GUJARAT TECHNOLOGICAL UNIVERSITY

BRANCH NAME: Chemical Engineering (05)
SUBJECT NAME: Chemical Reaction Engineering-II
SUBJECT CODE: 2170501
B.E. 7th Semester

Type of course: Chemical Engineering

Prerequisite: A course on Chemical Reaction Engineering-I (2160506)

Rationale: In this subject emphasis is on heterogeneous reaction engineering and non-ideal reactors, catalysis, leading finally to design considerations. The first part of this subject deals with residence time distributions, and how they can be used to characterize and design non-ideal reactors. Kinetics and design of reactors for non-catalytic fluid-fluid and fluid-particle reactions follows. And the last part of the subject deals with catalysis and catalytic reaction kinetics.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
				Theory Marks			Practical Marks			
L	T	P	C	ESE (E)	PA (M)		ESE (V)		PA (I)	
					PA	ALA	ESE	OEP		
3	0	3	6	70	20	10	20	10	20	150

Contents:

Sr. No.	Content	Total Hrs.	% Weightage
1.	**Non-Ideal Flow:** Basics of non-ideal flow, Residence time distribution, stimulus response techniques, The E,F and C Curves, their interrelationship, conversion in non-ideal flow reactors, Dispersion model, Chemical Reaction and dispersion, Intensity of fluid mixing. Tanks in series model, Deviation from plug flow, Models for real stirred tanks.	**10**	**18**
	Heterogeneous Non-Catalytic Systems:		
2.	**Heterogeneous Reactions: Introduction:** Rate steps involved in heterogeneous systems, Overall rate expression for linear and non linear process, contacting patterns for two-phase systems.	**4**	**9**
3.	**Fluid-Fluid systems:** Rate equation, rate equation for straight mass transfer, kinetic regimes of mass transfer and chemical reaction, rate equation for mass transfer and chemical reactions, film conversion parameter, fluid-fluid reactor design.	**8**	**14**
4.	**Fluid-Particle systems:** Fluid partial reaction kinetics, selection of a model, Shrinking Core Model for unchanging and changing size spherical partials, Diffusion through gas film and through ash layer controlling, Chemical reaction controlling, Shrinking core model, its limitations, Determination of rate controlling step.	**8**	**14**

Solid Catalyzed systems:			
5.	**Catalysis:** Catalysts, Physical properties of catalyst, surface area, void volume, solid density, pore volume distribution, Classification and preparation of catalyst, catalyst promoters. Catalyst inhibitors, Catalyst poisons, Nature and Mechanism of Catalytic reactions.	**9**	**18**
6.	**Solid-Catalysed reactions: Kinetics:** Adsorption isotherms and rates of adsorption and desorption. Kinetic regimes, rate equations for surface kinetics, Pore diffusion, determining rate controlling step, experimental methods for finding rates, product distribution in multiple reactions.	**9**	**18**
7.	**Introduction to Catalytic Reactors:** Packed bed catalytic reactors, fluidized bed reactors, trickle beds, slurry reactors.	**6**	**9**

Suggested Specification table with Marks (Theory):

Distribution Of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
15	20	20	10	5	0

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Octave Levenspiel, "Chemical Reaction Engineering", 3rd Edition, John Wiley & Sons (Asia) pvt. Ltd.
2. H. Scott Fogler, "Elements of Chemical Reaction Engineering" 3rd Edition November, Prentice Hall of India Pvt Ltd
3. J.M.Smith, "Chemical Engineering Kinetics", 2nd edition, McGraw-Hill
4. L. D. Schmidt, the Engineering of Chemical Reactions, Oxford Press.
5. J. J. Carberry, "Chemical and Catalytic Reaction Engineering", McGraw Hill, New York, 1976.

Course Outcome:

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

- Analyze the RTD studies for any flow reactor, to predict the deviation from ideal reactors by evaluating the dispersion number
- Analyze the various contacting pattern for two phase system and predict the rate equation for heterogeneous reactions.
- Analyze the best kinetic regimes for mass transfer and reaction for a given reaction and predict the rate equation.
- Predict the rate controlling step for the fluid - particle reactions.
- Classify catalysts and predict physical properties of catalyst, surface area, void volume, solid density pore volume distribution.
- Understand the nature and mechanism of catalytic reactions.

List of Experiments:

Experiments based on

- RTD studies in different reactors.
- Various models for non-ideal flow.
- Heterogeneous reaction kinetics etc.

Design based Problems (DP)/Open Ended Problem:

Open ended problems based on following topics can be selected,

- Study of various stimulus response techniques
- Study of resistance steps involved in heterogeneous reactions
- Finding rate expressions for given chemical reaction with mass transfer.
- And similar topics based on syllabus

Major Equipment:

- Tubular reactor for RTD analysis
- CSTR for RTD analysis
- Packed beds for RTD analysis etc

List of Open Source Software/learning website:

- NPTEL lecture series
- Literature available on Chemical Reaction Engineering
- MIT Open course lecture on Chemical Reaction Engineering

ACTIVE LEARNING ASSIGNMENTS:

Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.

GUJARAT TECHNOLOGICAL UNIVERSITY

BRANCH NAME: Chemical Engineering (05)
SUBJECT NAME: PROCESS EQUIPMENT DESIGN-II
SUBJECT CODE: 2170502
B.E. 7th SEMESTER

Type of course: Chemical Engineering

Prerequisite: The student should have basic understanding of Unit Operations of Chemical Engineering and mechanical properties associated with the material.

Rationale:

Equipment design involves modifications and additions to existing plants or creating design layouts of plant / equipments. With rapid rate of increase in the advancement of knowledge, it is important that the students should know the relevant application for equipment design. 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	Examination Marks						Total Marks
L	T	P	C	Theory Marks			Practical Marks			
				ESE (E)	PA (M)		ESE (V)		PA (I)	
					PA	ALA	ESE	OEP		
3	3	0	6	70	20	10	20	10	20	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	**Introduction :** Concept of internal & external design pressure, design stress & design temperature, Different types of equipments, Static & rotary equipments, Different types of static equipments, Various mechanical properties of material, Different methods of fabrication, Different types of welding joints, Joint efficiency, Radiography.	**04**	**8**
2	**Mechanical design of Pressure vessel:** Introduction of ASME Code sec-VIII, DIV-I & IS-2825, Classification of pressure vessel as per IS-2825,Mechanical design of Shell: shell subjected to internal pressure, Graphical & analytical method for Shell subjected to external pressure, design of shell for external pressure with & without stiffening ring, Different types of head, their selection criteria, Mechanical design of heads: Heads subjected to internal pressure, Graphical & analytical method for heads subjected to external pressure, Different types of Nozzles, their selection criteria, Design of nozzle pipe, Design of reinforcement pad by area for area method, Different types of flanges, Different types of standard flanges, their important features & selection criteria, Different types of flange facings & their	**20**	**37**

	selection criteria, Different types of gaskets, their selection criteria, Design of ring flange.		
3	**Mechanical design of Reaction Vessel**: Mechanical design of shell, head, Jacket, coil, agitator, nozzle, body flange, etc., Different types of agitators & their selection criteria, Different types of agitator shaft sealing system & their selection criteria, Different types of power transmission system, Determination of power required for agitation, shaft diameter, blade thickness, etc., Different types of jackets & their selection criteria, Selection between coil & jacket	**06**	**11**
4	**Mechanical design of Storage Tank:** Classification of storage tank as per IS-803, Capacity of storage tank, its diameter & height, Design of shell and bottom plate for storage tank, Design of Self supported conical roof, Design of structured supported conical roof as per API 620, Selection of column, girders and rafters, Roof curb angel, Floating roof.	**05**	**9**
5	**Mechanical design of Shell & Tube Heat Exchangers:** Mechanical design of Shell, tube, tube sheet, head, channel shell, , etc. of shell & tube heat exchanger	**05**	**9**
6	**Mechanical design of Vertical tall tower (Distillation Column):** Mechanical design of shell, head, tray support, nozzle, body flange, for Vertical tall tower, Determination of shell thicknesses at various heights for tray tower & packed tower in case of internal & external pressure, Different types of tray supports & their selection criteria, design of horizontal structural member with periphery ring type packing support	**08**	**15**
7	**Supports :** Different types of supports, Mechanical design of bracket support, skirt, support & saddle support	**06**	**11**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
7	21	21	7	14	-

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Process Equipment Design - Vessel Design - L.E. Brownell & E.H.Young, First Edition.
2. Illustrated Process Equipment Design by S B Thakore, Second edition,.
3. Process Equipment Design - M.V.Joshi & V V Mahajani, Third edition.
4. Process Equipment Design (Mechanical Aspects) By B.C.Bhattacharya.

Course Outcome:

After learning the course the students should be able to:

1. Design process equipment and modify the design of existing equipment to new process conditions or new required capacity.
2. Build a bridge between theoretical and practical concepts used for designing the equipment in any process industry.
3. Create understanding of equipment design with mechanical concept.
4. Review the importance of design concepts in process industry.

List of Tutorials:

- Prediction of Physical properties
- Estimation of various design parameters for various equipments.
- Solution of various problem used in the designing of equipments.

List of Open Source Software/learning website:

- Students can refer to video lectures available on the websites including NPTEL lecture series.
- Students can refer to the CDs available with some reference books for the solution of problems using software/spreadsheets. Students can develop their own programs/spreadsheets for the solution of problems.
- MIT Open course lecture on Equipment design.
- Literature available for Process design of equipment in plant / industry.

ACTIVE LEARNING ASSIGNMENTS:

The tutorials will be given to students which will cover entire content of the subject. The students will be required to solve all problems given in the tutorials. Some of the problems they have to solve using programming language or software. The list is given below:

- Excel Spreadsheets
- Polymath
- Matlab/Scilab, etc.

GUJARAT TECHNOLOGICAL UNIVERSITY

BRANCH NAME: Chemical Engineering (05)
SUBJECT NAME: Plant Design & Project Engineering
SUBJECT CODE: 2170503
B.E. 7th Semester

Type of course: Chemical Engineering

Prerequisite: A course on Plant Design and Project Economics (170503)

Rationale: In this subject emphasis is made on economics in the process industries and in design work, because applied economics and plant design deal with practical application of chemical engineering principles. The first part of the course is deal with design aspect, selection of equipments, importance of utilities and auxiliaries for any process industries and second part is deal with various cost involve in industrial processes, capital investments and investment returns, cost estimation and optimum economic design methods. Plant design project economics is introduced to fill the gap between technical knowledge commercial sustainability of any plant by imparting brief description of any plant from top to bottom approach ,where syllabus covers details from equipment design, plant layout, selection criteria's& economics required to make system feasible.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
				Theory Marks			Practical Marks			
L	T	P	C	ESE (E)	PA (M)		ESE (V)		PA (I)	
					PA	ALA	ESE	OEP		
3	0	0	3	70	20	10	0	0	0	100

Contents:

Sr. No.	Content	Total Hrs.	Percentage Weightage
1.	**Introduction:** Basic considerations in chemical engineering plant design, optimization and feasibility of plant design.	**3**	**6**
2.	**Process design aspects:** Selection of process-factors affecting process selection. Types of project design, Importance of Laboratory development pilot plant, safety factors, types of flow diagrams.	**4**	**7**
3.	**Selection of process equipments:** Standard versus special equipment-material of construction for process equipments, selection criteria, and specification sheets..	**4**	**7**
4.	**Process auxiliaries and Process utilities** Piping design, layout, and supports for piping insulations. Pipe fittings, types of valves, selection of valves, process control and instrumentation control system design. Process water, boiler feed water, water treatment, waste treatment and disposal, disposal, steam, oil heating system, chilling plant, compressed air and vacuum.	**6**	**12**

5.	**Plant location and layout:** Factors affecting plant location, factors in planning layouts, principles of plant layout, use of scale models	**7**	**13**
6.	**Cost estimation:** Cash flow and cumulative cash position for industrial operations, factors affecting estimation of investment and production cost, breakeven point and its significance, total capital investment, fixed and working capital investment &their estimations, type of estimates, cost indexes, method for estimating capital investment,	**8**	**15**
7.	**Estimation of total product cost** Estimation of total product cost: manufacturing cost, general expenses, Manufacturing cost: direct production cost, fixed charges, plant overhead cost.	**6**	**11**
8.	**Depreciation:** Types of depreciation, Method for determining depreciation: straight line method, decline balance method, sum of the year digit method, shrinking fund method etc, single unit and group depreciation, adjustment of depreciation account, evaluation of depreciation methods	**6**	**11**
9.	**Profitability, alternative investments and replacement:** Methods for profitability evaluation, Evaluation of Break Even Point, % rate of return, Practical factors in alternative investment and replacement Studies.	**4**	**7**
10.	**Project management*:*** Planning of project schedule by BAR CHART, Inventory control scheduling a project using CPM/PERT methods.	**6**	**11**

Suggested Specification table with Marks (Theory):

Distribution Of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
30	15	15	5	5	0

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. M.S. Peters and Timmerhaus, "Plant design and Economics for Chemical Engineers",McGraw Hill 3rd Edition.
2. F.C. Vibrandt and C.E. Dryden, "Chemical Engineering Plant Design", McGraw Hill Fifth Edition.
3. Coulson & Richardson's Chemical Engineering Volume 6, Butterworth-Heinemann, 1999 ,3rd Edition
4. Industrial Engineering and Management by O. P. Khanna, Dhanpat Rai & Sons, 1985 7th Edition.
5. Project Engineering: Suhas Mokashi ,Mcmillan Publisher.

Course Outcome:

After successfully completion if this course students will be able to,

- To learn basic economic concept, to understand and apply this concepts in the project works undertaken and to chemical engineering situation by solving problem
- Carry out the primary techno-economic feasibility of project.
- Select appropriate process for a project.
- Differentiate the equipment and able to prepare specification sheet.
- Understand piping and instrumentation diagram.
- Evaluate the project cost including capital investment, product cost, breakeven point, depreciation cost for equipment and the total project cost.
- Control and schedule of the project using CPME/PERT technique, calculations.
- Solve problem on profitability and replacement analysis.

List of Open Source Software/learning website:

- NPTEL lecture series
- Literature available on Plant design and project Economics.
- MIT Open course lecture on Chemical Reaction Engineering

ACTIVE LEARNING ASSIGNMENTS:

Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.

GUJARAT TECHNOLOGICAL UNIVERSITY

BRANCH NAME: Chemical Engineering (05)
SUBJECT NAME: Computer Aided Process Synthesis
SUBJECT CODE: 2170507
B.E. 7th SEMESTER

Type of course: Chemical Engineering

Prerequisite: Basics of heat transfer, mass transfer and reaction engineering

Rationale:
Chemical process design requires the selection of a series of processing steps and their integration to form a complete manufacturing system. This course emphasizes selection of the steps as individual operations and their integration to form an efficient process. Also, the process will normally operate as part of an integrated manufacturing site consisting of a number of processes serviced by a common utility system.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks			Practical Marks			
				ESE (E)	PA (M)		ESE (V)		PA (I)	
					PA	ALA	ESE	OEP		
4	0	3	7	70	20	10	20	10	20	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	**The Design Process:** Objectives, Design Opportunities, Steps in Product Process Design, Environmental, Protection, Safety Considerations, Engineering Ethics, Role of Computers	8	11
2	**Reactor Design and Reactor Network Synthesis:** Objectives, Reactor Models, Reactor Design for Complex Configurations, Reactor Network Design Using the Attainable Region	8	11
3	**Synthesis of Separation Trains:** Objectives, Introduction ,Phase Separation of Reactor Effluent, Criteria for Selection of Separation Methods, Selection of Equipment, Sequencing of Ordinary Distillation for the Separation of Nearly Ideal Fluid Mixtures, Heuristics for Determining Favourable Sequences, Marginal Vapour Rate Method,Complex and thermally coupled distillation,Sequencing of Ordinary Distillation for the Separation of Nearly Non-Ideal Fluid Mixtures	14	19

4	**Synthesis of Heat Exchanger Networks:** Objectives, Basic Heat Exchanger Network Synthesis (HENS), Minimum Utility Targets, Temperature Interval Method, Hohmann / Lochart Composite Curves (HCC), Grand Composite Curves (GCC), Pinch Design Approach to Inventing a Network, Networks for Maximum Energy Recovery, Minimum Number of Exchangers, Stream Splitting, Threshold and Optimum Approach Temperature, Derivation of Network Superstructures for Minimization of Annual Costs, Multiple Utility Design Problems	**24**	**34**
5	**Energy Integrated Distillation Processes:** Heat Integrated Distillation Trains, Impact of Pressure, Multi Effect Distillation, Heat Pumping, Vapour Recompression and Reboiler Flashing, Positioning of Heat Engines and Heat Pumps	**8**	**11**
6	**Design and Scheduling of Batch Processes:** Objectives, Introduction, Design of Batch Process Units, Design of Reactor-Separator Processes, Design of Single Product Processing Sequences, Design of Multi-Product Processing Sequencing	**10**	**14**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
14	14	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)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Lorens T. Biegler, E. Ignacio grossmann, Arthur W. Westerberg, Systematic Methods of Chemical Process Design, Prentice Hall International.
2. Warren D. Seider, J. D. Seader, Daniel R. Lewin, Product and Process Design Principles: Synthesis, Analysis, and Evaluation, 2nd Edition, Wiley.
3. Robin Smith, Chemical Process: Design and Integration, Wiley.
4. James M. Douglas, Conceptual Design of Chemical Processes, McGraw Hill International, 1988.

Course Outcome:
After learning the course the students should be able to:

1. Learn the basic heat exchanger network synthesis (HENS).
2. Develop the pinch design approach to inventing a network.
3. Study the derivation of network structures for minimization of annual costs.
4. Configure the multiple utility design problems.
5. Learn about the Environment Protection, Safety Considerations & Engineering Ethics.

6. Learn about the Energy Integrating in reactor networks
7. Understand the Energy Integrated Distillation Processes.
8. Understand the concept of reactor network synthesis. And enable to do the reactor network design using the attainable region.
9. Understand the production of multiple products
10. Design the Batch scheduling.
11. Understand the Design and Scheduling of Batch Processes.

List of Experiments:
Tutorials/Presentation/Practical based on above topics.

Design based Problems (DP)/Open Ended Problem:
Students are free to select any area of design for the Synthesis of Optimal chemical process based on chemical engineering applications.
1. Synthesis of Optimal Chemical Reactor Networks.
2. Synthesis and Optimization of Distillation Column Sequences for Separation of Multicomponent Products.
3. Synthesis of heat exchanger networks.

Major Equipment:

Computers software (Excel Spread-sheet, GAMS, etc.)

List of Open Source Software/learning website:

- Students can refer to video lectures available on the websites including NPTEL lecture series.
- Students can refer to the CDs available with some reference books for the solution of problems using software/spreadsheets.
- Most of these examples do not require specialist software and can be performed on spreadsheet software. Students can develop their own programs/spreadsheets for the solution of problems. Students can use GAMS software for the solution of LP, NLP, MILP, etc. optimization problems

ACTIVE LEARNING ASSIGNMENTS: Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.

GUJARAT TECHNOLOGICAL UNIVERSITY

BRANCH NAME: CHEMICAL ENGINEERING (05)

SUBJECT NAME: ENERGY TECHNOLOGY

SUBJECT CODE: 2170505

B.E. 7th SEMESTER

Type of course: Chemical Engineering.

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. This subject will guide students in the same direction.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks			Practical Marks			
				ESE (E)	PA (M)		PA (V)		PA (I)	
					PA	ALA	ESE	OEP		
3	0	0	3	70	20	10	0	0	0	100

Content:

Sr. No.	Topic	Teaching Hours	(%) Weightage
1.	**An Introduction to Energy Sources:** Energy sources (conventional & non-conventional), renewable energy resources, primary & secondary energy sources, energy chain, energy demand, national energy strategy & plan, energy management, energy audit & conservation	**02**	**4**
2.	**Definitions, Units & Measures** Proximate & ultimate analysis, calorific values, rank of coal, coking & caking, gasification, basis for reporting results of analysis, units & conversion factors	**03**	**6**
3.	**Solid Fuels** Wood & charcoal, peat, lignite, sub-bituminous & bituminous coals, semianthracite and anthracite coals, cannel & boghead coal, origin of coal, composition of coal, analysis & properties of coal, problems	**03**	**6**

4.	**Processing of Solid Fuels** Coal preparation, washability curve, dry & wet washing methods of coal, washer efficiency, gasification & liquefaction of solid fuels, problems.	**04**	**7**
5.	**Solar Energy** Solar radiation & related terms, measurement of solar radiation, solar energy collectors – flat plate collector, air collector, collectors with porous absorbers, concentrating collectors, applications & advantages of various collectors, selective absorber coatings, solar energy storage systems (thermal, electrical, chemical & mechanical), solar pond, applications of solar energy.	**04**	**8**
6.	**Wind Energy** Basic principles, power in wind, force on blades & turbines, wind energy conversion, site selection, basic components of wind energy conversion systems (WECS), classification of WECS, wind energy collectors, applications of wind energy	**04**	**7**
7.	**Energy from Biomass** Introduction, energy plantation, biomass conversion technologies, photosynthesis, biogas generation, factors affecting biogas generation, classification of biogas plants & their comparisons, types of biogas plants , biogas from plant wastes, community plants & site selection, digester design considerations, design calculations, methods of maintaining & starting biogas plants, properties & utilisation of biogas, thermal gasification of biomass, pyrolysis, alternative liquid fuels	**05**	**9**
8.	**Geothermal Energy** Geothermal resources, hydrothermal resources, liquid dominated systems, geopressured resources, petrothermal systems, magma resources, energy conservation & comparison with other resources, applications of geothermal energy	**05**	**9**
9.	**Energy from Oceans** Principle, OTEC, methods (open cycle & close cycle) energy from tides, components of tidal power plants, operation, methods of utilization of tidal energy, storage, ocean waves, wave energy conversion devices	**04**	**8**
10.	**Fuel Cell** Introduction, hydrogen – oxygen fuel cell, ion exchange membrane cell, fossil fuel cell, molten carbonate cell, advantages & disadvantages, conversion efficiency, polarisation, type of electrodes, applications of fuel cells	**05**	**9**
11.	**Hydrogen & Methanol** Properties of Hydrogen, production and application of	**05**	**9**

	hydrogen, thermochemical methods, fossil fuel methods, solar methods, storage & transportation, safety & management.		
12.	**Magneto Hydro-Dynamic (MHD) Power Generation** Principle, MHD system, open cycle system, closed cycle system, design problems & developments, advantages, materials for MHD generators, magnetic field & super conductivity	**05**	**9**
13.	**Nuclear Energy** Fission, fusion, fuel for nuclear fission reactor (exploration, mining, milling, concentrating, refining, enrichment, fuel fabrication, fuel use, reprocessing, waste disposal), Nuclear fuel cycle, storage & transportation, uranium enrichment process, nuclear reactor power plant, fast breeder reactor, boiling water reactor, pressurised heavy & light water reactor, Nuclear waste management.	**05**	**9**

Reference Books:

1. Fuels & combustion by Samir Sarkar, Orient Longmans(1974)
2. Solar Energy by Sukatame, Tata McGraw Hill, New Delhi
3. Energy Technology by Rao & Parulaker.
4. Energy Sources 2nd Ed. by G. D. Rai, Khanna Publications, New Delhi

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
30	15	15	5	5	0

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Course Outcome: After learning the course the students should be able:

1. To make students aware about all the energy sources available and the ways to turn it into power.
2. To understand the principles behind different non conventional energy sources.
3. To make student understand the global scenario of energy sector and to work on better economical solutions of it.
4. To utilize the renewable energy in problem solving where conventional energy are not fruitful and require replacement.
5. To understand the design and applications of power generating devices using renewable energy sources as per industrial requirement.

List of Tutorials:

Students can select any type of renewable energy and try to find out the application in chemical or other industries and can suggest modification in the energy production techniques, which can make the surrounding of plant environmental friendly and economical at the same time. Each group of students are expected to create a way to utilize renewable energy in innovative way and prepare report of project assigned to his/her group. In addition, each group is expected to give a power point presentation during the semester. The presenter will be selected randomly just prior to the presentation.

List of Open Source Software/learning website:

- **S**tudents can refer to video lectures available on various websites including NPTEL.
- Students can refer to the CDs which are available with some reference books for the solutions of problems using softwares. Students can develop their own programs for the solutions using excel, Chemical and other simulation softwares.

ACTIVE LEARNING ASSIGNMENTS:

Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.

GUJARAT TECHNOLOGICAL UNIVERSITY

BRANCH NAME: CHEMICAL ENGINEERING (05)
SUBJECT NAME: NANO TECHNOLOGY
SUBJECT CODE: 2170508
B.E. 7th SEMESTER

Type of course: Nanoscience and Nanotechnology

Prerequisite: Fundamental of Chemistry, thermodynamics and material Science

Rationale: To make students understand the use of concept of nanotechnology and nanoscience in the chemical industries and in consumer products. Nanotechnology will mean complete control of the structure of matter, building complex objects with molecular precision. In current scenario, engineers are finding a wide variety of ways to deliberately make materials at the nanoscale to take advantage of their enhanced properties such as higher strength, lighter weight, increased control of light spectrum, and greater chemical reactivity then their larger scale counterparts. So in order to move towards advanced materials and devices students should have the knowledge of nano science.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks			Practical Marks			
				ESE (E)	PA (M)		PA (V)		PA (I)	
					PA	ALA	ESE	OEP		
3	0	0	3	70	20	10	0	0	0	100

Content:

Sr. No.	Content	Total Hrs.	% Weightage
1.	**Generic methodologies for nanotechnology: classification and fabrication:** Introduction and classification, Summary of the electronic properties of atoms and solids, Effects of the nanometer length scale, Fabrication methods, Preparation, safety and storage issues.	8	15
2.	**Strategies for the scalable synthesis of quantum dots and related Nano dimensional materials –I:** Introduction, Defining Nano dimensional Materials, Potential Uses for Nanodimensional Materials, The General Methods Available for the Synthesis of Nanodimensional, Materials, Precipitative Methods, Reactive Methods in High Boiling Point Solvents.	9	16
3.	**Strategies for the scalable synthesis of quantum dots and related Nano dimensional materials –II:** Reactive methods in high boiling point solvents 20, hydrothermal and solvothermal methods 22, gas-phase synthesis of semiconductor nanoparticles 23, synthesis in a structured medium 24, the suitability of such methods for scaling	9	16

4.	**Nanotechnology and ceramics :** Introduction, Synthesis, Vapor Condensation Methods, Sputtering, Laser Method, Spray Pyrolysis, Thermo Chemical /Flame Decomposition of metal organic Precursors methods	**9**	**16**
5.	**Tools to characterize nanomaterials:** X-Ray Diffraction (XRD), Scanning Electron Microscopy, Transmission Electron Microscopy, Atomic Force Microscopy,UV/Visible Spectroscopy	**9**	**18**
6.	**Applications of nanomaterials:** Cosmetics and Consumer Goods, Nano Sensor, Nano catalysts, Water Treatment and the Environment, Paints, Food and Agriculture Industry.	**10**	**19**

Reference Books:

1. Nanostructures and Nanomaterials: Synthesis, Properties and Applications by G. Cao, Imperial College Press, 2004.
2. Nanoscale Science and technology by Robert Kelsall (editor), Ian W. Hamley (co-editor), Mark Geoghegan (co-editor) , ISBN: 978-0-470-85086-2
3. The Chemistry of Nanomaterials: Synthesis, Properties and Applications by C. N. R. Rao, A. Muller, A. K. Cheetham, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, ISBN: 3-527-30686-2.
4. Nanoscale Materials in Chemistry Edited by Kenneth J. Klabunde, John Wiley & Sons, Inc., ISBNs: 0-471-38395-3 (Hardback); 0-471-22062-0.
5. Textbook of Nanoscience and Nanotechnology, B.S. Muty, P. Shankar, Baldev Raj, B.B Rath and James Murday, University Press, IIM (ISBN-978 81 7371 738 3).
6. Introduction to Nanotechnology by Charles P. Poole Jr and. Frank J. Owens, Wiley-Inter science, 2003.

Suggested Specification table with Marks (Theory):

Distribution Of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
15	20	30	5	-	-

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Course Outcome: After learning the course the students should be able:

1) Understand bulk and Nanostructured materials.
2) Understand synthesis of nanomaterial with different.
3) Understand the basic principal of various characterization technique.
4) Understand the use of nanoscience and nanotechnology for various applications.
5) Students can understand the difficulties in synthesizing Nano particles and can work in the field of commercialization of Nano materials.

List of Tutorials:

Students can study different synthesis techniques for producing nanoparticles depending upon the types and properties of Nano materials. Each group of students are expected to create a way to synthesize nanomaterials in cheap and easier way at laboratory level and prepare report of project assigned to his/her group even students can study the instruments related to the characterization of Nano materials. In addition, each group is expected to give a power point presentation during the semester. The presenter will be selected randomly just prior to the presentation.

List of Open Source Software/learning website:

- **S**tudents can refer to video lectures available on various websites including NPTEL.
- Students can refer to the CDs which are available with some reference books for the solutions of problems using software. Students can develop their own programs for the solutions using excel, Chemical and other simulation software.

ACTIVE LEARNING ASSIGNMENTS:

Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.