of Polymers- Principles, theories & applications to polymers system with suitable illustration of the following techniques: Fourier transform infrared spectrometry, Ultraviolet Visible spectrometry, Nuclear magnetic resonance spectrometry, Mass spectrometry, X-ray diffraction spectrometry, Gas chromatography.	10
3	Determination of Viscosity- Polymer solutions & polymer melts: Their significance, application to polymers using different viscometers. Determination of viscoelastic properties of polymers & rubbers. Testing of Rubber Compounds by Mooney viscometer and Determination of vulcanization properties by ODR and MDR.	12
SECTION-B		
4	Material Characterization Tests: Melt flow rate, Rheometer, Dilute solution Viscosity of Polymers. Tests for Elevated Temperature Performance: Heat deflection temperature, Vicat softening temperature. Thermal Analysis Techniques: DSC, TGA, TMA and DMT & their applications to polymers with suitable examples	10
5	Electrical Properties- Surface volume resistivity, Breakdown voltage. Arc resistance, Ten Delta, etc. The theory behind these phenomena, application to polymers & evaluation., Mechanical properties : Their	10

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Bachelor of Engineering
Subject Code: CT2405
Subject Name: Testing of Polymer & Rubber

	principles & applications to polymers, Tensile strength, flexural strength, impact resistance, percentage elongation, Griffin theory, tear test, fatigue & wear, hardness, abrasion, compressive strength time dependent properties like creep, stress, relaxation, etc.	
6	Environmental Resistance- Stress cracking, effect of weathering, biological degradation, fire radiation Staining. Optical properties: Refractive index, gloss, color matching, haze. Fire test: Ignition of flame & spread, limiting oxygen index, rate of heat release, smoke toxicity test.	12

Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
40	25	15	10	5	5

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Reference Books:

1. Handbook of polymer Testing Roger Brown, Marcel Dekker Inc, 1999.
2. Polymer Chemistry, Seymour and Carraher, Marcel Dekker, 2003
3. Handbook of Rubber Technology, S Blow, Galgotia Publications Pvt. Ltd, 1998
4. Developments in Polymer Characterization 1-5 by J. V. Dawkins
5. Handbook o Plastics Testing Technology, Vishu Shah, 2nd Edition, A Wiley-Interscience Publication.

List of Experiments:

1. To calculate the Melt Flow Index for the given polymeric sample.
2. Determination of surface and volume resistivity of polymeric materials
3. Determination of dielectric strength of polymeric materials
4. Determination of limiting oxygen index
5. To Study the Abrasion resistance of rubber materials
6. Determine the dynamic properties of rubber by using Oscillating disk rheometer
7. Determine the dynamic properties of rubber by using Mooney Viscometer
8. Mechanical properties of polymeric materials: Universal testing machine (UTM)

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Bachelor of Engineering
Subject Code: CT2405
Subject Name: Testing of Polymer & Rubber

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	To recognize the knowledge of basic concepts and advancements in testing of polymer and rubber materials.	15
CO-2	To identify and evaluate the structural features of polymeric material by various analytical techniques.	15
CO-3	To apply this knowledge to polymeric solutions by performing various viscosity measurements techniques.	20
CO-4	To analyze the polymeric materials by performing various characterization techniques.	15
CO-5	To be able to determine various electrical and mechanical properties of polymer and rubber materials.	15
CO-6	To correlate between theoretical and practical concept by the evaluation of various environmental resistance properties.	20

List of Open Source Software/learning website:

- www.iri.net.in
- www.ipiindia.org
- Delnet
- Literature available under R&D in Polymer & Rubber industry.
- Polymer & Rubber journals 6. Polymer & Rubber dictionaries

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Bachelor of Engineering
Subject Code: CT2406
Subject Name: Physical Ceramics

Shroff S.R. Rotary Institute of Chemical Technology

Semester: VII

Type of course: Professional Elective Course

Prerequisite: The students should have a clear concept on fundamentals of ceramics, geology and materials sciences that will help them to have an easy grasp of the subject.

Rationale: The main objective of this subject is to offer an overview over the fundamentals and basics of glass and ceramic materials, the raw feed materials for batch preparation, their availability, their properties, their beneficiation processes, process of recovery and their application.

Teaching and Examination Scheme:

Teaching Scheme			Credits C	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs.
SECTION-A		
1	Ceramic crystal structures : Corundum , Wurtzite , Zinc blende, Rocksalt , Perovskite and Spinel structure etc. Atomic Mobility, Diffusion & Diffusivity, Laws of Diffusion , Diffusion in solids, Controlling diffusivity . Nernst-Einstein equation. Temperature & impurity dependence of diffusion. Diffusion in crystalline oxides, Dislocation. Boundary & surface diffusion.	10
2	Phase Transformations: Formal theory of transformation kinetics with examples. Spinodal decomposition. Thermodynamics & kinetics of nucleation & growth. Grain Growth, Sintering & Vitrification: Sintering - Single & multiphase Study of sintering - Kinetics, mechanisms of mass transport. Sintering variables, Sintering aids .Recrystallization & grain growth. Abnormal grain growth. Sintering vis-à-vis Vitrification. Sintering with a reactive liquid. Pressure sintering & hot pressing. Secondary phenomena. Firing shrinkage.	10
3	Microstructure & Characterisation: Features in microstructures.	10

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Bachelor of Engineering
Subject Code: CT2406
Subject Name: Physical Ceramics

	Microstructural observations - Optical & Electron Microscopy Techniques of sample preparation. Ceramic Phase Equilibrium Diagrams: Techniques of determining phase diagrams. One - two - , and three - components phase diagrams. Examples. Phase composition versus temperature. Non-equilibrium phases.	
SECTION-B		
4	Electrical Properties: Electrical conduction in materials, Electron mobility, Drift velocity, Relaxation time, Electrical resistivity, Energy band model : Insulators, Conductors, Semiconductors diagrams, Mechanism of electrical conduction in intrinsic and extrinsic semiconductors, Charge transport in pure silicon, Quantitative relationship of electrical conduction in intrinsic elemental semiconductors, Effect of temperature on intrinsic semiconductors. N - type and P - type semiconductors, Doping. Mass action law, Charge densities in intrinsic semiconductors. Electronic & Ionic conduction, Ceramic conductors like varistors, thermistors, resistors etc.	10
5	Optical Properties: Introduction. Light & electromagnetic spectrum, Electromagnetic waves in ceramics, Refractive index, Dispersion, Reflection and refraction. Transmission & reflection of light. Luminescence: Photo & Cathodes. Lasing action.	10
6	Magnetic Properties : Diamagnetism , Paramagnetism , Pauli paramagnetism , Ferromagnetism , Antiferromagnetism & Ferri magnetism - Ferrites .Soft & Hard magnetic materials- Ferrites, Mixed ferrites, Origin of interactions in ferro - and antiferro-and antiferri - magnetic materials. super and double exchange interactions.	10

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
19	26	13	11	11	20

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Recommended Books:

1. Ceramic Materials : Science & Engineering ,C. Barry Carter & M. Grant Norton, Springer New York, 2nd Ed, 2013
2. Introduction to Ceramics, Kingery W.D, Wiley New York :, 2nd Ed, 1976
3. Material Science ,Smith, Mcgraw Hill Higher Education, 4th Ed,2005

(Established under Gujarat Private Universities Act, 2009)

Bachelor of Engineering
Subject Code: CT2406
Subject Name: Physical Ceramics

List of Practical:

1. Powder Preparation -- Crushing fireclay grog. Size separation of grog.
2. Characterisation of different clays -- Ball clay, Plastic clay etc.
3. Determine grain B.D., Grain porosity, Grain Sp. Gr., Tap density of ceramic materials
4. Body preparation with Temporary binders (Dextrin, Starch etc.) and Ceramic binders.
5. Study of effect of Composition, Forming pressure & Firing temperature on some properties of refractory bricks.
6. Testing of various important properties of refractories as per IS
7. Refractory corrosion test
8. Fabrication of some high alumina & basic bricks

Course Outcomes:

After learning this course, students will be able to:

CO No.	CO statement
CO-1	To express their technical knowledge over fundamentals of the subject
CO-2	To understand the difference in raw materials of different kinds of ceramic materials and products
CO-3	To be able to utilize the knowledge of raw materials in correlating other highly technical subjects in the Glass & Ceramic Technology course curriculum
CO-4	To be able to apply this knowledge in their higher study, research work with related technical subjects.
CO-5	To build a bridge between theoretical and practical concept used in industry.
CO-6	To utilize the subject knowledge in solving industry oriented problems in the form of consultancy projects, industry defined projects.

List of Open-Source Software/learning website:

Reference to NPTEL lectures can be made for a better understanding regarding fluid flow under different conditions.

(Established under Gujarat Private Universities Act, 2009)

Bachelor of Engineering

Subject Code: CT2407

Subject Name: Pharmaceutical Drug Delivery and Biotechnology

Shroff S.R. Rotary Institute of Chemical Technology

Semester: - VII

Type of course: Professional Elective Course

Prerequisite: Needs of basic knowledge of pharmaceuticals and biotechnology

Rationale:

The main objective of this subject is to study various Drug delivery methods and familiarize students with areas of biotechnology and their application towards fermentation technology and genetic engineering principles

Teaching and Examination Scheme:

Teaching Scheme			Credits C	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	0	3	70	30	00	00	100

Content:

Sr. No.	Content	Total Hrs.
SECTION-A		
1	Oral Sustained-release and Controlled-release Formulations <ul style="list-style-type: none"> Principles and dose calculations Preformulation Formulation of matrix and reservoir type systems Liquid oral sustained release formulations Quality Control , large scale manufacture and layout design of oral sustained release formulations	10
2	Novel Drug Delivery Systems <ul style="list-style-type: none"> Introduction to Transdermal and Transmucosal (buccal, sublingual, nasal, vaginal, rectal) drug delivery systems 	5
3	Overview of Cosmetic products. <ul style="list-style-type: none"> Definition of cosmetics; historical background, classification of cosmetics and primary functions Brief overview of types of cosmetics [Skin care, haircare, nail care, eye care, dental products] Formulation Large scale manufacture and packaging with focus on equipment 	10

(Established under Gujarat Private Universities Act, 2009)

Bachelor of Engineering

Subject Code: CT2407

Subject Name: Pharmaceutical Drug Delivery and Biotechnology

SECTION-B		
4	Introduction to Pharmaceutical Biotechnology and its role in healthcare and diagnostics. Applications of biotechnology in food. Pharma and other industries with specific reference to enzymes	5
5	Fermentation Technology: <ul style="list-style-type: none"> • Introduction to fermentation Types of fermentation, microorganisms in fermentation, strain improvement, Fermenters and types; Stages of fermentation; typical fermentation types – batch, continuous, fed-batch; factors affecting fermentation, <ul style="list-style-type: none"> • Typical fermenter designs and explanation of design characteristics. Examples of industrial products • Enzyme Fermentation and Immobilization 	10
6	<ul style="list-style-type: none"> • Genetic Engineering principles & techniques and its applications in medicines, cloning and other fields 	5

Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
40	25	15	10	5	5

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Reference Books:

1. Pharmaceutical Dosage Forms and Drug Delivery Systems, Ansel, Philadelphia Fea & Febiger, 1985
2. Remington's Pharmaceutical Sciences, A. R. Gennaro Mac Pub. Co. Easton, Pennsylvania (1990)
3. The Theory & Practice of Industrial Pharmacy. L. Lachman, Herbert A. Lieberman & J. Kanig, Lea & Febiger, Philadelphia (1987)
4. Drug Delivery Device : Fundamentals & Applications, Tyle, New York, Marcel Dekker 1988
5. Pharmaceutical production Facilities Design & Application, G.C.Cole New York Ellis Horwood 1990
6. Indian Pharmacopoeia, British Pharmacopoeia, United States Pharmacopoeia.
7. Principles of fermentation technology, Stanbury P. F. and Whitaker A.
8. Basic bioreactor design, Riet K. V. and Tramper J.23. Elements of biotechnology, Gupta P.K. Industrial fermentations: Underkofler L. A. and Hickey R. J. Vol. I and II
9. Industrial fermentations; Paul W. Allen.

(Established under Gujarat Private Universities Act, 2009)

Bachelor of Engineering

Subject Code: CT2407

Subject Name: Pharmaceutical Drug Delivery and Biotechnology

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	To describe the preformulation & formulation methods of various drug delivery system, cosmetic products, biotechnology, fermentation technology and genetic engineering.	15
CO-2	To illustrate various drug delivery systems and cosmetics formulations, fermentation process, genetic engineering principles.	15
CO-3	To demonstrate the applications of new drug delivery systems, fermentation process, DNA technology,	20
CO-4	To analyse the new drug delivery methods, formulation of cosmetics, fermentation process and cloning methods.	15
CO-5	To explain the advantages & disadvantages manufacturing facilities of drug delivery systems, cosmetic products, enzyme fermentation, fermentation techniques and genetic engineering principles	15
CO-6	To evaluate the novel drug delivery system, Genetic engineering applications.	20

List of Open Source Software/learning website:

- Literature available on internet
- www.iri.net.in
- www.ipiindia.org
- Delnet

(Established under Gujarat Private Universities Act, 2009)

Bachelor of Engineering

Subject Code: CT2408

Subject Name: Industrial Applications of Pigments

Shroff S.R. Rotary Institute of Chemical Technology

Semester: - VII

Type of course: Professional Elective Course

Prerequisite: Basic Knowledge of Pigments is required.

Rationale: The main objective of this subject is to study the applications of Pigments.

Teaching and Examination Scheme:

Teaching Scheme			Credits C	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	0	3	70	30	00	00	100

Content:

Sr. No.	Content	Total Hrs.
SECTION-A		
1	Optical properties of pigments, crystalline modifications and other basic properties of pigments like Distinctness of Image, Flop effect etc.	08
2	Pigment finishing and standardization. Newer Technologies of pigment processing. Latent Pigment Technology, Pigment Flush.	08
3	Green Pigments: Introduction, Sources, examples, properties and application of Green Pigments	08
SECTION-B		
4	Pigments in organo electronics and other modern applications. Pigments in solar panels, Pigments for printing inks, and other applications.	10
5	Applications for Pigments: Paints, Oxidative Dried Coatings, Baked Enamels, Aqueous Dispersions of Synthetic Resins, and Pigments for Plastics	12
6	Other Areas of Application: Wood coloration, paper mass coloration and paper surface coating, cosmetics, textiles etc.	06

Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
20	30	30	10	10	-

(Established under Gujarat Private Universities Act, 2009)

Bachelor of Engineering

Subject Code: CT2408

Subject Name: Industrial Applications of Pigments

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Reference Books:

Industrial Organic Pigments, W. Herbst, K. Hunger, Third Edition, 2004

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	To get the introductory knowledge of optical properties of pigments	15
CO-2	To get the knowledge of latest technology for pigment processing	15
CO-3	To get the introductory knowledge of green pigments	20
CO-4	To get the knowledge of various industrial applications of pigments	15
CO-5	To get the knowledge of applications of pigments in paint and allied industries	15
CO-6	To get the knowledge of applications of pigments in other areas	20

List of Open Source Software/learning website:

- Literature available on internet
- Dyes dictionaries
- Delnet
- Literature available under R&D in Pigments & Paints industries
- Dyes & Pigments, Pigments & Resin & Paint India journals

(Established under Gujarat Private Universities Act, 2009)

Bachelor of Engineering
Subject Code: CT2409
Subject Name: Polymer and Rubber Characterization

Shroff S.R. Rotary Institute of Chemical Technology

Semester: - VII

Type of course: Professional Elective Course

Prerequisite: Student should know the basics of polymeric materials.

Rationale: The main objective of this subject is to provide the knowledge about the different types of characterization techniques of polymer and rubber materials.

Teaching and Examination Scheme:

Teaching Scheme			Credits C	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	0	3	70	30	00	00	100

Content:

Sr. No.	Content	Total Hrs.
SECTION-A		
1	Structures of various Polymers & Rubbers.	08
2	General Structural Features of Polymers Chemical & Physical structure, Thermal behavior, Glass Transition Temperature, Chain Flexibility, Crystallinity, Spherulites, Degradation & similar effects	10
3	Processing Parameters- The influence of processing parameters on the structure & properties of polymers & rubbers.	12
SECTION-B		
4	Molecular Weight Determination- Study of the respective principles, theories & application by the following techniques : Gradient elution technique, Gel permeation chromatography, Vapour pressure Osmometry, Cryoscopy & ebullioscopy	10
5	Product Design- Importance of additives in product design	10
6	Microscopy- Testing of flexible films for food applications, Permeability, Adhesion test, Peel test, shear test, Microscopy: Scanning electron microscopy (SEM), Transmission electron microscopy (TEM), Identification of polymers using chemical methods.	12

Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
40	25	15	10	5	5

(Established under Gujarat Private Universities Act, 2009)

Bachelor of Engineering

Subject Code: CT2409

Subject Name: Polymer and Rubber Characterization

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Reference Books:

1. Polymer Structure, Properties & application, R.D. Deanin, American Chemical Society, 1974.
2. Relating Materials Properties to structure, D. J. David, Technical Publishing Company Inc., 1999.
3. Polymer Science and Technology: Plastics, Rubbers, Blends and Composites, 3rd Edition by Dr Premamoy Ghosh.
4. Rubber Technology, Maurice Morton, Springer, 1st Ed, 1987
5. The Science and Technology of Rubber, Mark and Erman, Academic Press, 3rd Ed, 2005.
6. Rubber Processing, Robert Johnson, Hanser Publications, 2001
7. Rubber Compounding: Chemistry and Applications, Brendan Rodgers, CRC, 1st Ed, 2004.

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	To be able to identify the different structures of Polymers and Rubber.	15
CO-2	Students can evaluate various temperature values for Polymer and Rubber.	15
CO-3	To be able to analyse the various processing parameters.	20
CO-4	To be able to apply fundamental knowledge for the determination of molecular weight.	15
CO-5	To be able to understand the importance of additives in industries.	15
CO-6	To be able to test the various polymers and rubbers with the help of testing methods.	20

List of Open Source Software/learning website:

- Literature available on internet
- www.iri.net.in
- www.ipiindia.org
- Delnet

(Established under Gujarat Private Universities Act, 2009)

Bachelor of Engineering

Subject Code: CT2410

Subject Name: Advanced Ceramics

Shroff S.R. Rotary Institute of Chemical Technology

Semester: - VII

Type of course: Professional Elective Course

Prerequisite: The students should have a clear concept on fundamentals of ceramics, geology and materials sciences that will help them to have an easy grasp of the subject.

Rationale: The main objective of this subject is to offer an overview over the fundamentals and basics of glass and ceramic materials, the raw feed materials for batch preparation, their availability, their properties, their beneficiation processes, process of recovery and their application.

Teaching and Examination Scheme:

Teaching Scheme			Credits C	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	0	3	70	30	0	0	100

Content:

Sr. No.	Content	Total Hrs.
SECTION-A		
1	Engineering Ceramics: Boron carbide, Silicon carbide, Titanium carbide, Zirconium carbide, Hafnium carbide & Uranium carbide. Boron, Silicon & Aluminium nitrides. Molybdenum disilicide. Borides. SIALON. Graphites. Cermets & Composites.	10
2	Ceramics used in Advanced Applications: Nuclear energy, Magneto-hydrodynamic generation, Gas turbine blades, Abrasives, Aerospace, Diesel engines, Heat Exchangers, Cutting Tools, Wear Applications	10
3	Ceramics for Medical and Scientific products: Tissue attachment mechanism, Bio- active materials, nearly inert crystalline ceramics, porous ceramics, bioactive glass and glass ceramics, calcium phosphate ceramics, carbon base implant materials, ceramics for dental application	10
SECTION-B		

(Established under Gujarat Private Universities Act, 2009)

Bachelor of Engineering

Subject Code: CT2410

Subject Name: Advanced Ceramics

4	Ceramics for Optical Applications: CRT and TV picture tubes, Telecommunication and related uses, Information display, Laser, O-LED, LCD, Fiber optics, Electromagnetic windows.	10
5	Ceramics in Electrochemical Cells: Sodium sulphate cell (with β – alumina), Electrical ceramics for fuel cell and high energy batteries.	10
6	Effect of temperature on intrinsic semiconductors, N - type and P - type semiconductors, Doping. Mass action law, Charge densities in intrinsic semiconductors. Electronic & Ionic conduction, Ceramic conductors like varistors, thermistors, resistors etc. Piezoelectricity, Ferroelectricity.	10

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
19	26	13	11	11	20

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Recommended Books:

1. Introduction to Ceramics, Kingery W.D, Wiley New York, 2nd Ed, 1976
2. Material Science ,Smith F.H., Mcgraw Hill Higher Education, 4th Ed, 2005
3. Industrial ceramics ,Singer & Singer, Oxford & Ibh (From Technip), 1st Ed., 2008

Course Outcomes:

After learning this course, students will be able to:

CO No.	CO statement
CO-1	To express their technical knowledge over fundamentals of the subject
CO-2	To understand the difference in raw materials of different kinds of ceramic materials and products
CO-3	To be able to utilize the knowledge of raw materials in correlating other highly technical subjects in the Glass & Ceramic Technology course curriculum
CO-4	To be able to apply this knowledge in their higher study, research work with related technical subjects.
CO-5	To build a bridge between theoretical and practical concept used in industry.
CO-6	To utilize the subject knowledge in solving industry oriented problems in the form of consultancy projects, industry defined projects.



UPL UNIVERSITY
OF
SUSTAINABLE TECHNOLOGY



(Established under Gujarat Private Universities Act, 2009)

Bachelor of Engineering
Subject Code: CT2410
Subject Name: Advanced Ceramics

List of Open-Source Software/learning website:

1. NPTEL
2. MIT Open course lecture available on Internet etc.
3. Delnet

(Established under Gujarat Private Universities Act, 2009)

Bachelor of Engineering
Subject Code: CT2411
Subject Name: Renewable Energy Sources

Shroff S.R. Rotary Institute of Chemical Technology

Semester: VII

Type of course: Open Elective Course

Prerequisite: None

Rationale: To provide an idea of the challenges in the field of energy management and to provide a perspective on energy technology. Students will learn the systems dimensions of the energy problems and its historical perspective on energy technology and system development. For different types of energy sources utilization in industries, the procedure of power generation, transportation along with conventional and advanced application in different sectors should be known by the student.

Teaching and Examination Scheme:

Teaching Scheme			Credits C	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	0	3	70	30	00	00	100

Content:

Sr. No.	Content	Total Hrs.
SECTION-A		
1	Introduction to Renewable Energy Sources: Energy sources (conventional & non-conventional), primary & secondary energy sources, Renewable energy sources, classification and their prospects, Energy consumption, world energy future, energy needs for growing economy, energy sector reforms, energy conservation and its importance	06
2	Solar Energy: Solar radiation and related terms, measurement of solar radiation, solar energy collectors flat plate collector, air collector, concentrating collectors, application and advantages of various collectors, solar energy storage system (thermal, chemical, mechanical), solar pond, application of solar energy.	10
3	Wind Energy: Basic principles, power content in wind and utilization, force on blades and turbines, wind energy conversion system, site selection, basic components of wind energy conservation system (WECS), classification of WECS, wind energy collectors, applications of wind energy.	07

(Established under Gujarat Private Universities Act, 2009)

Bachelor of Engineering
Subject Code: CT2411
Subject Name: Renewable Energy Sources

SECTION-B		
4	Geothermal and Ocean Energy: Geothermal field and resources, hydrothermal resources, liquid dominated systems, applications of geothermal energy, Principle, OTEC, energy from tides, components of tidal power plants, operation, methods of utilization of tidal energy, storage	06
5	Biomass Energy: Introduction, biomass conversion technology, photosynthesis, biogas generation, factors affecting biogas generation, classification of biogas plants and their comparison, types of biogas plant, biogas from plant wastes, community plants and site selection, digester design consideration, design calculations, methods of maintaining and starting of biogas plant, properties and utilization of biogas	10
6	Fuel Cells and Hydrogen Energy: Introduction, hydrogen- oxygen fuel cell, ion exchange membrane cell, fossil fuel cell, molten carbonate cell. Advantages and disadvantages, conversion efficiency, type of electrodes, application of fuel cell, hydrogen storage, production and transportation, utilization of hydrogen gas, hydrogen as alternative fuel for vehicles.	06

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
40	25	15	10	10	-

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Recommended Books:

1. Non-Conventional Energy Sources, Rai .G. D., Khanna Publishers.
2. Energy Resources: Utilization and Technologies, Anjaneyulu Y, Francis T., BS Publication.
3. Non-Conventional Energy Sources, Khan B. H., Tata McGraw Hill.
4. Renewable Energy Resource: Basic Principles and Applications, Tiwari G. N, Ghosal M. K., Narosa Publishing House.
5. Solar Energy: Principles of Thermal Collections and Storage, S. P. Sukhatame and J. K. Nayak, Tata McGraw Hill, New Delhi
6. Energy Technology by Rao & Parulaker, Khanna Publishers.

(Established under Gujarat Private Universities Act, 2009)

Bachelor of Engineering
Subject Code: CT2411
Subject Name: Renewable Energy Sources

Course Outcomes:

After learning this course, students will be able to:

CO No.	CO statement
CO-1	To identify the present energy scenario and the need for energy conservation for future.
CO-2	To appreciate various methodologies of tapping energy from solar energy sources.
CO-3	To understand the design and applications of power generating devices using wind energy.
CO-4	To adopt the various aspects of geothermal and ocean energy with its utilization.
CO-5	To devise application strategies by converting non-conventional energy sources into usable form.
CO-6	To explore non-renewable energy resources and effective technologies.

List of Open-Source Software/learning website:

Reference to NPTEL lectures can be made for a better understanding regarding Renewable Energy under different conditions.

(Established under Gujarat Private Universities Act, 2009)

Bachelor of Engineering

Subject Code: CT2413

Subject Name: Process Modelling and Simulation

Shroff S.R. Rotary Institute of Chemical Technology

Semester: VIII

Type of course: Professional Core Courses

Prerequisite: Basics knowledge of unit operations, fundamental of process engineering, engineering mathematics and numerical computations.

Rationale: The Process Modelling and Simulation of chemical engineering processes is a subject of major importance for the knowledge of transport processes; improved design process and its kinetics. Modelling and simulation emphasize on the concept of modelling of chemical engineering processes, parameter estimations, decomposition of networks, application of numerical methods, data regression, convergence promotion, specific-purpose simulation, dynamic simulation, etc.

Teaching and Examination Scheme:

Teaching Scheme			Credits C	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	5	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs.
SECTION-A		
1	Introduction: Definition of Modelling and Simulation, importance of modelling for simulation, comparison of design and simulation, scope and applications of modelling and simulation.	03
2	Modelling Aspects: Definition of model, process model, deterministic and stochastic process, physical and mathematical modelling, classification of models, process to build a model, degrees of freedom analysis for model, empirical model, selecting functions to fit empirical data, Black-box model	06
3	Mathematical Modelling of Chemical Engineering Systems: Introduction, uses of mathematical models, characteristics of mathematical models, scope of coverage, principles of formulation, fundamental laws, continuity equations, energy equations, equation of motion, transport equation, equation of state, equilibrium, kinetics, formulation of dynamic models with various case studies based on mass,	10

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Bachelor of Engineering

Subject Code: CT2413

Subject Name: Process Modelling and Simulation

	component, momentum and energy balances, Fluid flow, heat transfer, mass transfer and reaction engineering phenomena.	
SECTION-B		
4	Examples of Mathematical Models of Chemical Engineering systems: flow tank, mixing tank, two heated tanks, PFR, CSTR, series of isothermal constant hold up CSTR, CSTR with variable holds up, gas-phase pressurized CSTR, non-isothermal CSTR, single-component vaporizer, batch reactor, reactor with mass transfer, ideal binary distillation column, batch distillation with holdup, Solvent Extraction, gas adsorption	10
5	Simulation: Role of simulation in chemical engineering, partitioning and tearing, sequential and modular approaches to process simulation, analytical and numerical methods for solving model equations, accuracy and error analysis, introduction to role of computation in simulation.	08
6	Chemical Process Plant Simulation : Steady state vs dynamic simulation, lumped system-partitioning equation, tearing equation, simultaneous equation, decomposition of networks, reachability matrix, selection of property perturbation method for simulation, Introduction to Various Professional Simulators and Equation Solver Software	08

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
05	10	25	15	10	05

Suggested Specification table with Marks (Theory):

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Recommended Books:

1. B Wayne Bequette, Process Dynamics: Modeling, Analysis and Simulation, Prentice Hall International Inc.
2. B V Babu, Process Plant Simulations, Gulf Publications.
3. William L. Luyben, Process Modeling, Simulation and Control for Chemical Engineers, McGraw Hill International Editions.
4. R Turton, R C Bailie, W B Whiting and J A Shaeiwitz, Analysis, Synthesis and Design of Chemical Processes, Prentice Hall International In.
5. W D Seider, J D Seader and D R Lewin, Product and Process Design Principles-Synthesis, Analysis, and Evaluation, 2nd ed., John Wiley and Sons Inc.
6. W. F. Ramirez, Computational Methods for Process Simulation, Second Edition, Butterworth Heinemann.

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Bachelor of Engineering

Subject Code: CT2413

Subject Name: Process Modelling and Simulation

List of Practical:

1. Familiarization to tools used for laboratory like Excel Spreadsheet, DWSIM
2. Solve Linear Programming problems in Excel Spreadsheet using solver
3. Estimate kinetic parameters of the reaction using batch reactor data
4. Plot ideal and non-ideal vapour liquid equilibrium (VLE) plots computing data using (i) ideal mixture assumption and (ii) using Van-Laar activity coefficient model
5. Determine composition of vapour and liquid streams in a flash distillation still using VLE data
6. Simulate continuous binary distillation column developing material and enthalpy balance in the column. Compute ideal number of plates using optimal reflux ratio.
7. Simulate multicomponent distillation with reboiler and condenser.
8. Develop material and energy balance for adiabatic combustion of methane and simulate the effect of excess air on performance of combustion.
9. Develop simulation of shell and tube heat exchange and evaluate Rating / Design.
10. Develop design and optimization of single and multiple effect evaporator
11. Develop simulation of fed batch reactor to evaluate effect of initial volume and feed recipe on productivity and yield

Course Outcomes:

After learning this course, students will be able to:

CO No.	CO statement
CO-1	Understand and State the fundamentals of general approach on the modeling of chemical systems.
CO-2	To understand computational techniques to solve the process models.
CO-3	To apply process models based on conservation principles and process data.
CO-4	Develop process flow sheet and understand to perform simulation by using software.
CO-5	Apply mathematical principles and techniques to solve the models for simulation.
CO-6	Analyse the technical feasibility of Industrial scale chemical manufacturing facility and Evaluate performance.

List of Open-Source Software/learning website:

Students can refer to video lectures available on the websites including NPTEL lecture series.

Student can use DWSIM, COCO, ChemSep open source software for simulation study.

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Bachelor of Engineering

Subject Code: CT2414

Subject Name: Validation and Regulatory Requirements

Shroff S.R. Rotary Institute of Chemical Technology

Semester: - VIII

Type of course: Professional Elective Course

Prerequisite: Student should know the basics of regulatory requirements.

Rationale: The course is designed to train the students in understanding the principles behind Good Manufacturing Practices (GMP), scientific and risk-based product development approaches, and validation and regulatory requirements for Pharmaceuticals.

Teaching and Examination Scheme:

Teaching Scheme			Credits C	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	0	3	70	30	00	00	100

Content:

Sr. No.	Content	Total Hrs.
SECTION-A		
1	Good Manufacturing Practices (GMP) and Facility Design <ul style="list-style-type: none"> • GMP: Personnel, Facility, Environmental and manufacturing factors • Quality assurance • Quality audits 	10
2	Validation: <ul style="list-style-type: none"> • Introduction to validation, process validation and scope • Priority order for pharmaceutical validation • Types of validation (prospective, retrospective. concurrent and revalidation) • Steps in validation • Case studies (solid, liquid, semisolid dosage forms) 	10
3	Case Studies on validation of Processes, Equipment's and Products	5
SECTION-B		
4	Regulatory Procedures for Pharmaceutical Product Market Approval as per USFDA Guidelines: Investigational New Drug (IND), New Drug Application	10

(Established under Gujarat Private Universities Act, 2009)

Bachelor of Engineering

Subject Code: CT2414

Subject Name: Validation and Regulatory Requirements

	(NDA) [505(b)(1) and (b)(2)], Abbreviated New Drug Application (ANDA) 505 (j) filing, Review and Approval process	
5	Legal Acts <ul style="list-style-type: none"> • Drugs and Cosmetics Act, 1940 and Drugs and Cosmetics Rules, 1945 • Drug Price Control Order (DPCO) 	5
6	Introduction to Regulatory Aspects of Pharmaceuticals <ul style="list-style-type: none"> • Introduction to regulatory aspects of pharmaceuticals, need, advantages and limitations • Introduction to major regulatory bodies worldwide • Rationale for regulatory harmonization and introduction of ICH • Introduction to Common Technical Document (CTD) Modules • Comparison of Indian and European guidelines w.r.t. USFDA guidelines 	10

Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
40	25	15	10	5	5

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Reference Books:

1. Beotra's Law of Drugs Medicines and Cosmetics K. K. Singh, L. R. Bugga for the Law Book Co. Pvt. Ltd., Allahabad
2. Modern Pharmaceutics, G. S. Banker, New York, Marcel Dekker (1990)
3. Fundamentals of Pharmacy, Blome H. E., Philadelphia, Fea and Febiger (1985)
4. Pharmaceutical Production Facilities: Design and Applications, G. C. Cole, New York, Ellis, Horwood (1990)
5. Microbial Quality Assurance in Pharmaceuticals Cosmetics and Toiletries, S. F. Bloomfield, Chichester, Ellis, Horwood (1998)
6. Pharmaceutical Product Development: Insights into Pharmaceutical Processes, Management and Regulatory Affairs, Patravale V, Rustomjee M, Dsouza J., CRC Press (2016)
7. Latest Editions of Indian Pharmacopoeia (IP), British Pharmacopoeia (BP), United States Pharmacopoeia (USP), Japanese Pharmacopoeia (JP), European Pharmacopoeia (Ph. Eur.)
8. Good Laboratory Practice Regulations, Weinberg, New York, Marcel Dekker (1995)

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Bachelor of Engineering

Subject Code: CT2414

Subject Name: Validation and Regulatory Requirements

9. Law of Drugs Medicines & Cosmetics, K.K. Singh , L.R. Bugga Beotra's ,Law Book co. Pvt. Ltd., Allahabad.
10. Pharmaceutical production Facilities Design & Application ,G.C.Cole New York Ellis Horwood 1990

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	To describe the GMP, Validation, Regulatory and DPCO requirements for pharma industry	15
CO-2	To analyze regulatory, validation and DPCO concepts	15
CO-3	To comprehend product and process validation and documentation required for the same	20
CO-4	To apply the regulatory pathways for new drug application and generic product development for various products	15
CO-5	To explain relevant regulations and laws governing the pharmaceutical manufacturing	15
CO-6	To evaluate the case studies on validation of processes, equipments and products	20

List of Open Source Software/learning website:

- Literature available on internet
- www.iri.net.in
- www.ipiindia.org
- Delnet

(Established under Gujarat Private Universities Act, 2009)

Bachelor of Engineering

Subject Code: CT2415

Subject Name: Nanotechnology in Colorant Industry

Shroff S.R. Rotary Institute of Chemical Technology

Semester: - VIII

Type of course: Professional Elective Course

Prerequisite: Basic Knowledge of Dyes & Pigment is required.

Rationale:

The main objective of this subject is to provide in the basic knowledge of nanotechnology and its applications in various colorant industries. To understand various nanotechnology advantages. To learn about synthesis methodology and incorporation of various nanoparticles in performance enhancement.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	0	3	70	30	00	00	100

Content:

Sr. No.	Content	Total Hrs.
SECTION-A		
1	Introduction to Nanotechnology: Nanomaterial & Manufacturing, Renewable energy generation, Nanotechnology in drug delivery, Nanotechnology in cosmetics, Bio-nanotechnology, Nanotechnology & information technology, Nanotechnology in agriculture and food industry, Environmental nanotechnology, Nanotechnology Health risk.	08
2	Synthesis methods of nanostructures: Top-Down and Bottom-up approach of synthesis, Chemical Routes for Synthesis of Nanomaterials: Chemical precipitation and co-precipitation; Sol-gel synthesis; Micro emulsions or reverse micelles; Solvo thermal synthesis.	10
3	Nanostructures and its applications: Carbon Nanotubes (CNT), Graphenes, Fullerenes, Nano Peapods, Quantum Dots and Semiconductor Nanoparticles Metal-based Nanostructures (Iron Oxide, Silver, Copper Nanoparticles) Nanowires Polymer-based Nanostructures including dendrimers, Nano fillers like clay, CaCO ₃ , CaSO ₄ .	10
SECTION-B		
4	Nano pigments: properties, examples, changes in characteristics of nanocomposite coating through nano sized additions,	08
5	Characterization techniques in analyzing Nanomaterials: Scanning/transmission electron microscopy (SEM/ TEM), XRD, Atomic Force Microscopy, Particle size analyzer (PSA) and their applications.	08
6	Risk of nanotechnology: Health Hazards associated with Nanomaterials, Negative consequences for	08

(Established under Gujarat Private Universities Act, 2009)

Bachelor of Engineering

Subject Code: CT2415

Subject Name: Nanotechnology in Colorant Industry

health and the environmental measures	
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Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
20	30	30	10	10	-

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Reference Books:

1. Makhlof, Abdel Salam Hamdy, "Handbook of Smart Coatings for Materials Protection" Elsevier, 2014.
2. Ghosh, Swapan Kumar, "Functional Coatings: by Polymer Microencapsulation" John Wiley & Sons, 2006.
3. Baghdachi, Jamil, Heidi Perez, and Amit Shah. "Design and Development of Self-healing Polymers and Coatings." Smart Coatings III. American Chemical Society, 2010.
4. Saji, Viswanathan S., and R. M. Cook, "Corrosion Protection and Control using Nanomaterials" Elsevier, 2012.

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	To get the knowledge of Nano technology	20
CO-2	To get the knowledge of synthesis methodologies of various nanoparticles.	20
CO-3	To get the awareness of recent developments and future challenges in relation to specialized formulation using nanoparticles	20
CO-4	To study different Nano pigments with their industrial applications	20
CO-5	To study various instrumental techniques for Nano particles analysis	10
CO-6	To get the knowledge of impact assessment of nanoparticles on health and environment and safety measures to prevent them.	10

List of Open Source Software/learning website:

- Literature available on internet
- Nano material dictionaries
- Delnet
- Literature available under R&D in Pigments & Paints industries
- Dyes & Pigments, Pigments & Resin & Paint India journals

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Bachelor of Engineering
Subject Code: CT2416
Subject Name: Recycling of Polymer & Rubber

Shroff S.R. Rotary Institute of Chemical Technology

Semester: - VIII

Type of course: Professional Elective Course

Prerequisite: Student should know the basics of polymeric structures its properties.

Rationale: The main objective of this subject is to provide the knowledge about the different types of characterization techniques of polymer and rubber materials.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	0	3	70	30	00	00	100

Content:

Sr. No.	Content	Total Hrs.
SECTION-A		
1	Introduction of Plastics Waste- Sources of plastics waste, Plastic identification and Separation techniques, recycling codes.	08
2	Plastics Waste Management- (Reduce, reuse, recycle – mechanical and chemical, recover), recycling classification- - primary - secondary - tertiary - quaternary recycling with examples. Recycling of polyolefin's - PVC, PET, polystyrene, polyamides-nylon-6 and nylon-6, 6, polyurethanes, mechanical process, applications of recycled materials, Handling of E-Waste.	10
3	Recycling of Rubber– comparison of thermoset and thermoplastic composites, reclaiming of rubber – fuel source – pyrolysis, Depolymerisation of scrap rubber, tyre retreading, uses of recycled rubber – asphalt modification, rubber tiles and other uses.	12
SECTION-B		
4	Introduction of Plastic and Rubber Packaging- Plastics performance all wrapped up, Flexible packaging material, Lamination techniques, Printing on films/ laminates.	10
5	Characteristics of Packaging- films such as – Permeability, Heat seal, Printing, Drop impact. Selection Criteria- Flexible packing materials. Product performance requirements for laminates.	10
6	Reclaiming of Rubber – fuel source – pyrolysis, de-polymerization of scrap rubber, tyre retreading, uses of recycled rubber – asphalt modification, rubber tiles and other uses. Sustainable approach in Plastic Recycling- Plastic Waste Recycling, Benefits of Plastic Recycling.	12

(Established under Gujarat Private Universities Act, 2009)

Bachelor of Engineering
Subject Code: CT2416
Subject Name: Recycling of Polymer & Rubber

Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
40	25	15	10	5	5

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Reference Books:

1. Progress in Rubber, Plastics and Recycling Technology
2. Recycling of Rubber By H. J. Manuel, W. Dierke
3. Recycled Polymers: Properties and Applications
4. Introduction to Plastics Recycling, 2nd Edition
5. Plastic Recycling by Sati Manrich, Amelia S.F. Santos

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	To be able to identify the various sources of Polymer wastes.	15
CO-2	To be able to apply this knowledge in Polymer & Rubber industries.	15
CO-3	To get a knowledge of how the material are recycle and how the packaging & what are recent trends in Polymer & Rubber Technology.	20
CO-4	To be able to understand the various polymer packaging testing methods.	15
CO-5	To be able to characterize the various plastic films.	15
CO-6	To be able to check the performance of the materials.	20

List of Open Source Software/learning website:

- Literature available on internet
- www.iri.net.in
- www.ipiindia.org
- Delnet

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Bachelor of Engineering
Subject Code: CT2417
Subject Name: Refractories-II

Shroff S.R. Rotary Institute of Chemical Technology

Semester: VIII

Type of course: Professional Elective Course

Prerequisite: The students should have a clear concept on basic chemistry, geology and Mineralogy that will help them to have an easy grasp of the subject.

Rationale: The main objective of this subject is to offer an overview over the fundamentals and basics of glass and ceramic materials, the raw feed materials for batch preparation, their availability, their properties, their beneficiation processes, process of recovery and their application.

Teaching and Examination Scheme:

Teaching Scheme			Credits C	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	0	4	70	30	0	0	100

Content:

Sr. No.	Content	Total Hrs.
SECTION-A		
1	Introduction of Monolithic Refractories, Shaped and Unshaped Refractories Advantages and Disadvantages, Classification of Unshaped Refractories Aggregates used in monoliths. Refractory cement and other additives, Additives for ramming and gunning materials	10
2	Classification of Castables: Conventional, Low cement, Ultra low cement, No or zero cement, Gel bonded and self flow castables, Silica free and Basic castables. Manufacture of Castables/Monoliths, Installation techniques, Applications. Refractory Cement, Mortars, Concrete, Ramming Mass	10
3	Non Oxide Refractories: Silicon Carbide - Fabrication Properties and applications. Nitride Refractories – Silicon nitride, boron nitride, Fabrication, properties and application Pure oxide Refractories - Alumina, Magnesia, and zirconia based Refractories	10

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Bachelor of Engineering
Subject Code: CT2417
Subject Name: Refractories-II

SECTION-B		
4	Carbon bearing Refractories: Importance of carbon bearing Refractories. Advantages of these Refractories, Properties variation with the amount of carbon in basic Refractories	10
5	Properties of pitch, tar and resin used in brick manufacturing, tempering of these bricks, application of antioxidants, wear mechanism in LD converter.	10
6	Chromite and mullite refractories. Carbon bearing refractories: MgO – C and Al ₂ O ₃ – MgO – C etc. Alumino-silicate Refractories: Significance of Phase diagram in the development of different phases –High alumina refractories	10

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
19	26	13	11	11	20

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Recommended Books:

1. Refractories- Production & Properties, J. H. Chesters, The Iron & Steel Institute, 2nd Ed., 1973
2. The Technology of Ceramics & Refractories, P.P. Budnikov, MIT Press, 2nd Ed., 2003
3. Monolithics Refractories: A Compressive Handbook, Subrata Banerjee, Answer Technology Inc., USA, 3rd Ed., 1998

Course Outcomes:

After learning this course, students will be able to:

CO No.	CO statement
CO-1	To express their technical knowledge over fundamentals of the subject
CO-2	To understand the difference in raw materials of refractories from other ceramic raw materials.
CO-3	To be able to utilize the knowledge of raw materials in correlating other highly technical subjects in the Glass & Ceramic Technology course curriculum
CO-4	To be able to apply this knowledge in their higher study, research work with related technical subjects.

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Bachelor of Engineering
Subject Code: CT2417
Subject Name: Refractories-II

CO-5	To build a bridge between theoretical and practical concept used in industry.
CO-6	To utilize the subject knowledge in solving industry oriented problems in the form of consultancy projects, industry defined projects.

List of Open-Source Software/learning website:

Reference to NPTEL lectures can be made for a better understanding regarding fluid flow under different conditions.

Bachelor of Engineering
Subject Code: CT2418
Subject Name: Process Optimization

Shroff S.R. Rotary Institute of Chemical Technology

Semester: VIII

Type of course: Open Elective Course

Prerequisite: Basic knowledge of differential calculus and basic mathematics.

Rationale: The objective of this subject is to study concepts of optimization in chemical engineering. In design, construction and maintenance of any engineering system, engineers have to take many technological and managerial decisions at several stages. The ultimate goal of all such decisions is either to minimize the effort required or to maximize the desired benefit. In this course, the optimization problem formulation, Linear Programming and Non Linear Programming are briefly introduced.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	0	3	70	30	00	00	100

Sr. No	Content	Total Hrs.
SECTION-A		
1.	Introduction to optimization: Historical development, Engineering applications of optimization, Statement of an optimization problem: Design vector, Design constraint, Constraint surface, Objective function, Obstacles in optimization.	6
2.	Developing Models for Optimization: Classification of Models, how to Build a Model, Selecting Functions to Fit Empirical Data, Factorial Experimental Designs, Degrees of Freedom, Examples of Inequality and Equality Constraints in Models, Basic formulation of objective function.	6
3.	Basic concept of optimization: Continuity of function, NLP problem statement, convexity and its applications, interpretation of the objective function in terms of its quadratic approximation, Economic Objective Functions.	6
SECTION-B		
4.	Optimization of Unconstrained Functions: One-Dimensional Search: NLP Problem, Convexity, Necessary and Sufficient Conditions, Scanning and Bracketing Procedures, Newton and Quasi-Newton Methods, Polynomial Approximation Methods.	6

Bachelor of Engineering
Subject Code: CT2418
Subject Name: Process Optimization

Shroff S.R. Rotary Institute of Chemical Technology

5.	Linear Programming (LP): Geometry of Linear Programs, Simplex Algorithm, Sensitivity Analysis, Linear Mixed Integer Programs, LP Software.	8
6.	Mixed Integer Programming: Branch-and-Bound Methods Using LP Relaxations, Solving MINLP Problems Using Branch-and-Bound Method, Solving MINLPs Using Outer Approximation. Applications of Optimization: Optimal Pipe Diameter, Plant wide Management and Optimization.	8

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	20	20	20	20	10

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Textbooks:

1. Singiresu S. Rao, Engineering Optimization: Theory and Practice, 3rd Edition, New Age International Publishers, 2013.
2. Thomas F. Edgar, David Mautner Himmelblau, Leon S. Lasdon, Optimization of Chemical Processes, 2nd Edition, McGraw Hill, 2001.

Reference Books:

1. Dutta Suman, Optimization in Chemical Engineering, 3rd Edition, Cambridge University Press, 2016
2. Edwin K.P. Chong, Stanislaw H. Zak, Introduction to Optimization, 4th Edition, Wiley India, 2017.

Course Outcomes:

After Learning this course, students will be able to:

Sr. No.	CO statement
CO-1	Comprehend the techniques and applications of Engineering optimization.
CO-2	Understand characteristics of a general linear programming problem
CO-3	Apply basic concepts of mathematics to formulate an optimization problem
CO-4	Analyze various methods of solving the unconstrained minimization problem
CO-5	Comprehend and appreciate variety of performance measures for various optimization problems.
CO-6	Understand Integer programming problems with its applications.



UPL UNIVERSITY
OF
SUSTAINABLE TECHNOLOGY

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Bachelor of Engineering
Subject Code: CT2418
Subject Name: Process Optimization

Shroff S.R. Rotary Institute of Chemical Technology

List of Open Source Software/learning website:

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

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Bachelor of Engineering

Subject Code: CT2419

Subject Name: Introduction to Sustainable Engineering

Shroff S.R. Rotary Institute of Chemical Technology

Semester: - VIII

Type of course: Open Elective Course

Prerequisite: Basic Knowledge of Sustainability

Rationale: The main objective of this subject is to study the area of sustainability and concepts of sustainability engineering

Teaching and Examination Scheme:

Teaching Scheme			Credits C	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
			ESE (E)	PA (M)	ESE (V)	PA (I)		
3	0	0	3	70	30	00	00	100

Content:

Sr. No.	Content	Total Hrs.
SECTION-A		
1	<p>Sustainable Development and Role of Engineers: Introduction, Why and What is Sustainable Development, THE SDFs, Paris Agreement and Role of Engineering, Sustainable Development and the Engineering Profession, Key attributes of the Graduate Engineering</p> <p>Sustainable Engineering Concepts: Key concepts – Factor 4 and Factor 10: Goals of sustainability, System Thinking, Life Cycle Thinking and Circular Economy</p>	08
2	<p>Sustainable Engineering and Concepts, Principles and Frame Work: Green Economy and Low Carbon Economy, Eco Efficiency, Triple bottom Line, Guiding principles of sustainable engineering, Frameworks for sustainable Engineering.</p> <p>Tools for sustainability Assessment: Environmental Management System, Environmental Auditing, Cleaner Production Assessment, Environmental Impact Assessment, Strategic Environmental Assessment.</p>	08
3	<p>Fundamentals of Life Cycle Assessment: Why and What is LCA, LCA Goal and Scope, Life cycle inventory, Life Cycle Impact Assessment, Interpretation and presentation of Results, Iterative Nature of LCA, Methodological Choices, LCI Databases and</p>	08

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Bachelor of Engineering

Subject Code: CT2419

Subject Name: Introduction to Sustainable Engineering

	LCA Softwares, Strength and Limitations of LCA.	
SECTION-B		
4	Environmental Life Cycle Costing, Social Life Cycle Assessment, and Life Cycle Sustainability Assessment: Introduction, Environmental Life Cycle Costing, Social Life Cycle Assessment, Life Cycle Sustainability, LCA Applications in Engineering: Environmental Product Declarations and Product Category Rules, Carbon and Water Foot Printing, Energy systems, Buildings and the Built Environment, Chemical and Chemical Production Food and Agriculture	08
5	Introduction to Environmental Economics: Introduction – What Is Environmental Economics?, Valuing the Environment, Market-based Incentives (or Economic Instruments) for Sustainability, Command-and-Control versus Economic Instruments, A Simple Model of Pollution Control	05
6	Integrating Sustainability in Engineering Design: Problems Solving in Engineering, conventional to Sustainable Engineering Design Process, Design for Life Guidelines and Strategies, Measuring Sustainability, Sustainable Design through sustainable procurement criteria, Case studies on sustainable Engineering Design Process – Sustainable Process Design, Sustainable Production Design Sustainable product design in Chemical Technology.	08

Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
20	30	30	10	10	-

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Reference Books:

1. Introduction to Sustainability for Engineers, ToolseeramRamjeawon, CRC Press, 1stEdn., 2020
2. Sustainability Engineering: Concepts, Design and Case studies, Prentice Hall, 1stEdn, 2015
3. System Analysis for sustainable Engineering: Theory and applications, Ni bin Chang, McGraw Hill Publications, 1stEdn., 2010
4. Engineering for Sustainable development: Delivery a sustainable development goals, UNESCO, International Centre for Engineering Education, France, 1stEdn., 2021
5. Introduction to Sustainable Engineering, Rag. R.L. and Ramesh Lakshmi Dinachandran, PHI Learning Pvt. Ltd., 2ndEdn, 2016

(Established under Gujarat Private Universities Act, 2009)

Bachelor of Engineering

Subject Code: CT2419

Subject Name: Introduction to Sustainable Engineering

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	Elucidate the basics of sustainable development, sustainable engineering and its role in engineering	15
CO-2	Application of Sustainable Engineering Concepts and Principles in Engineering	15
CO-3	To study the fundamentals of Life Cycle Assessment	15
CO-4	Apply the Principle, and methodology of Life Cycle Assessment Tool to engineering system	20
CO-5	To Introduce to Environmental Economics	15
CO-6	Understand integration methods of sustainability to Engineering Design	20

List of Open Source Software/learning website:

- Literature available on internet
- Dyes dictionaries
- Delnet
- Sustainability journals