Scheme of Instruction and Syllabi
of
Choice Based Credit System (CBCS) of

BE / B.TECH V AND VI SEMESTERS
OF
FOUR YEAR DEGREE COURSE
IN

CHEMICAL ENGINEERING

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY™
(An Autonomous Institution)
Affiliated to OU; All U.G. and 5 P.G. Programmes (Civil, CSE, ECE, Mech. & EEE)
Accredited by NBA; Accredited by NAAC - 'A' Grade (UGC); ISO Certified 9001:2015
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CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY (A)

Choice Based Credit System (with effect from 2018-19)

B.Tech (Chemical Engineering)

SEMESTER -V

S.N	Course Code	Title of the Course	Scheme of Instruction: Periods per week		Scheme of Examination			
			L/T	P/D	Duration in Hours	Maximum Marks: CIE	Maximum Marks: SEE	Credits
THEORY								
1.	16CH C11	Chemical Reaction Engineering - II	4	--	3	30	70	4
2.	16CH C12	Mass Transfer Operations – I	4	--	3	30	70	4
3.	16CH C13	Process Instrumentation	3	--	3	30	70	3
4.	--	Elective-II	3	--	3	30	70	3
5.	--	Elective-III	3	--	3	30	70	3
PRACTICALS								
6.	16CH C14	Mechanical Unit Operations Lab	--	3	3	25	50	2
7.	16CH C15	Process Heat Transfer Laboratory	--	3	3	25	50	2
Elective-II Labs.								
8.	16CH E 06	Surface Coating Technology Lab.	--	3	3	25	50	2
	16CH E07	Technology Of Vegetable Oils And Fats Lab.	--	3	3	25	50	2
Total			**17**	**9**	**--**	**225**	**500**	**23**

L: Lecture, T: Tutorial, D: Drawing, P: Practical

SNO	ELECTIVE-II Course Code	Title of Elective –II Course
1	16CH E 02	Surface Coating Technology
2	16CH E 03	Technology of Vegetable Oils and Fats

SNO	ELECTIVE-III Course Code	Title of Elective –III Course
1	16CH E 04	Corrosion Engineering
2	16CH E 05	Mineral Processing Technology

16CH C 12

CHEMICAL REACTION ENGINEERING - II

Instruction	4L Hours per week
Duration of End Examination	3 Hours
Semester End Examination	70 Marks
CIE	30 Marks
Credits	4

Course Objectives:

1. To understand various models in non-ideal reactors.
2. To understand properties of solid catalysts.
3. Develop rate laws for reactor design based on reaction data from a reactor or set of reactors in heterogeneous systems.
4. To understand concepts of catalysts deactivation.
5. To develop kinetics for solid – fluid and fluid – fluid reactions.

Course Outcomes: On successful completion of this module, students should be able to

1. Predict conversions in non-ideal reactors using various models.
2. Understand phenomena for catalytic activity and determine various properties of catalysts.
3. Describe the steps in a catalytic mechanism, derive a rate law theoretically and the effects of pore diffusion.
4. Derive rate equations and other kinetics parameters of catalytic reactions from experimental data.
5. Analyze performance of catalysts when deactivating.
6. Understand the concepts of fluid-fluid and fluid particle reaction kinetics.

UNIT - I

Analysis of Non ideal Reactors - Basic concepts, Compartment models - hints, suggestions and possible applications. Dispersion number from C and F curves, Conversion using dispersion and tanks in series models for the first order irreversible reaction.

UNIT - II

Solid Catalysts - Adsorption, adsorption isotherms, surface area, void volume and solid density, pore volume distribution. Theories of heterogeneous catalysis, classification of catalysts, catalyst preparation, promoters and inhibitors.(to the extent covered in J.M. Smith only).

UNIT - III

Solid Catalyzed Reactions - Introduction; Development of rate expressions from L- H - H - W models for reaction A + B $\Leftrightarrow$ R + S under adsorption, surface reaction and desorption controlling condition. Pore diffusion resistance combined with surface kinetics (Single cylindrical pore, first order reaction) Porous catalyst particles. Experimental methods for finding rates.

UNIT - IV

Catalyst deactivation- Mechanisms of catalyst deactivation, the rate and performance equations: The rate equation from experiment, determining the rate for batch solid in contact with fluid in batch, mixed flow and plug flow modes for independent deactivation. Effect of pore diffusion resistance.

UNIT - V

Kinetics of fluid - fluid reactions: The rate equation for straight mass transfer of A (absorption). The general rate equation and the rate equation for reaction with mass transfer.

Kinetics of fluid-particle reactions: selection of a model, PCM, SCM, comparison of models with real situations. Shrinking core model for spherical particles of unchanging size: Diffusion through gas film controls, Diffusion through ash layer controls, chemical reaction controls. Rate of reaction for shrinking spherical particles.

Text Books:

1. Octave Levenspiel, Chemical Reaction Engineering, John Wiley & Sons - Third edition, 1999.
2. J M Smith, Chemical Engineering kinetics, McGraw - Hill, Third Edition, 1981.

Suggested Reading:

1. H Scott Fogler, Elements of Chemical reaction Engineering, Prentice - Hall, Fourth edition, 2005.
2. Gavhane, Chemical Reaction Engineering-II, Nirali Prakashan.

16CH C 12

MASS TRANSFER OPERATIONS – I

Instruction	4L Periods per week
Duration of University Examination	3 Hours
University Examination	70 Marks
Sessionals	30 Marks
Credits	4

Course Objectives: This course help the students to understand

1. The rate equations
2. Mass transfer coefficients,
3. Interphase Mass transfer
4. Humidity, Enthalpy of Vapor-gas Mixture(Air- water vapor)
5. Various unit operations viz., absorption, humidification, drying.

Course Outcomes: At the end of the course, the students will be able to

1. Write rate equations for any mass transfer operations.
2. Calculate the mass transfer coefficients using different corelations.
3. Calculate the resistances offered by gas-phase and liquid phase.
4. Design Absorber/Stripper by equilibrium method to find the number of theoretical Stages.
5. Design Cooling towers(able to find the height of packed bed required).
6. To find the total time required in in-direct heating tray dryers.

UNIT - I

Diffusion and Mass Transfer – Mass transfer operations & their applications. Molecular diffusion –Fick's first law – steady state molecular diffusion in binary mixtures of gases, liquids and solids – Determination of diffusivity in gases by Stefan-Maxwell method: estimation of diffusion coefficients in binary mixtures of liquids and gases by correlation.

Eddy diffusion – Basic concepts of mass transfer theories – Film mass transfer coefficients for the cases of equimolar counter diffusion and diffusion of one component (A) in stagnant component (B) - Correlation's for mass transfer coefficients and Reynolds & Colburn analogies.

UNIT - II

Interphase Mass Transfer – overall mass transfer coefficients – Two resistance theory – Gas phase and liquid phase controlled situations. Gas – liquid contact: Description of Continuous and stage wise contact equipment, packing for packed columns – Liquid distribution. Mass transfer coefficients in packed columns, Flooding in packed and plate columns, Ideal stage, Murphree, Point and Overall column efficiency, Comparison of packed and plate columns.

UNIT - III

Absorption and Stripping: counter current and co-current isobaric absorption and stripping of single component – Operating Lines – Minimum flow rates – Determination of number of plates – absorption factor.Determination of number of transfer units and height of a continuous contact packed absorbers. Kremser – Brown equation for tray towers and packed towers.

UNIT - IV

Humidification: Vapour, gas mixtures – Humidity and relative saturation. Dew point adiabatic saturation and wet bulb temperatures – psychrometric charts – Enthalpy of gas vapor mixtures.Humidification and Dehumidification – Operating lines and design for water cooling tower . Equipments of Water- Cooling towers and Spray chambers.

UNIT - V

Drying:Equipments for Drying, moisture contents of solids – equilibrium, bound and unbound moisture.Design conditions – Rate of batch drying under constant drying conditions – Mechanism of batch drying – total time for batch drying.

Text Books:

1. R.E. Treybal, "Mass Transfer operations", 3rd Edition, McGraw Hill Book Co., 1981

Suggested Reading:

1. Christie John Geonkoplis "Transport Processes and Separation Process Principles", 4th edition. PHI, New Delhi., 2009.
2. J Coulson and Richardson,"Fluid Flow, Heat and Mass Transfer", Volume 1, 6th Edition, Pergoman Press, 2009.

16CH C 13

PROCESS INSTRUMENTATION

Instruction	3 hours per week
Duration of End Examination	3 Hours
Semester End Examination	70 Marks
Continuous Internal Evaluation	30 Marks
Credits	3

Course Objectives: This course helps the students to understand the:

1. Fundamental elements of industrial instruments and their characteristics.
2. Different types of temperature measuring instruments and their industrial applications.
3. Different types of pressure measuring instruments.
4. Methods applied for composition analysis in process industries
5. Different types of flowmeters and level measuring devices.

Course Outcomes: At the end of the course, the students will be able to:

1. Identify and select instruments based on their purpose and function as required in process industry.
2. Select temperature measuring instrument based on the range of operation.
3. Select pressure measuring instrument based on their application.
4. Identify and apply different methods of composition analysis in process industry.
5. Select flow measuring instrument based on type of fluids.
6. Select level measuring instrument based on their need in process industry.

Unit I: Importance of industrial instrumentation

Need, significance, applications and classification. Functional units – elements of instruments and their functions as sensors, transducers, transmitters and receivers. Static and dynamic characteristics of instruments.

Unit II: Temperature measurement

Expansion thermometers – types, mercury in glass, bimetallic, pressure spring type, drawbacks for industrial applications. Industrial thermocouples – types and range of operation, lead wires, need of thermowells.

Industrial resistance thermometers – types of sensors, Resistive Temperature Detectors [RTD], Thermistors. Infrared thermometry – pyrometers, radiation receiving elements, radiation pyrometer, optical pyrometer.

Unit III: Pressure measurement

Manometers types – U-tube, well type, enlarged leg, inclined leg, ring balance type. Elastic transducer elements – bourdon, bellow and diaphragm.

Electrical pressure transducers – Linear variable differential transformer (LVDT) and strain gauge. Introduction to standard vacuum gauge – McLeod gauge and Pirani gauge.

Unit IV: Flow and Level measurement

Flowmeters – head type, area type, mass flowmeter, electromagnetic flowmeters. Level measurement – hydrostatic head, float type, RF capacitance, Radar type.

Unit V: Analytical Techniques

Spectroscopic analysis, absorption type – infrared, UV, X-ray and NMR. Emission and Mass spectroscopy.

Analysis of moisture in gases (humidity) by psychrometer, hygrometer, dew point methods. Introduction to chromatography – types, uses, Gas Liquid Chromatography, Thin layer Chromatography.

Text Books:

1. Principles of industrial instrumentation, D. Patranabis, 2nd ed., Tata-McGraw Hill Edu. (India) Pvt.Ltd., New Delhi, 2013.
2. Industrial Instrumentation, Donald P. Eckman., CBS pub & distr. Pvt. Ltd., New Delhi, 2004.

Suggested Reading:

1. Instrumentation operation, measurement, scope and application, N. V. S. Raju, B S Pub., Hyd., 2016.
2. Introduction to measurements and Instruments, Arun K. Ghosh, PHI learning Pvt. Ltd., New Delhi, 2013.

16 CH E 02

SURFACE COATING TECHNOLOGY
(ELECTIVE –II)

Instruction	3 Hours per week
Duration of End Examination	3 Hours
Semester End Examination	70 Marks
CIE	30 Marks
Credits	3

Course Objectives:

1. To give fundamental concepts in paints (including industrial paints and domestic paints)
2. Basic properties, uses of main ingredients like pigments, extenders, binders, solvents.
3. To know more about paint application systems (both air drying paints and stoving paints of liquid paints and power paints).
4. Study of paint formulation including manufacturing of different types of paints and special paints.
5. Study about quality of paints (including paint tests and paint defects).

Course Outcomes:

1. To identify the suitable paints for domestic and Industries.
2. To study more about specific paint manufactures.
3. To know main ingredients of paints,their manufacturers and properties.
4. To come across the usage of different types of solvents for both industrial paints and domestic paints and also about paint solid structures (Resins).
5. To identify the suitable application methods for powder and liquid paints and also to develop paint testing Lab.
6. The student can differentiate between normal paints and special paints and their applications and uses.

UNIT-I

Introduction: Surface coatings- Scope, properties, applications & uses. Major components of surface coatings. Fundamentals of film formation

Classification of Paints: Air drying paints, stoving paints, their properties and uses. Liquid paints & powder paints, their properties & uses.

Manufacture of Paints: Distempers- Manufacture, properties & uses. Powder Paints- Manufacture, properties & uses. Enamel - Manufacture, properties & uses.

UNIT – II

Pigments: Importance of pigments - their basic properties, uses & their applications. Classification of pigments: Inorganic & organic pigments.

Special properties of pigments: Criteria for selection of color, tinting strength, fastness to light, bleeding, hiding power, refractive index, particle size & anti-corrosive properties.
Manufacture of Pigments: Titanium di-oxide, red lead, Ultramarine blue.

UNIT – III
Extenders: Importance, properties & significance.
Manufacture of Extenders: Blanc fixe, China clay, Gypsum, Mica & talc.
Solvents: Importance, uses & their properties,
Manufacture of solvents: Turpentine, Alcohols- Methyl Alcohol, Ethyl Alcohol, n-Propyl Alcohol .
Natural Resins: Rosin & shellac. Synthetic Resins: Alkyd resins, phenolic resins, amino resins.

UNIT – IV
Application methods of paints: Air drying paints, industrial liquid stoving paints & industrial stoving powder paints. Brush application, Roller coating, spray application, electrostatic spray application.
Testing of Paints: Wet paint & dry paint testing film like thickness, adhesion, resistance ,gloss, impact & paint coverage. Defects in paints & paintings & their remedies: defects in grinding skinning, sagging, bleeding, flooring, floating, brushing, orange peel, fish eye, brush marks, lifting.

UNIT – V
Special Coatings: Importance, Significance & their applications.
Powder Coatings, Water soluble coatings, aluminum coatings, water proof coatings, heat resistant coatings, automobile coatings, fire retardant coatings, space, air craft coatings, swimming pool coatings and Anti Micro growth Paints (Marine Paints).

Text Books:

1. W.M. Morgans, "Outline of Paint Technology", Edward Arnold Publishers, London, 1990
2. R. Lambourne& T A Strivens, "Paint & Surface coatings", Second edition, 1999

Suggested Reading:

1. Patton Temple, "C Pigment Flow & Pigment Dispersion", Wiley Inter science, 1979
2. Swaraj Paul, " Surface Coatings science and technology" , 1995

16CH E 03

TECHNOLOGY OF VEGETABLE OILS AND FATS (ELECTIVE –II)

Instruction	3 Hours per week
Duration of End Examination	3 Hours
Semester End Examination	70 Marks
CIE	30 Marks
Credits	3

Course Objectives:

1. To impart knowledge about sources, types and composition of oils and fats
2. To comprehend the physicochemical characteristics
3. To familiarize the students about extraction and processing
4. To study the production of value added products from oils and fats
5. To study the methods of preparation of soaps and detergents

Course Outcomes: At the end of the course the student will be able to:

1. Analyze the various properties of fats and oils to determine their use in food, soap and other industries
2. Identify unit operations involved in extraction of oils
3. Know the methods of purification of oils and fats
4. Know about the degradation occurring during storage of oils and fats and prevention methods
5. Understand the mechanism Hydrogenations of oils
6. Know the techniques involved in the preparation of soaps

UNIT – I

History and general introduction: Oils, fats, waxes,essential oils, their sources and composition. Natural glyceride constituents of oils and fats: Triglycerides, fatty acids, their nomenclature, and structural formulas. Distribution of fatty acids among glyceride molecules : Even and Random Distribution theories .Non-Glyceride Components: Phosphatides, sterols, pigments, tocopherols, tocotrienols, oryzanol, β-carotene

UNIT – II

Classification of Oils and Fats with Examples, Physical and chemical properties, iodine value, saponification value, hydroxyl value of oil and fats. Detailed glyceride composition of the following oils – palm, palm kernel, coconut, cotton seed, peanut, sunflower, safflower, sesame, rice bran and mustard, linseed (flax seed), soya been, Tung, castor oil, lard, tallow and fish oils. Industrial applications of Non Traditional oils - Neem, Karanja and Jatropa

UNIT– III

Chemical Reactions of Oils and Fats:

Reactions in the fatty acid chain - Hydrogenation, Oxidation reactions, .Esterification and Interesterification, Saponification, formation of metal soaps, Hydrogenolysis, formation of fatty amines, fatty amides and fatty chlorides, Halogenation, Addition of Maleic anhydride, sulfation, sulfonation Chemical oxidation(hydroxylation), atmospheric oxidation (rancidity), Polymerization, Isomerisation.

Reaction of hydroxyl groups

UNIT – IV

Storage, Pre-treatment of Oil Seeds, Mechanical expression of oils, Solvent extraction of oils, Fat splitting (chemical and enzymatic methods)

UNIT – V

Chemical and Physical Refining: De-gumming, neutralization, refining losses, Miscella refining, Bleaching, dewaxing, and Deodorization.

Partial and Total Hydrogenation: Mechanism, selectivity, continuous process, preparation of Raney Nickel catalysts.

Soap Manufacture: Selection of raw materials, Full boil process, INS factor and Solubility ratio.

Text Books:

1. Ed. D Swern, “Bailey’s Industrial Oils and Fats Products” , Wiley Inter Science publication, N.Y. John Wiley and Sons ,6th Edition, 2006

Suggested Reading:

1. M M Chakrabarty , “Chemistry and Technology of Oils and Fats”, Allied Publishers Pvt.Ltd., 1st Edition, 2007
2. O P Narula, “Treatise on fats,Fatty acids and Oleochemicals”, Vol I and II, Industrial Consultants (India), 1994
3. R J Hamilton , “Recent Advances in Chemistry and Technology of Fats and Oils”, Elsevier Applied Science 1987
4. Chemistry and Technology of Oils and Fats, 2003, Edited by M.M. Chakraborty

16CH E 04

CORROSION ENGINEERING
(ELECTIVE “ III)

Instruction	3L Hours per week
Duration of End Examination	3 Hours
Semester End Examination	70 Marks
CIE	30 Marks
Credits	3

Course Objectives: This course helps the students to understand the:

1. Definition and classification of corrosion.
2. Principles of corrosion, common corrosion forms,
3. Different corrosion testing methods.
4. Corrosion control methods and material selection for cost reduction.
5. Modern theories to explain corrosion

Course Outcomes: At the end of the course, student will be able:

1. Identity the type of corrosion.
2. Correlate the damage with the cause of corrosion.
3. Identify the correct method of testing any corrosion.
4. Select the appropriate preventive method to avoid corrosion.
5. Select the significant coating for corrosion prevention.
6. Apply modern method of corrosion measurement.

UNIT–I: Introduction:
Definition, corrosion environments, damage, classification of corrosion. Principles and corrosion rate expressions. Environmental effects such as velocity, temperature, galvanic coupling. Metallurgical and other aspects

UNIT– II: Different forms of corrosion:
Uniform attack, galvanic corrosion, crevice corrosion, fitting corrosion, inter–granular corrosion, selective leaching, erosion corrosion, stress corrosion and hydrogen damage. Pitting: pit shape and growth, velocity, metallurgical variables, evaluation of pitting damage, prevention.

UNIT– III: Corrosion testing methods:
Classification, purpose, surface preparation, measuring and weighing, duration, plant interval test, NACE test methods, slow – strain rate test and paint test.

Composites testing: Exposure techniques, Huey test, Sea water test, Stress corrosion, Corrosion of palstics, Invivo corrosion.

UNIT–IV: Corrosion prevention methods:

Selection of metals and alloys–Cast iron, steel, Al, Mg, Ti, Composites and Refractory metals. Non-metallics: Thermosetters, laminates and reinforced plastics, Rubbers, Wood, Ceramics, Carbon and Graphite. Alteration of environment such as changing mediums, lowering temperature, design rules, design of cathodic and anodic protection, selected coating techniques to prevent corrosion; Failure analysis. High temperature corrosion.

UNIT – V: Advanced techniques:

Modern theory–principles and applications, electrode kinetics, predicting corrosion behavior, corrosion prevention, Corrosion rate measurements in Petroleum Industry with examples.

Text Books:

1. Pierre R. Roberge, " Handbook of Corrosion Engineering", 2nd edition, MCGraw-Hill, Newyork, 2012
2. Zaki Ahmad, "Principles of Corrosion Engineering and Corrosion Control", Butterworth-Heinemann, 2006.

Suggested Reading:

1. Pierre R Roberge, "Corrosion Engineering – Principles and Practice, MCGraw-Hill, 2008
2. Pierre R. Roberge, Corrosion Basics: An Introduction, NACE International, 2006.

Web resources :

1. www.academia.edu/5491377/corrosion_engineering_mars_g._fontana

16CH E 05

MINERAL PROCESSING TECHNOLOGY

ELECTIVE - III

Instruction	3 hours per week
Duration of End Examination	3 Hours
Semester End Examination	70 Marks
Continuous Internal Evaluation	30 Marks
Credits	3

Course objectives:

1. Review all unit operations in mineral processing technology and the mineral concentration processes.
2. Introduce students to the importance and principles of materials handling in the mineral processing plant with special emphasis on feeding and conveying of bulk material.
3. Provide students the opportunities to acquire practical skills in concentrates handling, grade.
4. Determination, recovery and loss calculation and participatory laboratory experiments.

Course Outcomes: At the completion of this course, students will be able to

1. Understand the principles governing a range of processes applied in the mineral industry.
2. Describe typical unit processes and flow-sheets for production of a number of metals.
3. Apply basic engineering principles to the design of mineral processes.
4. Produce conceptual designs for simple extraction processes.
5. Understand the operation of beneficiation units for coal and mineral.

UNIT – I: Introduction to Mineral Processing, Scope and importance. Properties and Types of Minerals

Ore handling: removal of harmful materials - sampling of ores: moisture sampling, assay sampling, sampling systems, sample division methods.

UNIT – II:

Mineral Liberation, degree of liberation, concentration, measures of assessing metallurgical performance viz., recovery, ration of concentration, grade, enrichment ratio.

Laboratory sizing: particle size and shape, sieve analysis, sub sieve techniques, centrifugal methods (warman cyclosizer), microscopic sizing, online particle size analysis.

UNIT – III:

Classification: Principle, types of classifiers – Gravity concentration: principle, concentration in vertical surren (Jigging), Jigs, types of Jigs viz., Harz Jig, circular and radial jigs, coal jigs (Baum and Batac jigs) – Gravity concentration in streaming currents: pinched sluice, cones, spirals, shaking tables.

UNIT –IV:

Heavy medial separation: Principle, liquids and suspension for heavy media separation.

Separation vessels : Gravitational vessels (Wemco Cone separator, Drum separator)

Centrifugal separators: (Vorsyl separator, LARCODEMS, Dyna whirlpool separator) DMS cyclone DMS circuits.

UNIT – V:

Floatation – History and theory: contact angle, work of adhesion; Floatation Reagents: collectors, frothers, regulators; and their action – Floatation practice: ore and pulp preparation, reagents and conditioning- Flotation Machines: pneumatic (Davcra cell, flotation column, Jameson cell, froth separators) and mechanical (Denver cell, Wemco cell) electro flotation, skin flotation, Case studies: i) Coal Beneficiation process. ii) Different methods for fine particles collections(Copper, Iron, Au).

Text Books:

1. B.A.Wills – "Mineral Processing Technology " –7th edition Maxwell International Edition - 1987.
2. S.K.Jain "Ore Processing"Oxford and TBHY Publishing Co. (P) Ltd., India (1986).
3. S. K. Jain, Ore Processing, Oxford- IBH Publishing Company, 2005.

Suggested Reading:

1. Ashoka Gupta & Denis Yen, "Mineral Processing Design and Operations", 1st Edition, Elsevier Publishers.

16CH C 14

MECHANICAL UNIT OPERATIONS LAB.

Instruction	3 Periods per week
Duration of University Examination	3 Hours
University Examination	50 Marks
Sessionals	25 Marks
Credits	2

Course Objectives:

1. To provide student the opportunity to acquire practical skills in mechanical unit operations.
2. To introduce students the importance and principles of material handling.
3. To provide an overall view of size reduction equipments.
4. To know the techniques of separating solids based on size by different methods.
5. To impart the concept and functioning of filtration unit.

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

1. Understand mechanical unit operations and their role in chemical engineering industries.
2. Understand the nature of solids, their characterization, handling and the processes involving solids.
3. Analyze the performance of size reduction equipment and calculate the power and efficiency requirements.
4. Understand the solid-fluid separation process and operation.

LIST OF EXPERIMENTS

(Minimum of 8 Experiments in the list are to be performed)

1. Verification of the laws of size reduction using Jaw crusher.
2. Verification of the laws of crushing using drop weight crusher and determination of work index.
3. Determination of laws of crushing in a pulverizer.
4. Verification of the comminution laws and critical speed of a ball mill
5. Analysis of various sizes of given material by sieve analysis and determination of cumulative and differential analysis.

6. Determination of the specific cake resistance and medium resistance in a vacuum filter or plate and frame filter press.
7. Calculation of the effectiveness of screen in horizontal and inclined position (vibrating screens)
8. Determination of separation factors of air and hydraulic classifiers.
9. Determine settling rate classification of particles using cyclone separator and to determine the efficiency
10. Determination of the froth flotation characteristics in mineral concentration.

16CH C 15

PROCESS HEAT TRANSFER LABORATORY

Instruction	3 Periods per week
Duration of University Examination	3 Hours
University Examination	50 Marks
Sessionals	25 Marks
Credits	2

Course Objectives:

1. To make students to understand the basic concepts of fundamentals of heat transfer modes.
2. To make students learn the applications of modes of heat transfer.

Course Outcomes:

1. At the end of the semester the students will be in a position to know the principles involved in different modes of heat transfer.
2. They will be in a position to design and analyze heat exchangers such as shell and tube, extended surface exchangers etc.
3. Thermal conductivity of insulating materials can be found by them involving conduction mode. Emissivity of given surfaces will be found based on radiation phenomenon.

LIST OF EXPERIMENTS

(Minimum of 8 Experiments in the list are to be performed)

1. Determination of Thermal conductivity of given insulating powder under steady state conditions.
2. Determination of interface temperatures in composite wall under steady state conditions.
3. Determination of heat transfer coefficient in Natural convection.
4. Determination of overall heat transfer coefficient in unsteady conditions
5. Determination of inside heat transfer coefficient in coil heat exchangers
6. Determination of overall heat transfer coefficient and effectiveness of a Double pipe heat exchanger

7. Determination of heat transfer area in a 1-2- shell and tube heat exchangers
8. Determination of heat transfer coefficient on a single tube by film wise and drop wisecondensation.
9. Determination of emissivity and Boltzmann's constant of a sample body
10. Determination of heat transfer coefficient in forced convection.
11. Determination of fin efficiency of longitudinal fins of extended surface
12. Determination of peak flux and critical temperature drop in pool boiling of saturated liquid
13. Determination of heat transfer coefficient of a pin fin under free convection.
14. Determination of heat transfer coefficient of a pin fin under forced convection

16CH E 06

SURFACE COATING TECHNOLOGY LAB
(ELECTIVE – II LAB)

Instruction	3 Periods per week
Duration of University Examination	3 Hours
University Examination	50 Marks
Sessionals	25 Marks
Credits	2

Course Objectives : To make the students

1. understand the theoretical concepts of organic surface coating technology (Paints)
2. perform the experimental procedures on paints to determine various properties.
3. practice various application systems of powder paints and liquid paints

Course Outcomes :

1. Students are able to understand the importance of Organic surface coatings.
2. Students are able to perform different paint tests and analyze the quality of paints.
3. Student can differentiate between lacquers , varnishes and paints.

LIST OF EXPERIMENTS

(Minimum of 8 experiments are to be performed)

1. Preparation of panels for painting (power coating or liquid paints)
2. Powder particles size analyser
3. Determination of apparent viscosity of paints (only liquid paints)
4. Determination of resistance to scratching under a specified load of a dried film of paint
5. Measurement of paint film thickness using dry film thickness gauge (finish paint)
6. Determination of flexibility and adhesion of the paints (as per 101 BS 3960 m and size ¼ inch)
7. Determination of impact resistance of the painted panel
8. Measurement of hardness of magnesium phosphate coating or zinc phosphate coating
9. Measurement of gloss of painted film at 45 degree angle

10. Determination of drying consistency of different paints
11. Determination of coverage or spreading capacity of different paints
12. Salt Spray Test (only for Powders)

Text Books:

1. Industrial Hand Books
   a). Berger Protection Protective Coatings – Product Data Manual
   b). Goodlass Nerolac Paints Product Data Manual
2. ICI Paints Quality Manual Book

16CH E 07

TECHNOLOGY OF VEGETABLE OILS AND FATS LABORATORY (ELECTIVE -II)

Instruction	3 Periods per week
Duration of University Examination	3 Hours
University Examination	50 Marks
Sessionals	25 Marks
Credits	2

Course objectives: - To make students to understand the

1. Theoretical concepts by performing the practicals on some of the important physical and chemical properties of oils and fats.
2. Procedure involved in knowing the characteristics of different oils and fats.

Course Outcomes: - At the end of the semester the students will be in a position

1. to analyze the different oil samples
2. to carry out various techniques used to determine quality oils and fats.

Technology of vegetable oils and fats laboratory (Elective II -Lab)

1. Determination of Acid value of given samples
2. Determination of percentage of free fatty acid present in the given sample and its acid value
3. Determination of Iodine value of given sample
4. Determination of saponification value of given oil samples
5. Determination of the hydroxyl value of given samples
6. Determination of unsaponifiable matter of given oil sample
7. Determination of melting point of fats.
8. Determination of the percentage of moisture and volatile matter under the conditions of test
9. Determination of total fatty matter (TFM) in soaps

Note: - A minimum of 8 experiments should be performed

Reference Books and suggested readings:

1. BIS specifications; IS- 548, part I,II & III
2. A text book of oil and fat analysis By Cocks & Reid
3. Modern Technology in Oils and Fats Industry, Vol-II, OTAI (NZ)

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY (A)

Choice Based Credit System (with effect from 2018-19)

B.Tech (Chemical Engineering)

SEMESTER -VI

S.NO	Course Code	Title of the Course	Scheme of Instruction Periods per week		Scheme of Examination			
			L/T	P/D	Duration in Hours	Maximum Marks CIE	Maximum Marks SEE	Credits
THEORY								
1.	**16CH C16**	Bio Chemical Engineering	3	--	3	30	70	3
2.	**16CHC 17**	Chemical Engineering Thermodynamics – II	4	--	3	30	70	4
3.	**16CH C18**	Chemical Process Safety	3	--	3	30	70	3
4.	**16CH C19**	Process Dynamics and Control	4	--	3	30	70	4
5.	**16CH C20**	Process Modeling Simulation And Optimization	4	--	3	30	70	4
6.	--	Elective-IV	3	--	3	30	70	3
PRACTICALS								
7.	**16CH C 21**	Chemical Reaction Engineering Laboratory	--	3	3	25	50	2
8.	**16CH C 22**	Process Dynamics And Control Laboratory		3	3	25	50	2
9.	**16CH C23**	Process Modeling Simulation Laboratory	--	3	3	25	50	2
Total			**21**	**9**	**--**	**255**	**570**	**27**

L: Lecture, T: Tutorial, D: Drawing, P: Practical

SNO	ELECTIVE-IV Course Code	Title of Elective –II Course
1	16CH E 08	Energy Engineering.
2	16CH E 09	Fluidization Engineering.
3	16CH E 10	Pharmaceutical Technology

L: Lecture T: Tutorial D: Drawing P: Practical

CIE - Continuous Internal Evaluation SEE - Semester End Examination

16CH C 16

BIO CHEMICAL ENGINEERING

Instruction	3 Hours per week
Duration of End Examination	3 Hours
Semester End Examination	70 Marks
CIE	30 Marks
Credits	3

Course Objectives:

1. To understand the functions of living cells
2. To apply the principles of Chemical Engineering to bioprocesses.
3. Conduct analysis on the biological factors that are important in the design, operation, performance, and/or monitoring of a biological process
4. To understand the significance of microbes
5. To understand the applications of different bio processes

Course Outcomes: On successful completion of this module, students should be able to

1. Describe the basic structure and function of cells & Relate cell function to products and processes useful to man
2. Understand classification, growth concepts and various types of interactions in microbes
3. Significance of enzymes as biocatalysts.
4. Identify and explain the basic features of bioreactors
5. Describe the principles of the various separation procedures involved in the downstream processing of products
6. Understand various other aspects of bioprocess technology viz, fermentation types, media formulation, environmental biotechnology and commercial aspects.

UNIT – I Basic Concepts of Biochemical Engineering, Molecular Biology& Bio Chemistry

Biochemical Engineering Principles, Biophysics and cell doctrine:
Atomic Theory and Cell Theory, Important cell types, structure and functions of a typical cell and their components, Transport across cell membranes: Passive and facilitated diffusion, Active transport.

Structure and functions of Bio Molecules:
Carbohydrates, lipids, Nucleotides to Nucleic Acids – RNA and DNA, Amino acids to Proteins - the building blocks of biochemical life.

Biosynthesis and Metabolic Pathways:
Biosynthesis of Small and Macro Molecules Introduction of metabolic pathways and end products of glucose metabolism

UNIT – II Introductory Microbiology

Introduction to Microbiology: Classification and Industrial uses of Microorganisms Growth and Reproduction of Microbes: Growth cycle phases for batch cultivation. Monod's growth kinetics – Growth Rate dependant classification of Microorganisms Microbial Genetics: Recombinant DNA technology and mutant populations. Multiple Interacting Microbial populations: Neutralism, Mutualism, Commensalism, Amesanalism, Predatism and Parasitism

UNIT – III Enzyme Technology

Enzymology: Enzymes as Biocatalysts - The enzyme substrate complex and enzyme action and Classification of Enzymes based on Functions.

Kinetics of Enzyme Catalyzed Reactions: Simple enzyme kinetics with one and two substrates. Determination of rate constants, substrate activation and inhibition, modulation and regulation of enzyme activity / effect of PH and temp on enzyme activity

Immobilized Enzyme Technology: Types of Enzyme immobilization, Immobilized enzymes in industrial processes, Cofactors, Apo-enzymes and Coenzymes utilization and regeneration

UNIT – IV Bioreactors and Down Stream Techniques - Introduction

Design and Analysis of Biological Reactors: Batch and Continuous Stirred Tank Reactors, Enzyme reactors Ideal Reactors for kinetic measurements: The ideal batch reactor / The ideal continuous flow stirred tank reactor - Alternate bio-reactor configurations

Separation Processes: Filtration, Centrifugation, Adsorption, Reverse osmosis, Dialysis, Electrophoresis, Sedimentation and Extraction Purification Processes: Precipitation, Crystallization, and Chromatography

UNIT – V Bioprocess Technology

Fermentation Technology: Types of Fermentation ,Medium formulation and Culture Propagation, Environmental biotechnology: Effluent treatment.

Industrial Biotechnology: Commercial enzymes, Antibiotics and single cell protein

Text Books:

1. James, E Bailey and David F Ollis, "Biochemical Engineering fundamentals", 2ndEdition, McGraw-Hill Internal Edition.1986

Suggested Reading:

1. Michael L Shuler and Fikret Kargi, "Bioprocess Engineering: Basic Concepts". Second Edition Prentice Hall, 2002
2. Coulson & Richardson's' Chemical Engineering" Vol 3, Third Edition, Elsevier Publishers, 2006
3. D.G., Rao, "Introduction to BioChemcial Engineering" Second Edition, TMGH Pvt Ltd, 2010

16CH C 17

CHEMICAL ENGINEERING THERMODYNAMICS – II

Instruction	4 Hours per week
Duration of End Examination	3 Hours
Semester End Examination	70 Marks
CIE	30 Marks
Credits	4

Course Objectives: This course helps the students to understand about

1. The concepts of Partial and Molar properties, Chemical Potential, Fugacity& Fugacity coefficients.
2. The concepts of fugacity in mixtures and various methods to obtain Fugacity Coefficient in mixtures.
3. Phase Rule and Various models used to determine the activity coefficients.
4. Calculation procedure to generate Vapor- Liquid equilibrium (VLE) in form of T-X-Y or P-X-Y for miscible binary mixtures.
5. Methodology adopted to determine equilibrium constant.

Course Outcomes: The students will be able to

1. Calculate the Partial Properties and Fugacity coefficients using various equations.
2. Calculate Fugacity and Fugacity Coefficients for miscible binary Mixtures.
3. Calculate and determine the activity coefficients by various models.
4. Calculate the Vapor- Liquid equilibrium (VLE) in form of T-X-Y or P-X-Y for miscible binary mixtures using various models.
5. Generate the Vapor- Liquid equilibrium (VLE) in form of T-X-Y or P-X-Y for miscible binary mixtures using various models.
6. Calculate and determine equilibrium constant and composition of product mixture at given temperature and pressure.

UNIT - I

Criterion of Phase Equilibrium: Fundamental property relations, Chemical potential, Gibss -Duhem equation, Partial Properties, Relation between Partial Properties and Molar properties, Chemical potential equation for an ideal gas, Fugacity, Fugacity Coefficients, Determination of Fugacity Coefficient by equations of states (Virial, Vander Waal, R.K. equation.)

UNIT - II

Solution Thermodynamics: Fugacity of pure liquids, Fugacity for Mixtures, Poynting factor, Residual Properties, Excess Properties, Lewis Randall Rule, Activity Coefficients.

UNIT - III

The Nature of Phase Equilibrium: The Phase Rule, Duhem's Theorem, Models to calculate Activity Coefficients (Margules Equation, Van-laar, Wilson), Introduction to UNIQUAC, UNIFAC. Method to get activity coefficients (Margules and Van laar) by using Excess Gibbs Free Energy models.

UNIT - IV

Application of Phase Equilibrium: To get T-x-y, P-x-y, Using Raoult's law, Modified Raoult's law for miscible binary mixtures, following methods of BUBBL-T, Dew-T, BUBBL-P, DEW-P. Algorithm to find VLE by Peng- Robinson, R-K- Equation.

UNIT - V

Chemical Reaction Equilibrium: Reaction Coordinate, Equilibrium criteria for chemical reactions, equilibrium constant and effect of temperature , temperature and pressure effects on conversion, Calculation of equilibrium conversion for single reactions in homogenous systems, Duhem's Theorem for reacting systems.

Text Books:

1. J M Smith and H C VanNess, "Introduction to Chemical Engineering Thermodynamics", McGraw Hill, International Edition,Fourth edition, 1987.

Suggested Reading:

1. Pradeep Ahuja, "Chemical Engineering Thermodynamics", PHI Publishers, EEE, 2009
2. YVC Rao, "Chemical Engineering Thermodynamics" Universities Press, 2003.

16CH C 18

CHEMICAL PROCESS SAFETY

Instruction	3 Hours per week
Duration of End Examination	3 Hours
Semester End Examination	70 Marks
CIE	30 Marks
Credits	3

Course Objectives: This course helps the students to understand the:

1. Importance of safety culture in process industry.
2. Disregard for ethical decision making based on numerous case studies.
3. Interaction and implementation of trade-offs concept in chemical plant operation.
4. Examples of problems that can occur with inadequate process design, improper process modification.
5. Different case studies related to industrial processes

Course Outcomes: At the end of the course, the students will be able to:

1. Evaluate effect of chemical hazards and risks of toxicants.
2. Analyze chemical incidents and possible consequences to plant facilities, workers, and the general public.
3. Apply the technique of safe process design.
4. Analyze fire and explosion hazards.
5. Integrate safety concepts into chemical plant design.
6. Follow the ethics during process plant operation.

UNIT – I

Introduction: Process industrial safety –definition, importance. Safety awareness – Safety aspects of site selection, plant planning and layout, check list, inline arrangement of tower drums, exchangers, pumps and main pipelines.

Case studies of major disasters due to safety violations: Chernobyl disaster, Bhopal disaster, recent oil spills. Chemical hazards and workers safety, industrial process case studies.

UNIT – II

Organized labor interest in safety: Involvement of unions in accident prevention, recommendation of occupational health committees. Work Policy of MCA in accident prevention at process industries. Risk assessment procedures (HAZOP) and typical operational practices. Necessary precautionary measures (OSHA).

Hazards: Identification and operability studies. Involvement of chemical criminals in process industries and their prevention. DOW Fire and explosion index, calculation of the DOW Fire and EI. Chemical safety data sheets and guides.

UNIT – III

Safety education and training: Training of personnel, on- the- job and job instructed training, meeting and instructional presentations. Effects of toxic Agents, chemicals and smoke on skin, eyes, respiratory tract, digestive tract. Primary protection equipment (PPE) – types, significance and applications. Measuring safety effectiveness: criteria for effective measurement, disabling (Lost-time) injuries, frequency rate, severity rate. Problem related safe-t-score. Involvement of inspector of factories in accident prevention. The technique of safe process design, separation sections, materials handling, storage sections, flowsheet review.

UNIT – IV

Fires and explosions: Definition of fire, fire triangle, Classification of fires as Class - A, B, C and D. Reaction of fires. Fire extinguishers: Portable fire extinguishers applications and their uses, Construction and working of water, Mechanical foam, CO_2, stored powder, ABC powder. Automatic multiple CO_2 extinguishers in chemical process industries.

UNIT – V

Emergency preparation and accident investigation: On-site and off-site emergency plan and infrastructure, learning from accidents, layered investigation, equipments aiding in diagnosis. Safety audit: Introduction, essentials, requirements, programs and procedures.

Text Books:

1. D. A. Crowl and J.F. Louvar, “Chemical Process Safety”, Prentice Hall, New Delhi, 2011.
2. Howard H. Fawcett and W. S. Wood, “Safety & Accident prevention in chemical operations”, 2nd Ed., John Wiley and Sons Inc, 1982.

Suggested reading

1. Coulson and Richadson, “Chemical Engineering Design”, 3rd ed., Vol 6, TMH, 1999.
2. Fulekar M.H, “Industrial Hygiene and Chemical Safety”, I.K. International Publisher, 2006.
3. Sanders R.E., “Chemical Process Safety: Learning from case Histories”, Butterworth-Heinemann (Elsevier) pub, 2005.

16CH C 19

PROCESS DYNAMICS AND CONTROL

Instruction	4L Hours per week
Duration of End Examination	3 Hours
Semester End Examination	70 Marks
CIE	30 Marks
Credits	4

Course Objectives: To provide a conceptual and methodological framework to

1. Analyze the transient behavior of simple chemical processes (using mathematical modeling from first principles and Laplace transforms)
2. Feedback control of processes - concepts, terminology, methods, and performance
3. Linearise relative to steady state
4. Obtain solution of linear dynamic problems in the laplace domain
5. Understand advanced control strategies with industrial examples

Course Outcomes: At the end of the course the student will be able to:

1. Characterize and analyze the dynamic behavior of linear systems (1^{st} and 2^{nd} order)
2. Understand the importance of various modes of control
3. Construct block diagrams for simple chemical processes
4. Analyze stability of simple feedback control systems
5. Analyze and tune process controllers to achieve desired performance
6. Empirically identify process dynamics

UNIT – I

Introduction: Response of First order system, Transfer Function, Transient response to step, impulse, sinusoidal forcing function, physical examples of first order systems, liquid level, mixing process, concept of time constant, linearization, response of first order systems in series, interacting and non-interacting systems

UNIT – II

Response of Second Order Systems: Transient response of under damped, critically damped, over damped systems to step, impulse and sinusoidal forcing functions. Transportation lag

Control Systems: Negative and Positive feedback control systems, Servo and Regulatory control problems, Development of Block diagram, Controllers and final control elements, Ideal transfer functions of P, PI, PD and PID controllers

UNIT – III

Control system block diagrams and Stability: Reduction of physical control systems to block diagrams. Closed loop transfer functions for servo & regulator problems. Overall Transfer functions for multi loop control systems. Transient response of simple control systems for servo and regulator problems, measurement lags. Stability of a control system by Routh's Criterion

UNIT – IV

Root Locus: concept of root locus, plotting of the root locus diagram for feedback control systems, Transient response of control system from root locus plot.

Frequency response: Bode diagrams for first order, first order system in series, second order systems and for controllers and transportation lag. Bode stability criterion. Gain margin and phase margin

UNIT – V

Advanced Control Strategies: Cascade Control, Feed Forward Control, Ratio control

Controller Tuning and Process Identification: ISE, ITAE, IAE, Ziegler-Nicholas and Cohen-Coon tuning methods, process identification by step, frequency and pulse testing

Control valves: Construction, sizing, Characteristics and valve positioner (only theoretical aspects)

Text Books:

1. Donald R Coughanowr , Steven E LeBlanc, "Process Systems Analysis and Control", 3rd ed., McGraw Hill Inc, 2009

Suggested Reading:

1. George Stephanopoulos , "Chemical Process Control: An Introduction to Theory and Practice", PHI, 1984
2. Michael L Luyben, William L Luyben, "Essentials of Process Control", McGraw-Hill, 1997
3. Seborg, Edgar, Mellichamp and Doyle, "Process Dynamics and Control", 3rd Edition, Wiley India Pvt. Ltd., 2014

16CH C 20

PROCESS MODELING SIMULATION AND OPTIMIZATION

Instruction	4 Hours per week
Duration of End Examination	3 Hours
Semester End Examination	70 Marks
CIE	30 Marks
Credits	4

Course Objectives: This course helps the students to understand the:

1. Fundamental laws of mass and of energy.
2. Uses and types of mathematical models.
3. formulate linear and non-linear process models.
4. formulate ODE process models and curve-fitting.
5. significance of optimization principles.
6. open-loop simulation and design of chemical processes.

Course outcomes: At the end of the course, the students will be able to:

1. formulate a process model by applying fundamental laws of mass and energy balance.
2. formulate linear and non-linear process models for chemical processes and apply numerical methods and MATLAB codes to solve them.
3. formulate ODE process models and solve by numerical methods and MATLAB coding.
4. fit polynomial functions as process models and solve by regression analysis and MATLAB coding.
5. optimize using different elimination methods of non-linear programming.
6. design and simulate chemical processes.

Note: Use of "MATLAB" programming techniques for problem solving.

UNIT – I: Formulation of process models

Definition of mathematical modeling, process models, types and uses, principles of formulation. Fundamental laws of mass and energy. Application of laws and process models to develop – Total continuity equation, component continuity equations, energy equation, momentum equation.

UNIT – III: Numerical solutions of linear and non-linear process models

Formulation of linear simultaneous process models and solutions by direct methods of Gauss-Elimination and Gauss-Jordan methods and indirect Gauss-Seidel method.

Understanding the concept of ill-conditioning. Formulation of non-linear process models and solutions by Bisection, Regula-falsi and Newton Raphson methods.

UNIT – II: Curve-fitting and numerical solutions of ordinary differential process models

Curve-fitting and engineering problem solving by linear and nonlinear least square analysis. Formulation of ordinary differential process models and solutions by Euler's method and Runge-Kutta fourth order method.

UNIT – IV: Chemical process optimization

Introduction, engineering applications, statement of an optimization problem, design constraints, objective function, classification of optimization problems.
Non-linear programming – elimination methods like unrestricted search, exhaustive search, dichotomous search, Fibonacci method, golden-section method.

UNIT – V: Simulation of chemical processes

Application of mathematical modeling and open loop simulation and design of gravity flow tank, two-heated tanks, three CSTRs in series, batch reactor, binary distillation column.

Textbooks:

1. Applied numerical methods with MATLAB for engineers and scientists, Steven C. Chapra, 3rd ed., Tata-McGraw Hill Edu. (India) Pvt.Ltd., New Delhi, 2012.
2. Process Modeling, Simulation and Control for Chemical Engineers, by William L. Luyben, 2nd ed., McGraw Hill Pub. Co., New Delhi, 1990.
3. Engineering optimization, theory and practice, Singiresu S. Rao, 3rd ed., New-age Intl. Pvt. Ltd., Hyderabad, 1999.

Reference books:

1. Numerical methods for chemical engineering: Applications in MATLAB, Kenneth J. Beers, Cambridge Univ. press., New York, 2007.
2. Numerical methods in engineering and science (with programs in C, C++ and MATLAB), B. S. Grewal, 10th ed., Khanna pub., Nagpur, 2014.
3. Applied mathematical methods for chemical engineers, Mickley H.S., Sheerwood T.K., Reed C.E., McGraw Hill book Co., New York, 1957.

16CH E 08

ENERGY ENGINEERING (ELECTIVE IV)

Instruction	3 Hours per week
Duration of End Examination	3 Hours
Semester End Examination	70 Marks
CIE	30 Marks
Credits	3

Course Objectives:

1. To impart knowledge on various energy sources and their applications
2. To introduce emerging technologies viz., fuel cells, bio fuels etc.
3. To know the process of crude fuels
4. To understand the advantages and disadvantages of various energy sources
5. To familiarize the concepts of energy audit and conservation

Course Outcomes: At the end of the course the student will be able to understand:

1. The significance and classification of energy sources.
2. The basic principles and fundamentals of conventional energy sources
3. The basics and applications of various non-conventional energy sources.
4. The production and future perspectives of bio fuels
5. The significance of future energy resources
6. The importance of energy auditing and conservation

UNIT – I

Introduction: Introduction to conventional and non conventional energy sources, alternative energy sources, their significance & availability, consumption patterns in India. Energy survey and policies for India

UNIT – II

Conventional Energy Sources:

Wood and wood Charcoal, products of wood carbonization Coal and Coal derived fuels, characteristics, production methods and uses. Oil and Gases: Fuels derived from oil and gases, Characteristics, production methods and uses. Technology for combustion of fuels derived from oil and gas. Shale oil and gas, oil sands

UNIT – III

Non conventional Energy Sources:

Solar Energy: Basics, Types of Solar Energy Collectors, Applications- Solar Distillation, pumping, production of hydrogen.

Photo Voltaic Cells: Introduction, Types of photo voltaic Cells, Applications, Electrical Storage and Future developments

Wind-Energy: Introduction, Basic principles of wind energy conversion. Types of wind machines.

UNIT – IV

Bio Fuels: Introduction, Bio mass conversion technologies- Wet processes, dry processes, Bio-gas generation. Factors affecting bio-digestion, Classification of biogas plants Production methods, characteristics, uses of bio-diesel, bio-butanol and bio-ethanol, Second generation bio-fuel feed stocks.

Fuel Cells: Working principle, Types, Advantages, Current and Future Applications.

Nuclear Energy: Nuclear fission and fusion fuels processing, nuclear reactions and nuclear reactors.

UNIT - V

Energy Auditing and Conservation: Short term, medium term, long term schemes, energy conversion, energy index, energy cost, representation of energy consumption, Sankey diagram, energy auditing. Conservation methods in process industries, theoretical analysis, practical limitations.

Text Books:

1. G D Rai, "Non -conventional energy sources," Khanna Publishers, 4th edition, 2000.
2. Samir Sarkar, "Fuels and Combustion", Universities Press, 3rd Edition 2009.

Suggested Reading:

1. Om Prakash Gupta, "Fundamentals of Nuclear Power Reactors", Khanna Publishers S Srinivasan, "Fuel Cells: From Fundamentals to Applications", Springer, 2006.

16CH E 09

FLUIDIZATION ENGINEERING
(ELECTIVE IV)

Instruction	3 Hours per week
Duration of End Examination	3 Hours
Semester End Examination	70 Marks
CIE	30 Marks
Credits	3

Course Objectives: This course helps the students to understand:

1. Basic fundamentals of fluidization and fluidized bed behavior.
2. Minimum fluidization and pressure drop across the bed.
3. Various models to analyze the behavior and mixing patterns.
4. Heat and mass transfer aspects of fluidized bed.
5. Concepts of fluidized bed combustion chamber.

Course Outcomes: At the end of the course, the students will be able to:

1. Calculate the minimum fluidization velocity and optimum operating fluidization velocity.
2. Design the cooling tube length for required heat transfer area.
3. Design the fluidized bed in terms of pressure drop across the bed.
4. Design the distributors, TDH, height, diameter, power consumption of compressor for air.
5. Distinguish between boiler and furnaces, methods of starting up.
6. Calculate the amount of chemicals required to control the emission like SO2.

UNIT – I

INTRODUCTION:

Processes involving contact between solid particles and a Fluid, Packed Beds, Fluidized Beds advantages and disadvantages of fluidized beds for industrial applications. Fundamental fluidized bed behavior, Fast fluidization, circulating fluidized beds. Particles and Fluidization: Physical properties of solid particles, size and shape, size range, surface area of particles in a bed, Bed voidage, classification of particles according to Fluidization characteristics, pressure drop across packed beds, minimum fluidization velocity and its determination.

UNIT – II

TWO – PHASE THEORY OF FLUIDIZATION:

Bubbles and Fluidization Regimes, Bubble rise velocity, Bed expansion, Bubble growth and slugging, Mixing, Elutriation and Transport of solids, General mechanism of mixing of particles, mixing and segregation of particles, Terminal velocity of particles, Elutriation, transport disengaging height, solids transport. Davidson's Model, Diffusion model, Bubbling bed model ideal mixing stage model, two regime models.

UNIT – III

FLUIDIZED BED HEAT TRANSFER:

Heat Transfer in Beds of Particles, Gas -to- particle heat transfer, Bed – to- surface heat transfer, particle convection component, interphase gas connective component, Radioactive component, Estimation of Bed–to surface Heat Transfer coefficient, Heat Transfer between the Bed-Distributor, side walls, immersed tubes or components, Heat Transfer to surfaces located above the Bed, Free surface, Design for physical operation, Batch and continuous operation for Mass & Heat Transfer and Drying of solids.

UNIT IV

DESIGN OF SIMPLE FLUIDIZED BEDS:

Introduction, Estimation of Bed Dimensions and Fluidizing velocity, Transport disengaging Height, Distributors, Heat removal from fluidized beds from cooling tubes in the bed, optimum size of a fluidized bed reactor. Power consumption.

UNIT – V

FLUIDIZED BED COMBUSTION:

Introduction, combustion systems for solid fuels combustors and the first law of thermodynamics, fluidized Bed combustion of solid fuels size of fluidized bed combustion system, size of inert particles in the bed, turndown efficiency of fluidized bed combustion, Equipment, combustion of fuel particles in a fluidized bed, Distinguish between boiler and furnaces, methods of starting up, circulating or fast fluidized bed combustion systems, control of emission of SO_x ,CO and CO_2

Text Books:

1. J.R. Howard Adam Hilger, "Fluidized Bed Technology -Principles & Applications", IOP, Pub Ltd., NY. 1989.

Suggested Reading

1. Diazo Kuni & Octave Levenspiel, " Fluidization Engineering", 2nd Edition, John Wiley and Sons, 2002.
2. John M. Matsen, Grace John R , "Fluidization", Springer-Verlag New York Inc., 1980.

16CH E 10

PHARMACEUTICAL TECHNOLOGY
(ELECTIVE IV)

Instruction	3 Hours per week
Duration of End Examination	3 Hours
Semester End Examination	70 Marks
CIE	30 Marks
Credits	3

Course Objectives: The students will able to understand

1. Grade of chemicals, Principles & Various Tests.
2. Preparation & testing of Pharmaceuticals & final chemicals.
3. The Concepts & Principles to draw the flow sheets.
4. Methods & equipment used for Tablets, Capsules Preparation
5. Sterilization methods.

Course Outcomes: At the end of the Course Students will able to

1. Get a know how about the grades, Identify the Impurities & limit tests.
2. Prepare & test the Properties of Pharmaceuticals & fine Chemicals.
3. Draw flow sheets for Manufacturing Pharmaceuticals.
4. Draw flow sheets for Manufacturing Chemicals.
5. Have a theoretical knowledge about tablet & Capsule making.
6. Know various sterilization methods.

UNIT I

Introduction : A brief outline of grades of chemicals, sources of impurities in chemicals, principles (without going into details of individual chemicals) of limit test for arsenic, lead, iron, chloride and sulfate in Pharmaceuticals.

UNIT II

Outlines of Preparation, properties, uses and testing of the following Pharmaceuticals - sulfacetamide, paracetamol, riboflavin, nicotinamide, Outlines of Preparation, properties, uses and testing of the following fine chemicals - Methyl orange, fluorescence, procaine hydrochloride, para amino salicylic acid, isonicatinic acid hydrazide.

UNIT III

Study of Manufacture & Production of Pharmaceuticals – aspirin, penicillin, calcium gluconate with uses Properties flow sheets and testing Methods.

UNIT IV

Study of Manufacture & Production of Chemicals with flowsheets, properties uses and testing of the following: ferric ammonium citrate, pthallic anhydride and phenol flourobenzene process and benzene sulfate process, other processes in outline only.

UNIT V

Tablet making, coating, granulation and granulation equipments Preparation of capsules, extraction of crude drugs. Sterilization: introduction, risk factor, methods of sterilization, heat (dry and moist), heating with bactericide, filtration, gaseous sterilization and radiation sterilization, suitable example to be discussed.

TEXT BOOKS:

1. Remington's Pharmaceutical Science,16th ed, Mac publishing company, 1980.
2. Industrial Chemicals, 3rd ed., Faith, Kayes and Clark, John Wiley & Sons,. 1965.

Suggested Reading:

1. Blently's Text Book of Pharmaceutical Chemistry, 8th ed, H A Rawlins, B Tindell and Box,. Oxford University Press, London, 1977.

16CH C 21

CHEMICAL REACTION ENGINEERING LABORATORY

Instruction	3Hours per week
Duration of End Examination	3 Hours
Semester End Examination	50 Marks
CIE	25 Marks
Credits	2

Course Objectives: Students will be able to understand

1. Reaction kinetics in homogenous systems.
2. Reaction kinetics in heterogeneous systems.
3. Behavior of non Ideal reactors.

Course Outcomes: Students will able to

1. Find rate equations in batch reactor, mixed flow reactor, PFR, packed bed Reactor.
2. understand the concept of reaction and mass transfer in a liquid –liquid and solid-liquid system.
3. Predict conversion in adiabatic reactor.
4. Determine the extent of non –ideality in tubular reactor.

LIST OF EXPERIMENTS
(Any Eight Experiments to be performed)

1. Studies in Batch Reactor: To find the Arrhenius form of temperature dependency of reaction
2. Studies in Mixed Flow Reactor (CSTR) : To find kinetics from reactor performance of CSTR
3. Studies in Tubular Reactor: To determine the rate constant and to verify the order of reaction
4. Mass Transfer with Chemical Reaction: (Liquid – Liquid Reaction System) To find out the mass transfer coefficient in a stirred cell: With chemical reaction and without chemical reaction
5. Mass Transfer with Chemical Reaction: (solid – Liquid Reaction System) To find the mass transfer co-efficient without chemical reaction and with chemical reaction.
6. R.T D Studies in Packed bed reactor: To determine the axial mixing (axial dispersion) in the packed column.

7. R T D Studies in Tubular Column To determine the variance of residence time distribution and the dispersion number in a tubular column.
8. Studies in Batch Reactor: With Equimolar Feed (M = 1) : To determine the rate constant and to verify the order of reaction by differential & integral methods of analysis.
9. Studies in Batch Adiabatic Reactor: to determine the kinetics of an exothermic reaction from the Temperature of the reaction system.
10. Studies in Mixed Flow Reactors in series: To compare the actual & ideal performances of a Reaction system.
11. Studies in Packed bed: To determine the rate constant and to verify the order of reaction from performance of the reactor.

16CH C 22

PROCESS DYNAMICS AND CONTROL LABORATORY

Instruction	3 Hours per week
Duration of End Examination	3 Hours
Semester End Examination	50 Marks
CIE	25 Marks
Credits	2

Course Objectives: Students will be able to understand

1. Dynamic response of first and second order processes
2. The difference between interacting and non-interacting systems
3. Characteristics of various controller modes
4. Method and significance of controller tuning
5. Relation between valve stem position and the fluid flow through a control valve

Course Outcomes: Students will able to

1. Evaluate the step response and frequency response of first order systems
2. Identify the difference between closed loop and open loop operations
3. Choose the controller mode for a particular requirement in the system
4. Determine the characteristics of a second order under damped system
5. Determine the controller parameters using tuning rules
6. Analyze the stability of a system using Frequency response (Bode Plots)

LIST OF EXPERIMENTS

(Minimum of EIGHT experiments has to be performed)

1. Determination of order and time constant of a first order system
2. Determination of frequency response of a first order system
3. Determination of Bode plot from dynamic studies of first order system
4. Study the effect of PID controller parameters on closed loop servo response
5. Feedback controller tuning by Zeigler-Nicholas method
6. Feedback controller tuning by Cohen-Coon method
7. Determination of dynamics of interacting liquid level system
8. Determination of dynamics of non-interacting liquid level system
9. Determination of dynamics of a first order system (thermometer)

10. Determination of second order under damped characteristics from the dynamics of second order system (manometer/thermo well)
11. Determination of pneumatic valve characteristics
12. Study of cascade control system

Note: Experiments (1 to 5) can be designed on any of the following computer controlled systems.

a. Liquid-Level
b. Flow
c. Temperature
d. Pressure

16CH C 23

PROCESS MODELING SIMULATION LABORATORY

Instruction	3 hours per week
Duration of End Examination	3 Hours
Semester End Examination	50 Marks
Continuous Internal Evaluation	25 Marks
Credits	2

Course Objectives: This practical course helps the students to understand the:

1. Application of their MATLAB coding skills learnt in previous semesters, as a prerequisite for problem solving.
2. Formulation of a process models leading to ODE.
3. Formulation of a process models leading to linear equations.
4. Formulation of a process models leading to non-linear equations.
5. Open-loop simulation through MATLAB coding for simple chemical processes.

Course outcomes: At the end of the course, the students will be able to:

1. Develop and solve ODE for chemical processes and apply numerical methods to solve them using MATLAB.
2. Develop and solve linear equations and apply numerical methods to solve them using MATLAB.
3. develop and solve non-linear equations and apply numerical methods to solve them using MATLAB.
4. Fit polynomial functions to given data and solve by regression analysis using MATLAB.
5. Solve the process models developed for open-loop simulation of selected unit operations in chemical engineering using MATLAB.

LIST OF EXERCISES

Note: The Programs are to be written in "MATLAB"
PART – A: Chemical engineering problem solving [All exercises are compulsory]

1. Solution of ordinary differential equations by Euler's method, Runge-Kutta fourth order method
2. Solution of set of linear simultaneous equations by Gauss-elimination, Gauss-Jordan and Gauss-Seidel methods

3. Solution of non-linear equations by bisection, Newton Raphson and Richmond iteration methods
4. Curve fitting by Linear Least square analysis.

PART – B: Application for open loop simulation(Any four process systems)

1. Two-heated Tanks in series
2. Three CSTRs in series at isothermal, constant holdup condition
3. Batch Reactor
4. Vapor Liquid Equilibrium
5. Ideal Binary distillation
6. Gas-Phase Pressurized CSTR

PART – C: Demonstration of process simulators

Application of process simulation software packages. Understanding the basic concepts and steps involved for developing process flowsheet.

Suggested Reading:

1. Applied numerical methods with MATLAB for engineers and scientists, Steven C. Chapra, 3rd ed., Tata-McGraw Hill Edu. Pvt.Ltd., New Delhi, 2012.
2. Process Modeling, Simulation and Control for Chemical Engineers, by William L. Luyben, 2nd ed., McGraw Hill Pub. Co., New Delhi, 1990.
3. Numerical methods in engineering and science (with programs in C, C++ and MATLAB), B. S. Grewal, 10th ed., Khanna pub., Nagpur, 2014.