RAJIV GANDHI PROUDYOGIKI VISHWAVIDYALAYA, BHOPAL

Credit Based Grading System

Chemical Engineering, VI-Semester

CM-6001 Process Equipment Design-I

Course Objective

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

Unit I: Mechanics of materials- Stress- Strain relationships of elastic materials subjected to tensile, compressive and shear forces, Elastic and plastic deformation, General design considerations; Design of shell, bottom plates, self supported, and column supported roofs, wind girder, nozzles and other accessories.

Unit II: Unfired pressure vessel- Pressure vessel codes, classification of pressure vessels, Design of cylindrical and spherical shells under internal and external pressures; Selection and design of flat plate, tor-spherical, ellipsoidal, and conical closures, compensations of openings. High pressure Vessels: Stress analysis of thick walled cylindrical shell, Design of monobloc and multiplayer vessels.

Unit III: Tall vertical & horizontal vessels-Pressure, dead weight, wind, earthquake and eccentric loads and induced stresses; combined stresses, Shell design of skirt supported vessels. Vessel supports; Design of skirt, lug, and saddle supports.

Unit IV: Bolted Flanges- Types of Flanges, and selection, Gaskets, Design of non- standard flanges, specifications of standard flanges. Fabrication of Equipment; major fabrication steps; welding, non-destructive tests of welded joints, inspection and testing, vessel lining, materials used in fabrication of some selected chemical industries.

References:

1. Brownell, N.E and Young, H.E; Process Equipment Design; John Wiley
2. Bhattacharya, B.C; Introduction of Chemical Equipment Design; CBS Publishers, Delhi.
3. Perry RH; Hand book of Chemical Engg; Mc Graw Hill Pub
4. I.S.: 2825-1969 – Code For Unfired Pressure Vessels.
5. I.S. 803-1962, Code for Practice for Design, Fabrication and Erection of Vertical and Mild Steel Cylindrical Welded Oil Storage Tanks.
6. Joshi, M.V.; Process Equipment Design.
7. Ludwig EE; Applied Process Design in Chemical and Petrochemical

RAJIV GANDHI PROUDYOGIKI VISHWAVIDYALAYA, BHOPAL

Credit Based Grading System

Chemical Engineering, VI-Semester

CM-6002 Mass Transfer-II

Course Objective

The objective of this subject is to introduce the undergraduate students with the most important separation equipments in the process industry, and provide proper understanding of unit operations. At the end of study the student will come to know basic operations of cooling towers, dryer, as well as design of a adsorber and calculations involved in liquid-liquid extraction and solid liquid extraction.

Unit I Adsorption: Adsorption theories, types of adsorbent; activate d carbon, silica and molecular sieves. Batch and column, adsorption; Break through curves, Liquid percolation and gas adsorption, calculation.

Unit II Humidification and Dehumidification: Humidification : General Theory, psychometric chart, fundamental concepts in humidification & dehumidification, wet bulb temperature, adiabatic saturation temperature, measurement of humidification calculation of humidification operation, cooling towers and related equipments.

Unit III Drying: Equilibrium mechanism theory of drying, drying rate curve. Batch and continuous drying for tray driers, Drum dryers, spray and tunnel dryers.

Unit IV Leaching and Crystallization: Leaching: solid liquid equilibrium, Equipment, principles of leaching, concurrent and counter current systems and calculation of number of stage required. Crystallization: Factors governing nucleation and crystal growth rates, controlled – growth of crystals, super saturation curve, principle and design of batch and continuous type equipment.

Unit V Liquid –Liquid extraction: Liquid equilibrium & Ponchon – Savarit method, Mc-Cabe-Thiele method, packed & spray column, conjugate curve and tie line data, plait point, ternary liquid – liquid extraction, operation and design of extraction towers analytical & graphical solution of single and multistage operation in extraction, Co-current, counter current and parallel current system.

References:

1. Mc-Cabe, W.L. Smith J.M. – Unit Operation in Chemical Engg.,5th edition Tata McGraw Hill Hogakusha, Tokyo, New Delhi.
2. Coulson J.M. Richardson J.F.-Chemical Engg., Vol 2, Edition-2, Butserworth Heinmann, Oxford, New Delhi.
3. Treybal R.E. – Mass Transfer Operation – 3rd edition, Mc. Graw Hill Book Co. New York.

List of Experiment (Pl. expand it):

1. To study the rate dissolution of a rotating cylinder and then to calculate the mass transfer coefficient.

2. Study of Adsorption in a packed bed for a Solid liquid system, plotting the breakthrough curve of adsorption for a given system
3. To study the performance of forced draft water-cooling tower.
4. To study the drying characteristics of a wet granular material using natural and forced circulation in tray dryer.
5. Studies on solid-liquid extraction column.
6. To study the yield of crystals of a saturated solution using open tank type agitated batch crystallizer.
7. To study the yield of crystals of a saturated solution using Swenson walker crystallizer.
8. To draw the tie lines and plot equilibrium curve for given ternary system.
9. Liquid- Liquid extraction in a packed column for co-current and counter current flow of binary systems.
10. To Study on Liquid-Liquid extraction on a spray Extraction Column.

Note: Each student should perform at least eight experiments from the above list.

RAJIV GANDHI PROUDYOGIKI VISHWAVIDYALAYA, BHOPAL

Credit Based Grading System

Chemical Engineering, VI-Semester

CM-6003 Chemical Process Control

Course Objective

The objective this course enables the students to know about control methods and make the students knowledgeable in various types of measuring instruments used in chemical process industries.

Unit I Construction and characteristics of final control elements such as Proportional, Integral, PD, PID controllers, pneumatic control valve, principles and construction of pneumatic and electronic controllers.

Unit II Process instrumentation diagrams and symbols, process instrumentation for process equipments such as Distillation column Absorption column, Heat Exchanger, Reactors, Evaporators, fluid storage vessels.

Unit III Laplace Transform, Linear open loop system, first order system and their transient response. Dynamic response of a pure capacitive process, Transportation lag, Dynamic response of a first order lag system.

Unit IV Second order system and their transient response. Interacting and non-interacting system. Linear closed loop system, block diagram of closed loop transfer function, controllers, transient response of closed loop system.

Unit V Stability concept, Routh stability criterion, relative stability, Hurwitz stability criterion, Nyquist's stability criterion. Root locus technique, introduction to frequency response, Bode diagram, Bode stability criterion, gain and phase margins, Ziegler Nichols controller setting.

References:

1. Coughnower & Koppel – Process System Analysis and Control- McGraw Hill, New York.
2. D. P. Eckman – Automatics Process Control – McGraw Hill, New York.
3. Peter Harriot – Process Control – McGraw Hill, New York.
4. J. J. Nagrath & M. Gopal; Control System Engineering.

List of Experiment (Pl. expand it):

1. To study the characteristics of control valves (linear, quick opening, etc)
2. To study the dynamics of liquid level systems of non-interacting and interacting types.

3. To study the response of mercury in glass thermometer with and without a thermowell.
4. To study the characteristics of an electronic PID controller.
5. To study the characteristics of a current to pneumatic converter.
6. To study the effectiveness of computer control of a distillation column.
7. To study the effectiveness of a computer control of a heat exchanger.
8. To study to effectiveness of a computer control of a chemical reactor
9. To study to dynamics of a pressure tanks.
10. To calibrate an air purged liquid level indicator.

Note: Each student should perform at least eight experiments out of the above list.

RAJIV GANDHI PROUDYOGIKI VISHWAVIDYALAYA, BHOPAL

Credit Based Grading System

Chemical Engineering, VI-Semester

CM-6004 Chemical Reaction Engineering-I

Course Objective

To apply knowledge from calculus, differential equations, thermodynamics, general chemistry, and material and energy balances to solve reactor design problems, To examine reaction rate data to determine rate laws, and to use them to design chemical reactors, To simulate several types of reactors in order to choose the most appropriate reactor for a given need, To design chemical reactors with associated cooling/heating equipment.

Unit I Classification of reactions: Definition of reaction rate, Variables affecting the rate, concept of reaction equillibria, order of reaction and its determination, theoretical study of reaction rates, collision and activated complex theory, Mechanism of reaction series, Parallel and consecutive reaction, autocatalytic reactions, chain reaction, polymerization reaction.

Unit II Interpretation of kinetic data: Integral and differential method of analysis, variable volume reactions, total pressure method of kinetic analysis

Unit III Classification of Reactors: Concept of ideality, Development of design equations for\batch, semi batch, tubular and stirred tank reactor, Design of Isothermal and non-isothermal batch, CSTR, PFR, reactors. Combination of reactors, Reactors with recycle, yield and selectivity in multiple reactions.

Unit IV Multiple Reactions in Batch: continuous stirred tank and Plug flow reactors uniqueness of steady state in continuous stirred tank reactor, optimum temperature progression, thermal characteristics of reactors.

Unit V Non ideal reaction: RTD dispersion model, Tank and series model, recycle model, segregated flow in mixed models, evaluation of RTD characteristics.

References:

1. Smith J.M; Chemical Engineering Kinetics; Mc Graw Hill.
2. Denbigh & Turner K.G; Chemical Reaction Theory an Introduction; United Press.
3. Copper & Jeffery's GVJ; Chemical Kinetics and Reactor Engineering; Prentice Hall
4. Levenspiel O; Chemical Reaction Engg; Willey Eastern, Singapore.
5. Houghen Watson & Ragatz; Chemical Process Principles Part Iii; Asian Pub-House Mumbai
6. Fogler H.S; Elements of Chemical Reaction Engineering; PHI

List of Experiment (Pl. expand it):

1. To determine velocity rate constant of the hydrolysis of ethyl acetate by sodium hydroxide.
2. To study the rate constant of hydrolysis of an ester-catalyzed by acid.
3. Determine the rate constant and order of reaction between Potassium per sulphate and potassium iodide.
4. To study temperature dependency of rate constant, evaluation of activation energy and verification of Arrhenius law.
5. To study a consecutive reaction system (hydraulic model)
6. To study a parallel reaction system (hydraulic model)
7. To study a homogeneous reaction in a semi-batch reactor under isothermal conditions.
8. Study of non catalytic homogeneous saponification reaction in CSTR.
9. To study a non-catalytic homogeneous reaction in a plug flow reactor.
10. To study the residence time distribution behavior of a back mix reactor.
11. To study the RTD behavior of a tubular reactor.
12. To study the RTD behavior of a packed bed reactor.
13. To study the behavior of a continuous flow reactor system-three reactor in series.
14. To study the kinetics of thermal decomposition of calcium carbonate.
15. To study a homogeneous catalytic reaction in a batch reactor under adiabatic conditions.
16. Study of non catalytic saponification reaction in a tubular flow reactor.

Note: Each student should perform at least eight experiments out of the above list.

RAJIV GANDHI PROUDYOGIKI VISHWAVIDYALAYA, BHOPAL

Credit Based Grading System

Chemical Engineering, VI-Semester

Elective-II CM-6005 (I) Process Safety & Hazards Management

Course Objective

To know about Industrial safety programs and toxicology, Industrial laws, regulations and source models. To understand about fire and explosion, preventive methods, relief and its sizing methods. To analyze industrial hazards and its risk assessment.

Unit- I Introduction: Origin of process hazards, Laws Codes, Standards, Case Histories, Properties of Chemicals, and Health hazards of industrial substances.

Unit - II Toxicology: Toxic materials and their properties, effect of dose and exposure time, relationship and predictive models for response, Threshold value and its definitions, material safety data sheets, industrial hygiene evaluation.

Unit – III Fire & Explosion: Fire and explosion hazards, causes of fire and preventive methods. Flammability characteristics of chemical, fire and explosion hazard, rating of process plant. Propagation of fire and effect of environmental factors, ventilation, dispersion, purifying and sprinkling, safety and relief valves.

Unit- IV Energy Hazards: Electrical hazards, noise hazard, radiation hazard in process operations, hazards communication to employees, plant management and maintenance to reduce energy hazards. Risk Analysis: Component and plant reliability, event probability and failure, plant reliability, risk analysis,

Unit- V Analysis and Assessment: HAZOP AND HAZAN, event and consequence analysis (vapour cloud modelling) Designing for safety, measurement and calculation of risk analysis. Hazard Assessment: Failure distribution, failure data analysis, modeling for safety, safety training, emergency planning ad disaster management, case studies.

References:

1. Crawl D.A. and Louvar J.A., “Chemical process safety fundamentals with applications, Prentice Hall of India, New Delhi.
2. Wentz, C.A., “Safety health and environmental protection,” McGraw Hill, 2001.
3. Smith, B.D., “Design of equilibrium state process,” McGraw Hill l.
4. Van Winkle, “Distillation,” McGraw Hill.

RAJIV GANDHI PROUDYOGIKI VISHWAVIDYALAYA, BHOPAL

Credit Based Grading System

Chemical Engineering, VI-Semester

Elective-II CM-6005 (II) Fuel Cell Technology

Course Objective:

Provide thorough understanding of performance characteristics of fuel cell power plant and its components. Outline the performance and design characteristics and operating issues for various fuel cells. Discuss the design philosophy and challenges to make this power plant economically feasible. Thus at the successful end of the course, the students will have sufficient knowledge for working in a fuel cell industry or R&D organization.

Unit I Fundamentals:

Electrochemical cells, electrolytic cell, galvanic cell, construction and working, Faraday's law of electrolysis, problems on displacements, classification of electrodes , Nernst's theory, single electrode potential, EMF of cell, EMF series, common types of cells.

Unit II Introduction:

Potential convention, current conventions, equilibrium constants, mass transfer limited current, Cottrell equation, factors affecting reaction rate and current, mechanism involving electrode reactions, reversibility kinetics, Butler-Volmer Equations, Tafel plots , Tafel equation, equations governing modes of mass transfer –Nernst-Planck Equation, Ficks law of diffusion, concept of Helmholtz plane.

Unit III Hydrogen fuel cell:

Introduction to hydrocarbon based fuel cells, general issues, fossil fuels and other fuels used, H2production from renewable sources and storage, working of H2 fuel cell, safety issues, steam reforming, internal reforming, cost estimation.

Unit IV Proton Exchange Membrane Fuel Cell:

Introduction, working of PEMFC, electro chemistry modeling, exchange current density, local surface over potential (activation loss), current & mass conversion, gas phase species diffusivity, membrane phase electronic conductivity, osmotic drag coefficient, back diffusion flux, fuel crossover.

Unit V Solid Oxide Fuel Cells:

Introduction, working of SOFC, modeling SOFC(Nernst voltage, current distribution, & over potential of electrolytes, electric potential field) modeling current transport & potential field, activation over potential, cell potential, treatment of electrolyte interface, Ohmic over potential, Activation over potential, Modeling electrochemical potential.

Unit VI Fuel Cell Systems:

System processes –fuel processing, rejected heat utilization, system optimization – pressurization, temperature utilization, heat recovery, fuel cell networking, life cycle analysis of fuel cells, hybrid systems –introduction to microbial and enzymatic fuel cell.

References:

1. Bokris John O' m, Srinivasan S., "Fuel cells-their electrochemistry", McGraw Hill 1969.
2. Appleby A.J. Fralkes F. R., "Fuel cell handbook", Van Nostrand Reinhold 1989.
3. Kordesch Karl, Simader G., "Fuel cells and their applications", VCH publications 1996. 41
4. U S Department of energy, "Fuel cell: a handbook",
5. Leo J.M.J., Blomen, Mugerwa M. N., "Fuel cell systems", Plenum Press

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Credit Based Grading System

Chemical Engineering, VI-Semester

Elective-II CM-6005 (III) Non-Conventional Energy Sources

Course Objective

To make the students understand the different non-conventional energy source advancement and their application in worldwide. To gain knowledge on environmental problems due use of conventional energy sources.

Unit- I Introduction:

Energy scenario of supply and demand in India and the world, energy consumption in various sectors, potential of non-conventional energy resources.

Unit- II Solar Energy:

Solar radiation and its measurement, limitations in the applications of Solar Energy, Solar collectors – types, and constructional details. Solar water heating, applications of Solar Energy for heating, drying, space cooling, water desalination, solar concentrators, photovoltaic power generation using silicon cells.

Unit- III Wind Power:

Principle of energy from wind, windmill construction and operational details and electricity generation and mechanical power production. Tidal Power: Its meaning, causes of tides and their energy potential, enhancement of tides, power generation from tides and problems. Principles of ocean thermal energy conversion (OTEC) analysis and sizing of heat exchangers for OTEC.

Unit- IV Geothermal Energy:

Geo technical wells and other resources dry rock and hot aquifer analysis , harnessing geothermal energy resources.

Unit- V Energy Storage and Distribution:

Importance, biochemical, chemical, thermal, electric storage. Fuel cells, distribution of energy.

References:

1. Rai, G.D., “Non-Conventional Energy Sources,” Khanna Publishers, New Delhi, 2001.
2. Twiddle, J. Weir, T. “Renewable Energy Resources,” Cambridge University Press, 1986.
3. Kreith, F. and Kreider, J. F., “Principles of Solar Engineering,” McGraw Hill, 1978.
4. Veziroglu, N., “Alternative Energy Sources,” Volume 5 & 6, McGraw-Hill, 1978.
5. Sarkar, S., “Fuels and Combustion,” 2nd ed., Orient Longman, 1989.

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Credit Based Grading System

Chemical Engineering, VI-Semester

Elective-II CM-6005 (IV) IPR (Intellectual Property Rights)

Course Objective

Acquaint the students with the basic concepts of Intellectual Property Rights; and sensitize the students with the emerging issues in IPR and the rationale for the protection of IPR.

UNIT I Introduction

Introduction and Justifications of IPR, Nature of IP, Major forms of IP- *Copyright, Patent, Trade Marks Designs, Geographic indication, layout design of Semi conductors, Plant varieties, Concept & Meaning of Intellectual Property.*

Major international documents relating to the protection of IP - *Berne Convention, Paris Convention, TRIPS*. The World Intellectual Property Organization (WIPO).

UNIT II Copyright

Meaning and historical development of copyright , Subject matter , Ownership of copyright, Term of copyright, Rights of owner, Economic Rights, Moral Rights. Assignment and licence of rights, Infringement of copyright, Exceptions of infringement, Remedies, *Civil, Criminal, Administrative*, Registration Procedure.

UNIT III Patents

Meaning and historical development,. Criteria for obtaining patents, Non patentable inventions, Procedure for registration, Term of patent, Rights of patentee, Compulsory licence, Revocation, Infringement of patents, Exceptions to infringement, Remedies, Patent office and Appellate Board.

UNIT IV – Trade Marks, Designs & GI

Trade Marks: Functions of marks, Procedure for registration, Rights of holder, Assignment and licensing of marks, Infringement, Trade Marks Registry and Appellate Board.

Designs: Meaning and evolution of design protection, Registration, Term of protection, Rights of holder, unregistered designs.

Geographical Indication: Meaning and evolution of GI, Difference between GI and Trade Marks, Registration, Rights, Authorised user.

UNIT V Contemporary Issues & Enforcement of IPR

IPR & sustainable development, The Impact of Internet on IPR. IPR Issues in biotechnology, E-Commerce and IPR issues, Licensing and enforcing IPR, Case studies in IPR

Course Outcome:

1. Students will be able to understand Primary forms of IPR
2. Students will be able to asses and critique some basic theoretical justification for major forms of IP Protection
3. Students will be able to compare and contrast the different forms of IPR in terms of key differences and similarities.
4. Students will be able understand the registration procedures related to IPR.
5. Students will be exposed to contemporary issues and enforcement policies in IPR.

References:

1. P. Narayanan, Intellectual Property Law, Eastern Law House

2. . Neeraj Pandey and Khushdeep[Dharni, Intellectual Property Rights, PHI, 2014

3. N.S Gopalakrishnan and T.G. Agitha, Principles of Intellectual Property, Eastern Book Co. Lucknow, 2009.

4. Anand Padmanabhan, Enforcement of Intellectual Property, Lexis Nexis Butterworths, Nagpur, 2012.

5. Managing Intellectual Property The Strategic Imperative, Vinod V. Sople, PHI.

6. Prabuddha Ganguli, " Intellectual Property Rights" Mcgraw Hill Education, 2016.

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Credit Based Grading System

Chemical Engineering, VI-Semester

CM-6006 Chemical Process Plant Simulation Lab-II

CM- 6006- Chemical Process Plant Simulation Lab -II

Simulation Study of Various Chemical Process with the help of following Softwares :

1. Introduction to Polymath software: Understanding its function & working.
2. Prodyn: Understanding its functions & working.
3. Practical exercise using MATLAB, CHEMCAD & Prosimulator.

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Credit Based Grading System

Chemical Engineering, VI-Semester

CM-6007 Creativity and Entrepreneurship Development

Course Objective:

- Understand and use tools for generating entrepreneurial ideas and problem solving.
- Understand and use tools for the selection of ideas.
- Understand and gain the skills that are needed to implement ideas in today's society
- Understand Entrepreneurship's part in process that includes idea generation and implementation.
- Understand the concept of Entrepreneurship and its place in today's society

Course Outcomes:

- Recognize an opportunity for a user group and frame an appropriate design challenge that addresses the need for the user.
- Practice observation, interview and empathy skills to evolve a thorough understanding of the needs of the user.
- Share and integrate team leanings.
- Generate, develop and describe creative ideas that address the design challenge.

Syllabus:

1. The concept of Entrepreneurship, its history and its place in society.
2. The concept of Entrepreneurship and its relation to concept of innovation.
3. Creative processes for idea generation and problem solving.
4. Business plan.
5. Role of creativity, innovation and business research.
6. Entrepreneurship opportunities in contemporary business environment.

Reference Books :

1. Dollinger M.J. "Entrepreneurship strategies and resources," 3rd edition Pearson Education New Delhi.
2. Panda, Shiba charan "Entrepreneurship development", Anmol publication New Delhi.
3. Richard Blundel & Nigel locket, "Exploring Entrepreneurship : practices & perspectives Oxford.
4. Charles E. Banford & Garry D. Bruton, "Entrepreneurship – A small business Approach, Mcgrawhill Education.
5. P. Narayana Reddy, "Entrepreneurship" : Text and cases, Cengage learning
6. Rajeev Roy, "Entrepreneurship" Oxford.