Course No.	Course Name	L-T-P - Credits	Year of Introduction
MA201	LINEAR ALGEBRA AND COMPLEX ANALYSIS	3-1-0-4	2016

Prerequisite : Nil

Course Objectives

COURSE OBJECTIVES

- To equip the students with methods of solving a general system of linear equations.
- To familiarize them with the concept of Eigen values and diagonalization of a matrix which have many applications in Engineering.
- To understand the basic theory of functions of a complex variable and conformal Transformations**.**

Syllabus

Analyticity of complex functions-Complex differentiation-Conformal mappings-Complex integration-System of linear equations-Eigen value problem

Expected outcome .

At the end of the course students will be able to
(i) solve any given system of linear equations
(ii) find the Eigen values of a matrix and how to diagonalize a matrix
(iii) identify analytic functions and Harmonic functions.
(iv)evaluate real definite Integrals as application of Residue Theorem
(v) identify conformal mappings(vi) find regions that are mapped under certain Transformations

Text Book:

Erwin Kreyszig: Advanced Engineering Mathematics, 10th ed. Wiley

References:

1.Dennis g Zill&Patric D Shanahan-A first Course in Complex Analysis with Applications-Jones&Bartlet Publishers
2.B. S. Grewal. Higher Engineering Mathematics, Khanna Publishers, New Delhi.
3.Lipschutz, Linear Algebra,3e **(** Schaums **Series)**McGraw Hill Education India 2005
4.Complex variables introduction and applications-second edition-Mark.J.Owitz-Cambridge Publication

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Complex differentiation Text 1[13.3,13.4] Limit, continuity and derivative of complex functions	3	
	Analytic Functions	2	
	Cauchy–Riemann Equation(Proof of sufficient condition of analyticity & C R Equations in polar form not required)-Laplace's Equation	2	
	Harmonic functions, Harmonic Conjugate	2	15%
II	Conformal mapping: Text 1[17.1-17.4] Geometry of Analytic functions Conformal Mapping,	1	
	Mapping $w = z^2$ conformality of $w = e^z$.	2	15%

	The mapping $w = z + \frac{1}{z}$ Properties of $w = \frac{1}{z}$ Circles and straight lines, extended complex plane, fixed points Special linear fractional Transformations, Cross Ratio, Cross Ratio property-Mapping of disks and half planes Conformal mapping by $w = \sin z$ & $w = \cos z$ (Assignment: Application of analytic functions in Engineering)	1 3 3	
FIRST INTERNAL EXAMINATION			
III	Complex Integration. Text 1[14.1-14.4] [15.4&16.1] Definition Complex Line Integrals, First Evaluation Method, Second Evaluation Method Cauchy's Integral Theorem(without proof), Independence of path(without proof), Cauchy's Integral Theorem for Multiply Connected Domains (without proof) Cauchy's Integral Formula- Derivatives of Analytic Functions(without proof)Application of derivative of Analytical Functions Taylor and Maclaurin series(without proof), Power series as Taylor series, Practical methods(without proof) Laurent's series (without proof)	2 2 2 2 2	15%
IV	Residue Integration Text 1 [16.2-16.4] Singularities, Zeros, Poles, Essential singularity, Zeros of analytic functions Residue Integration Method, Formulas for Residues, Several singularities inside the contour Residue Theorem. Evaluation of Real Integrals (i) Integrals of rational functions of $\sin\theta$ and $\cos\theta$ (ii)Integrals of the type $\int_{-\infty}^{\infty} f(x)dx$ (Type I, Integrals from 0 to ∞) (Assignment : Application of Complex integration in Engineering)	2 4 3	15%
SECOND INTERNAL EXAMINATION			
V	Linear system of Equations Text 1(7.3-7.5) Linear systems of Equations, Coefficient Matrix, Augmented Matrix Gauss Elimination and back substitution, Elementary row operations, Row equivalent systems, Gauss elimination-Three possible cases, Row Echelon form and Information from it.	1 5	20%

	Linear independence-rank of a matrix Vector Space-Dimension-basis-vector space$\mathbf{R^3}$ Solution of linear systems, Fundamental theorem of non-homogeneous linear systems(Without proof)-Homogeneous linear systems (Theory only	2 1	
VI	Matrix Eigen value Problem Text 1.(8.1,8.3 &8.4) Determination of Eigen values and Eigen vectors-Eigen space Symmetric, Skew Symmetric and Orthogonal matrices –simple properties (without proof) Basis of Eigen vectors- Similar matrices Diagonalization of a matrix-Quadratic forms- Principal axis theorem(without proof) (Assignment-Some applications of Eigen values(8.2))	3 2 4	20%
END SEMESTER EXAM			

QUESTION PAPER PATTERN:

Maximum Marks : 100 Exam Duration: 3 hours

The question paper will consist of 3 parts.

Part A will have 3 questions of 15 marks each uniformly covering modules I and II. Each question may have two sub questions.

Part B will have 3 questions of 15 marks each uniformly covering modules III and IV. Each question may have two sub questions.

Part C will have 3 questions of 20 marks each uniformly covering modules V and VI. Each question may have three sub questions.

Any two questions from each part have to be answered.

Course No.	Course Name	L-T-P - Credits	Year of Introduction
MA202	Probability distributions, Transforms and Numerical Methods	3-1-0-4	2016

Prerequisite: Nil

Course Objectives

- To introduce the concept of random variables, probability distributions, specific discrete and continuous distributions with practical application in various Engineering and social life situations.
- To know Laplace and Fourier transforms which has wide application in all Engineering courses.
- To enable the students to solve various engineering problems using numerical methods.

Syllabus

Discrete random variables and Discrete Probability Distribution.
Continuous Random variables and Continuous Probability Distribution.
Fourier transforms.
Laplace Transforms.
Numerical methods-solution of Algebraic and transcendental Equations, Interpolation.
Numerical solution of system of Equations. Numerical Integration, Numerical solution of ordinary differential equation of First order.

Expected outcome .

After the completion of the course student is expected to have concept of
(i) Discrete and continuous probability density functions and special probability distributions.
(ii) Laplace and Fourier transforms and apply them in their Engineering branch
(iii) numerical methods and their applications in solving Engineering problems.

Text Books:

1. Miller and Freund's "Probability and statistics for Engineers"-Pearson-Eighth Edition.
2. Erwin Kreyszig, "Advanced Engineering Mathematics", 10th edition, Wiley, 2015.

References:

1. V. Sundarapandian, "Probability, Statistics and Queuing theory", PHI Learning, 2009.
2. C. Ray Wylie and Louis C. Barrett, "Advanced Engineering Mathematics"-Sixth Edition.
3. Jay L. Devore, "Probability and Statistics for Engineering and Science"-Eight Edition.
4. Steven C. Chapra and Raymond P. Canale, "Numerical Methods for Engineers"-Sixth Edition-Mc Graw Hill.

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	**Discrete Probability Distributions.** (Relevant topics in section 4.1,4,2,4.4,4.6 Text1)		
	Discrete Random Variables, Probability distribution function, Cumulative distribution function.	2	
	Mean and Variance of Discrete Probability Distribution.	2	
	Binomial Distribution-Mean and variance.	2	
	Poisson Approximation to the Binomial Distribution. Poisson distribution-Mean and variance.	2	15%

II	**Continuous Probability Distributions.** (Relevant topics in section 5.1,5.2,5.5,5.7 Text1) Continuous Random Variable, Probability density function, Cumulative density function, Mean and variance. Normal Distribution, Mean and variance (without proof). Uniform Distribution.Mean and variance. Exponential Distribution, Mean and variance.	 2 4 2 2	15%
FIRST INTERNAL EXAMINATION			
III	**Fourier Integrals and transforms. (**Relevant topics in section 11.7, 11.8, 11.9 Text2) Fourier Integrals. Fourier integral theorem (without proof). Fourier Transform and inverse transform. Fourier Sine & Cosine Transform, inverse transform.	 3 3 3	15%
IV	**Laplace transforms. (**Relevant topics in section 6.1,6.2,6.3,6.5,6.6 Text2**)** Laplace Transforms, linearity, first shifting Theorem. Transform of derivative and Integral, Inverse Laplace transform, Solution of ordinary differential equation using Laplace transform. Unit step function, second shifting theorem. Convolution Theorem (without proof). Differentiation and Integration of transforms.	 3 4 2 2 2	15%
SECOND INTERNAL EXAMINATION			
V	**Numerical Techniques**.(Relevant topics in section.19.1,19.2,19.3 Text2) Solution Of equations by Iteration, Newton- Raphson Method. Interpolation of Unequal intervals-Lagrange's Interpolation formula. Interpolation of Equal intervals-Newton's forward difference formula, Newton's Backward difference formula.	 2 2 3	20%
VI	**Numerical Techniques**. (Relevant topics in section 19.5,20.1,20.3, 21.1 Text2) Solution to linear System- Gauss Elimination, Gauss Seidal Iteration Method. Numeric Integration-Trapezoidal Rule, Simpson's 1/3 Rule. Numerical solution of firstorder ODE-Euler method, Runge-Kutta Method (fourth order).	 3 3 3	20%
END SEMESTER EXAM			

QUESTION PAPER PATTERN:

Maximum Marks : 100 Exam Duration: 3 hours

The question paper will consist of 3 parts.

Part A will have 3 questions of 15 marks each uniformly covering modules I and II. Each question may have two sub questions.

Part B will have 3 questions of 15 marks each uniformly covering modules III and IV. Each question may have two sub questions.

Part C will have 3 questions of 20 marks each uniformly covering modules V and VI. Each question may have three sub questions.

Any two questions from each part have to be answered.

Course code	Course Name	L-T-P - Credits	Year of Introduction
HS200	Business Economics	3-0-0-3	2016

Prerequisite: Nil

Course Objectives

- To familiarize the prospective engineers with elementary Principles of Economics and Business Economics.
- To acquaint the students with tools and techniques that are useful in their profession in Business Decision Making which will enhance their employability;
- To apply business analysis to the "firm" under different market conditions;
- To apply economic models to examine current economic scenario and evaluate policy options for addressing economic issues
- To gain understanding of some Macroeconomic concepts to improve their ability to understand the business climate;
- To prepare and analyse various business tools like balance sheet, cost benefit analysis and rate of returns at an elementary level

Syllabus

Business Economics - basic concepts, tools and analysis, scarcity and choices , resource allocation, marginal analysis, opportunity costs and production possibility curve. Fundamentals of microeconomics - Demand and Supply Analysis, equilibrium, elasticity, production and production function, cost analysis, break-even analysis and markets. Basics of macroeconomics - the circular flow models, national income analysis, inflation, trade cycles, money and credit, and monetary policy. Business decisions - investment analysis, Capital Budgeting decisions, forecasting techniques and elementary Balance Sheet and taxation, business financing, international investments

Expected outcome .

A student who has undergone this course would be able to

i. make investment decisions based on capital budgeting methods in alignment with microeconomic and macroeconomic theories.
ii. able to analyse the profitability of the firm, economy of operation, determination of price under various market situations with good grasp on the effect of trade cycles in business.
iii. gain knowledge on Monetary theory, measures by RBI in controlling interest rate and emerging concepts like Bit Coin.
iv. gain knowledge of elementary accounting concepts used for preparing balance sheet and interpretation of balance sheet

Text Books

1. Geetika, Piyali Ghosh and Chodhury, *Managerial Economics*, Tata McGraw Hill, 2015
2. Gregory Mankiw, *Principles of Macroeconomics*, Cengage Learning, 2006.
3. M.Kasi Reddy and S.Saraswathi, *Economics and Financial Accounting*. Prentice Hall of India. New Delhi.

References:

1. Dornbusch, Fischer and Startz, *Macroeconomics*, McGraw Hill, 11th edition, 2010.
2. Khan M Y, *Indian Financial System*, Tata McGraw Hill, 7th edition, 2011.
3. Samuelson, *Managerial Economics*, 6th edition, Wiley
4. Snyder C and Nicholson W, *Fundamentals of Microeconomics*, Cengage Learning (India), 2010.
5. Truett, Managerial Economics: Analysis, Problems, Cases, 8th Edition, Wiley
6. Welch, *Economics: Theory and Practice* 7th Edition, Wiley
7. Uma Kapila, *Indian Economy Since Independence, 26th Edition: A Comprehensive and Critical Analysis of India's Economy*, 1947-2015
8. C Rangarajan, *Indian Economy, Essays on monetary and finance*, UBS Publishers'Distributors, 1998
9. A.Ramachandra Aryasri, *Managerial Economics and Financial Analysis*, Tata McGraw-Hill, New Delhi.
10. Dominick Salvatore, *Managerial Economics in Global Economy*, Thomas Western College Publishing, Singapore.
11. I.M .Pandey, *Financial Management*, Vikas Publishing House. New Delhi.
12. Dominick Salvatore, *Theory and Problems of Micro Economic Theory.* Tata Mac Graw-Hill, New Delhi.
13. T.N.Hajela.*Money, Banking and Public Finance.* Anne Books. New Delhi.
14. G.S.Gupta. *Macro Economics-Theory and Applications.* Tata Mac Graw- Hill, New Delhi.
15. Yogesh, Maheswari, *Management Economics* , PHI learning, NewDelhi, 2012
16. Timothy Taylor , *Principles of Economics*, 3rd edition, TEXTBOOK MEDIA.
17. Varshney and Maheshwari. *Managerial Economics*. Sultan Chand. New Delhi

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	**Business Economics** and its role in managerial decision making-meaning-scope-relevance-economic problems-scarcity Vs choice (2 Hrs)-Basic concepts in economics-scarcity, choice, resource allocation- Trade-off-opportunity cost-marginal analysis- marginal utility theory, Law of diminishing marginal utility -production possibility curve (2 Hrs)	4	15%
II	**Basics of Micro Economics I** Demand and Supply analysis-equillibrium-elasticity (demand and supply) (3 Hrs.) -Production concepts-average product-marginal product-law of variable proportions- Production function-Cobb Douglas function-problems (3 Hrs.)	6	15%
FIRST INTERNAL EXAMINATION			
III	**Basics of Micro Economics II** Concept of costs-marginal, average, fixed, variable costs-cost curves-shut down point-long run and short run (3 Hrs.)- Break Even Analysis-Problem-Markets-Perfect Competition, Monopoly and Monopolistic Competition, Oligopoly-Cartel and collusion (3 Hrs.).	6	15%
IV	**Basics of Macro Economics** - Circular flow of income-two sector and multi-sector models- National Income Concepts-Measurement methods-problems-Inflation, deflation (4 Hrs.)-Trade cycles-Money-stock and flow concept-Quantity theory of money-Fischer's Equation and Cambridge Equation -velocity of circulation of money-credit control methods-SLR, CRR, Open Market Operations-Repo and Reverse Repo rate-emerging concepts in money-bit coin (4 Hrs.).	8	15%

SECOND INTERNAL EXAMINATION			
V	**Business Decisions I**-Investment analysis-Capital Budgeting-NPV, IRR, Profitability Index, ARR, Payback Period (5 Hrs.)- Business decisions under certainty-uncertainty-selection of alternatives-risk and sensitivity- cost benefit analysis-resource management (4 Hrs.).	9	20%
VI	**Business Decisions II** Balance sheet preparation-principles and interpretation-forecasting techniques (7 Hrs.)-business financing-sources of capital- Capital and money markets-international financing-FDI, FPI, FII-Basic Principles of taxation-direct tax, indirect tax-GST (2 hrs.).	9	20%
END SEMESTER EXAM			

Question Paper Pattern

Max. marks: 100, Time: 3 hours

The question paper shall consist of three parts

Part A
4 questions uniformly covering modules I and II. Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

Part B
4 questions uniformly covering modules III and IV. Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

Part C
6 questions uniformly covering modules V and VI. Each question carries 10 marks
Students will have to answer any four questions out of 6 (4X10 marks =40 marks)

Note: In all parts, each question can have a maximum of four sub questions, if needed.

Course code	Course Name	L-T-P-Credits	Year of Introduction
HS210	LIFE SKILLS	2-0-2	2016

Prerequisite : Nil

Course Objectives

- To develop communication competence in prospective engineers.
- To enable them to convey thoughts and ideas with clarity and focus.
- To develop report writing skills.
- To equip them to face interview & Group Discussion.
- To inculcate critical thinking process.
- To prepare them on problem solving skills.
- To provide symbolic, verbal, and graphical interpretations of statements in a problem description.
- To understand team dynamics & effectiveness.
- To create an awareness on Engineering Ethics and Human Values.
- To instill Moral and Social Values, Loyalty and also to learn to appreciate the rights of others.
- To learn leadership qualities and practice them.

Syllabus

Communication Skill: Introduction to Communication, The Process of Communication, Barriers to Communication, Listening Skills, Writing Skills, Technical Writing, Letter Writing, Job Application, Report Writing, Non-verbal Communication and Body Language, Interview Skills, Group Discussion, Presentation Skills, Technology-based Communication.

Critical Thinking & Problem Solving: Creativity, Lateral thinking, Critical thinking, Multiple Intelligence, Problem Solving, Six thinking hats, Mind Mapping & Analytical Thinking.

Teamwork: Groups, Teams, Group Vs Teams, Team formation process, Stages of Group, Group Dynamics, Managing Team Performance & Team Conflicts.

Ethics, Moral & Professional Values: Human Values, Civic Rights, Engineering Ethics, Engineering as Social Experimentation, Environmental Ethics, Global Issues, Code of Ethics like ASME, ASCE, IEEE.

Leadership Skills: Leadership, Levels of Leadership, Making of a leader, Types of leadership, Transactions Vs Transformational Leadership, VUCA Leaders, DART Leadership, Leadership Grid & leadership Formulation.

Expected outcome

The students will be able to

- Communicate effectively.
- Make effective presentations.
- Write different types of reports.
- Face interview & group discussion.
- Critically think on a particular problem.
- Solve problems.
- Work in Group & Teams
- Handle Engineering Ethics and Human Values.
- Become an effective leader.

Resource Book:

Life Skills for Engineers, Complied by ICT Academy of Kerala, McGraw Hill Education (India) Private Ltd., 2016

References:

- Barun K. Mitra; (2011), *"Personality Development & Soft Skills*", First Edition; Oxford Publishers.
- Kalyana; (2015) "*Soft Skill for Managers*"; First Edition; Wiley Publishing Ltd.
- Larry James (2016); "*The First Book of Life Skills*"; First Edition; Embassy Books.
- Shalini Verma (2014); *"Development of Life Skills and Professional Practice"*; First Edition; Sultan Chand (G/L) & Company
- John C. Maxwell (2014); "The 5 Levels of Leadership", Centre Street, A division of Hachette Book Group Inc.

Course Plan

Module	Contents	Hours L-T-P L	P	Sem. Exam Marks
I	Need for Effective Communication, Levels of communication; Flow of communication; Use of language in communication; Communication networks; Significance of technical communication, Types of barriers; Miscommunication; Noise; Overcoming measures, Listening as an active skill; Types of Listeners; Listening for general content; Listening to fill up information; Intensive Listening; Listening for specific information; Developing effective listening skills; Barriers to effective listening skills. **Technical Writing:** Differences between technical and literary style, Elements of style; Common Errors, **Letter Writing:** Formal, informal and demi-official letters; business letters, **Job Application**: Cover letter, Differences between bio-data, CV and Resume, **Report Writing:** Basics of Report Writing; Structure of a report; Types of reports. **Non-verbal Communication and Body Language:** Forms of non-verbal communication; Interpreting body-language cues; Kinesics; Proxemics; Chronemics; Effective use of body language **Interview Skills**: Types of Interviews; Ensuring success in job interviews; Appropriate use of non-verbal communication, **Group Discussion**: Differences between group discussion and debate; Ensuring success in group discussions, **Presentation Skills**: Oral presentation and public speaking skills; business presentations, **Technology-based Communication:** Netiquettes: effective e-mail messages; power-point presentation; enhancing editing skills using computer software.	2 3	2 4 4	See evaluation scheme

II	Need for Creativity in the 21st century, Imagination, Intuition, Experience, Sources of Creativity, Lateral Thinking, Myths of creativity Critical thinking Vs Creative thinking, Functions of Left Brain & Right brain, Convergent & Divergent Thinking, Critical reading & Multiple Intelligence. Steps in problem solving, Problem Solving Techniques, Problem Solving through Six Thinking Hats, Mind Mapping, Forced Connections. Problem Solving strategies, Analytical Thinking and quantitative reasoning expressed in written form, Numeric, symbolic, and graphic reasoning, Solving application problems.	2 2	2 2	
III	Introduction to Groups and Teams, Team Composition, Managing Team Performance, Importance of Group, Stages of Group, Group Cycle, Group thinking, getting acquainted, Clarifying expectations. Group Problem Solving, Achieving Group Consensus. Group Dynamics techniques, Group vs Team, Team Dynamics, Teams for enhancing productivity, Building & Managing Successful Virtual Teams. Managing Team Performance & Managing Conflict in Teams. Working Together in Teams, Team Decision-Making, Team Culture & Power, Team Leader Development.	3 3	2 2	
IV	Morals, Values and Ethics, Integrity, Work Ethic, Service Learning, Civic Virtue, Respect for Others, Living Peacefully. Caring, Sharing, Honesty, Courage, Valuing Time, Cooperation, Commitment, Empathy, Self-Confidence, Character Spirituality, Senses of 'Engineering Ethics', variety of moral issued, Types of inquiry, moral dilemmas, moral autonomy, Kohlberg's theory, Gilligan's theory, Consensus and controversy, Models of Professional Roles, Theories about right action, Self-interest, customs and religion, application of ethical theories. Engineering as experimentation, engineers as responsible experimenters, Codes of ethics, Balanced outlook on. The challenger case study, Multinational corporations, Environmental ethics, computer ethics,	3 3 3	2 2	

	Weapons development, engineers as managers, consulting engineers, engineers as expert witnesses and advisors, moral leadership, sample code of Ethics like ASME, ASCE, IEEE, Institution of Engineers(India), Indian Institute of Materials Management, Institution of electronics and telecommunication engineers(IETE), India, etc.	3		
V	Introduction, a framework for considering leadership, entrepreneurial and moral leadership, vision, people selection and development, cultural dimensions of leadership, style, followers, crises. Growing as a leader, turnaround leadership, gaining control, trust, managing diverse stakeholders, crisis management Implications of national culture and multicultural leadership Types of Leadership, Leadership Traits. Leadership Styles, VUCA Leadership, DART Leadership, Transactional vs Transformational Leaders, Leadership Grid, Effective Leaders, making of a Leader, Formulate Leadership	4 2 2	2 2	
END SEMESTER EXAM				

EVALUATION SCHEME

Internal Evaluation

(Conducted by the College)

Total Marks: 100

Part – A

(To be started after completion of Module 1 and to be completed by 30th working day of the semester)

1. Group Discussion – Create groups of about 10 students each and engage them on a GD on a suitable topic for about 20 minutes. Parameters to be used for evaluation is as follows;

(i)	Communication Skills	–	10 marks
(ii)	Subject Clarity	–	10 marks
(iii)	Group Dynamics	-	10 marks
(iv)	Behaviors & Mannerisms	-	10 marks

(Marks: 40)

Part – B

(To be started from 31st working day and to be completed before 60th working day of the semester)

2. Presentation Skills – Identify a suitable topic and ask the students to prepare a presentation (preferably a power point presentation) for about 10 minutes. Parameters to be used for evaluation is as follows;

(i)	Communication Skills*	-	10 marks
(ii)	Platform Skills**	-	10 marks
(iii)	Subject Clarity/Knowledge	-	10 marks

(Marks: 30)

* Language fluency, auditability, voice modulation, rate of speech, listening, summarizes key learnings etc.

** Postures/Gestures, Smiles/Expressions, Movements, usage of floor area etc.

Part – C

(To be conducted before the termination of semester)

3. Sample Letter writing or report writing following the guidelines and procedures. Parameters to be used for evaluation is as follows;

(i)	Usage of English & Grammar	-	10 marks
(ii)	Following the format	-	10 marks
(iii)	Content clarity	-	10 marks

(Marks: 30)

External Evaluation

(Conducted by the University)

Total Marks: 50 Time: 2 hrs.

Part – A

Short Answer questions

There will be one question from each area (five questions in total). Each question should be written in about maximum of 400 words. Parameters to be used for evaluation are as follows;

(i) Content Clarity/Subject Knowledge
(ii) Presentation style
(iii) Organization of content

(Marks: 5 x 6 = 30)

Part – B

Case Study

The students will be given a case study with questions at the end the students have to analyze the case and answer the question at the end. Parameters to be used for evaluation are as follows;

(i) Analyze the case situation
(ii) Key players/characters of the case
(iii) Identification of the problem (both major & minor if exists)
(iv) Bring out alternatives
(v) Analyze each alternative against the problem
(vi) Choose the best alternative
(vii) Implement as solution
(viii) Conclusion
(ix) Answer the question at the end of the case

(Marks: 1 x 20 = 20)

Course No.	Course Name	L-T-P-Credits	Year of Introduction
CH201	CHEMICAL PROCESS CALCULATIONS	3-1-0-4	2016

Prerequisite : Nil

Course Objectives

1. To familiarise the conversion of units in different systems of units
2. To understand the basic concepts of concentration and other physical parameter.
3. To perform material and energy calculations for different Chemical Engineering processes.

Syllabus

Introduction to Chemical Engineering, Chemical process Industry, Unit Operations and Unit Processes, Units and Dimensions, Conversion of units, Conversion of equations.

Concepts of atomic weight, equivalent weight and mole, Composition of solids, liquids and solutions.

Ideal gas laws, gaseous mixtures, real gas laws, Average molecular weight, Compressibility factor, compressibility factor charts, Critical properties, pseudo critical properties.

Vapour Pressure: Effect of temperature on vapour pressure. Application of Clausius Clapeyron equation. Vapour pressure plots, Henry's law, Raoult's law, vapour pressure of immiscible liquids.

Material Balance without chemical reactions, material balance for unit operations- distillation, drying, evaporation, absorption etc. Recycling and bypass operations.

Material Balance with chemical reactions, Combustion of solid, liquid and gaseous fuels, Calorific value, proximate and ultimate analysis of coal, Orsat analysis, Material Balance problems for different unit Operations.

Energy Balance: Heat capacity, work, internal energy, heat capacities, Latent heat, enthalpy changes, energy balance for flow and non-flow processes, Standard heats of reaction, combustion, and formation- effect of temperature and pressure on heat of reaction. Hess law of constant heat summation, temperature of reaction, adiabatic reaction temperature.

Expected Outcome

At the end of the course students will be able to

1. Use the basic principles of chemical engineering and calculation of composition and other physical quantities.
2. Calculate different variables using state equations
3. Develop and solve material and energy balance equations
4. Compute the saturation temperature, relative humidity and wet bulb temperature

References Books:

1. K. V. Narayanan and B. Lakshmikutty, " Stochiometry and Process Calculations", Prentice Hall of India.
2. Bhatt and Vora, Stochiometry, T. M. H.
3. Himmelblau David M., "Basic Principles and Calculations in Chemical Engineering", Prentice Hall of India.

Course plan			
Module	**Contents**	**Hours**	**Sem. Exam Marks**
I	Introduction to Chemical Engineering, Chemical process Industry, Unit Operations and Unit Processes. Units and Dimensions: System of Units, Basic and Derived quantities, Conversion of units, Conversion of equations- problems. Specific gravity scales Concepts of atomic weight, equivalent weight and mole. Composition of solids, liquids and solutions (weight percent, mole percent, molarity, normality etc.), other expressions for concentration.	8	15%
II	Ideal gas laws, gas constant, gaseous mixtures, real gas laws, Vander Waals equation, Redlich- Kwong equation, Benedict- Web- Rubin Equation, Average molecular weight and density. Compressibility factor, compressibility factor charts, Critical properties, pseudo critical properties-problems.	8	15%
FIRST INTERNAL EXAMINATION			
III	Vapour Pressure: Effect of temperature on vapour pressure. Application of Clausius-Clapeyron equation. Vapour pressure plots, Cox charts, Duhrings Lines, Ideal Solutions and non-ideal solution - Henry's law, Raoult's law, Bubble point, Flash Vapourization, vapour pressure of immiscible liquids. Humidity, Dew point, Dry and Wet bulb Temperature, Adiabatic saturation, Humidity charts	9	15%
IV	Material Balance without chemical reactions- Introduction, key component, steps for solving material balance problems, material balance for unit operations- distillation, drying, evaporation, absorption etc. Recycling and bypass operations.	9	15%
SECOND INTERNAL EXAMINATION			
V	Material Balance with chemical reactions; definition of terms (limiting reactant, percentage yield etc.) Combustion of solid, liquid and gaseous fuels, Calorific value, proximate and ultimate analysis of coal, Orsat analysis. Material Balance problems for oxidation, chlorination, nitration, hydrogenation and related processes. Recycling, bypass and purging operations.	10	20%
VI	Energy Balance: Thermophysics. Heat capacity, work, internal energy, heat capacity of solids, liquids and gaseous mixtures, Latent heat, enthalpy changes, energy balance for flow and non-flow processes.	12	20%

	Thermochemistry: Standard heats of reaction, combustion, and formation- effect of temperature and pressure on heat of reaction. Hess law of constant heat summation, temperature of reaction, adiabatic reaction temperature.		
END SEMESTER EXAMINATION			

Evaluation Scheme

- **Internal Evaluation: Total Marks: 50**
  (i) *Total Marks for Assignment/Seminar/Project/Case study or any other appropriate tool used for the evaluation of the course outcomes:* **10**
  A minimum of above two tools shall be used. If more than 2 tools are used, proportionate change shall be made in the marks so that the total contribution of marks for item (i) above remains at 10.
  (ii) Marks for Tests: Two tests each carrying 40% weightage shall be conducted with total contribution of **40 marks**.

- **External Evaluation :** University Examination
  Maximum Marks : 100
  Exam Duration : 3 Hours

Question Paper Pattern:

There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.
(2 x15= 30 Marks)

There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.
(2 x15= 30 Marks)

There shall be **Three questions** uniformly covering Modules 5 and 6, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 20 marks for all the subdivisions put together.
(2 x20= 40 Marks)

Course No.	Course Name	L-T-P Credits	Year of Introduction
CH202	PROCESS HEAT TRANSFER	3-1-0-4	2016

Prerequisite : Nil

Course Objectives

- To introduce the fundamental concepts of various modes of heat transfer.
- To offer a prefatory on the principle and application of heat.
- To emphasise the fundamental theory, analysis and applications of heat transfer
- To present a physical picture of the convection process
- To step into the aspects of process design principles of various heat transfer equipment.

Syllabus

Modes of heat transfer - conduction - thermal conductivity - steady-state conduction - critical thickness of insulation - transient heat conduction- convection - forced convection and natural convection heat transfer - analogy between heat and momentum transfer - dimensional analysis - empirical equations for heat transfer coefficient - Radiation heat transfer - heat exchange equipment - extended surface heat exchangers - condensers, shell and tube and contact type. Heat transfer in extended surfaces (fins). Evaporation – boiling-condensation

Expected Outcomes:

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

1. Identify and distinguish various modes of heat transfer, examine the mechanisms involved and the associated governing laws.
2. Use appropriate governing equations and analyse the different modes of heat transfer in different geometries and systems under steady and transient processes.
3. Compare the different transfer processes based on the concept of analogy
4. Interpret the concepts of evaporation, various types, selection and the concepts involved in the basic design of single and multi-effect evaporators.

References:

1. McCabe W.L., Smith J.C. &Harriott P., Unit Operations in Chemical Engineering, McGraw Hill
2. Hollman J.P., Heat Transfer, McGraw Hill
3. Coulson J.M. & Richardson J.F., Chemical Engineering, Vol. I and II, ELBS, Pergamon Press
4. Geankopolis C J, Transport Processes and Separation Process Principles, Prentice Hall of India, 4th Edition, Eastern Economy Edition (2004)
5. Incropera F P and DeWitt D P, Introduction to Heat Transfer, 2nd Ed John Wiley New York (1996).
6. Welty J.R., Engineering Heat Transfer, John Wiley
7. M.Necati. Ozizik, Heat transfer - A basic Approach, McGraw-Hill College (1985)
8. Kern D.Q., Process Heat Transfer, McGraw Hill
9. Datta B.K., Heat Transfer: Principles and Applications, Prentice Hall India

Module	Content	Hours	Sem. Exam Marks
I	Basic Concepts**:** Overview of applications of heat transfer in different fields of engineering, modes of heat transfer-conduction, convection and radiation, heat transfer with and without change of phase. Material properties of importance in heat transfer, Thermal conductivity, Specific heat capacity, Isotropic and anisotropic materials.	8	15%
	Conduction Heat Transfer: General heat conduction equation in Cartesian, cylindrical and spherical coordinates (derivation is required only for Cartesian geometry).		
	Boundary Conditions - Different Boundary conditions applied in heat transfer problems. Formulation of heat transfer problems - with and without generation of heat (uniform and non-uniform heat generation) at steady and unsteady state for different boundary conditions.		
	One dimensional steady state heat conduction without generation of heat**:** Fourier heat conduction equation, thermal conductivity of solids, liquids and gases-comparison between them, effect of temperature on thermal conductivity; thermal diffusivity.		
	Conduction through systems of constant thermal conductivity**:** -conduction through plane, cylindrical and spherical wall, combined boundary condition systems (conduction-convection systems), conduction through composite slab:-multilayered plane, cylindrical and spherical shells. Electrical analogy to heat flow. Numerical problems of practical importance based on the above topics.		
II	Thermal insulation**:** Analysis of Critical radius of insulation for cylinders, optimum thickness of insulation. Concept of optimum thickness of insulation. Concept of thermal contact resistance Numerical problems based on the above aspects.	8	15%
	Unsteady State heat Conduction**:** Analysis of transient heat flow with negligible internal resistance-lumped capacity analysis, concept of Biot Modulus and Fourier number-Numerical problems of practical importance. Features of Heisler charts. Use of Heisler charts for determination of temperature distribution and energy transfer (Numerical problems not required)		
	Convection**:** Mechanism, overview of continuity, momentum and energy balance equation,		
	Boundary layer concepts - thermal and velocity boundary		

	layers, boundary layer thickness, relationship between hydrodynamic and thermal boundary layer thickness for flow over flat plates.		
	The convective heat transfer coefficient - reference temperatures, thermal boundary layers for the cases of flow over a flat plate and flow through pipe, dimensionless numbers in heat transfer and their significance		
FIRST INTERNAL EXAMINATION			
III	Dimensional analysis: Rayleigh and Buckingham's pi theorem, its limitations, application of dimensional analysis to forced convection.	8	15%
	Forced Convection: General methods for estimation of convection heat transfer coefficient, Correlation equations for heat transfer in laminar and turbulent flow for external and internal flows for constant heat flux and wall temperature conditions- flow in a circular tube (both developing and developed flows with constant wall temperature-its analysis and constant heat flux conditions) and non-circular tubes, flow over flat plates, flow over cylinder, spheres and tube banks. Numerical problems of practical interest.		
	Natural Convection: Dimensional analysis**,** natural convection from vertical and horizontal surfaces under laminar and turbulent conditions for plates, cylinders under constant heat flux and wall temperature conditions, physical significance of Grashoff and Rayleigh numbers. Numerical problems of practical interest.		
	Analogy between momentum and heat transfer- Development of Reynold's and Prandtl analogy. Overview of Colburn and Von-Karman analogies (No derivation required). Comparison of different analogy expressions. Numerical problems.		
IV	Heat transfer by radiation**:** Introduction- theories of radiation, electromagnetic spectrum, thermal radiation, spectral emissive power, surface emission- total emissive power, emissivity. Radiative properties- Emmision, irradiation, radiosity, absorptivity, reflectivity and transmissivity. Concept of black and grey body, radiation intensity, Laws of black body radiation, non-black surfaces- Grey, white and real surface, Lambert's cosine law., radiation between black surfaces and gray surfaces, radiation shape factor, reciprocity theorem, radiation between large parallel gray planes-derivation of expression for rate of radiant energy exchange, concentric cylinders and spheres (no derivation required), radiation	9	20%

	between a small gray body and a large gray enclosure. Radiation shields.		
	Classification of heat exchangers**:** Classification according to transfer processes: Indirect-Contact heat exchangers, direct-contact heat exchangers; Classification according to number of fluids; Classification according to surface compactness: gas-to-fluid exchangers, liquid-to-liquid and phase-change exchangers; Classification according to construction features: tubular heat exchangers, plate-type heat exchangers, extended surface heat exchangers, regenerators; Classification according to flow arrangements: single-pass exchangers, multi-pass exchangers; Classification according to heat transfer mechanisms.		
	Basic construction of a shell and tube heat exchanger with details of the various parts.		
	Concept of overall heat transfer coefficient - Derivation of expression for overall heat transfer coefficient, Concept and types of fouling - fouling factors, determination of overall heat transfer coefficient with and without fouling		
	Derivation of expression for LMTD		
	Concept of logarithmic mean temperature difference and its correction factor - Heat exchanger analysis using LMTD method in parallel flow, counter flow exchanger, cross flow and multi-pass heat exchangers, Temperature – distance plots for different flow arrangements in single and multi-pass heat exchangers. NTU. Determination of area, length, number of tubes required for a given duty in different configurations using LMTD and NTUmethod of analysis.		
SECOND INTERNAL EXAMINATION			
V	Heat transfer in extended surfaces: Types of extended surfaces (fins), General conduction analysis of fins, boundary conditions. Reduction of general equation to determine temperature distribution and heat flux for fin of uniform cross section for infinitely long fin and fin with insulated tip (Derivations required). Expression for temperature distribution and heat flux for fin of uniform cross section with convective boundary condition at the fin tip (No derivation is required). Effectiveness of fins-justification for providing fins on a surface; efficiency of fins-expression for fin efficiency. Principle of fins for temperature measurement.	13	20%

	Evaporation: Principle of Evaporation, types of evaporators- their construction and operation:- Natural circulation evaporators, short tube vertical or calandria type evaporators, basket type vertical evaporators, long tube vertical evaporators, forced circulation evaporators, falling film evaporators, climbing or rising film evaporators, agitated thin film evaporators, the plate evaporator. Evaporator auxiliaries: - vacuum devices, steam traps and its variants, entrainment separators.		
	Single effect and multiple effect evaporators - Performance of evaporators, capacity and economy of evaporators, factors affecting the performance of evaporators. Overall heat transfer coefficient, effect of liquid head and boiling point elevation. Material and energy balances for single effect evaporator and the calculations on single effect evaporator. Numerical problems of practical interest. Temperature profile in evaporators.		
	Multiple effect evaporators: temperature profile of liquids in the evaporator, enthalpy of solution, Different feeding arrangements in multiple effect evaporators – their merits and demerits.		
VI	Boiling and Condensation: - Dimensionless parameters in boiling and condensation. Pool boiling - Boiling curve, hysteresis in the boiling curve, mechanism of nucleate boiling - modes of pool boiling, pool boiling correlations - Nucleate pool boiling - correlations - Yamagata et al correlation, Rohsenow correlation. Correlation for critical heat flux for nucleate pool boiling - Zuber correlation. Correlation for minimum heat flux - Zuber correlation. Correlations for film pool boiling.	10	20%
	Condensation: Physical mechanisms, types of condensation, factors affecting condensation, laminar film condensation on a vertical plate - detailed analysis by Nusselt to determine the heat transfer coefficient. Laminar film condensation on radial systems - condensation on spheres, horizontal tubes and for a vertical tier of horizontal tubes, condensation inside a horizontal tube, correlations, film condensation inside horizontal tubes. Drop wise condensation – correlations- Numerical problems. Comparison between drop-wise and film type condensation, promoters and inhibitors used in condensation.		
END SEMESTER EXAMINATION			

Evaluation Scheme

- **Internal Evaluation: Total Marks: 50**

  (i) *Total Marks for Assignment/Seminar/Project/Case study or any other appropriate tool used for the evaluation of the course outcomes:* **10**
  A minimum of above two tools shall be used. If more than 2 tools are used, proportionate change shall be made in the marks so that the total contribution of marks for item (i) above remains at 10.

  (ii) Marks for Tests: Two tests each carrying 40% weightage shall be conducted with total contribution of **40 marks**.

- **External Evaluation :** University Examination
  Maximum Marks : 100
  Exam Duration : 3 Hours

Question Paper Pattern:

There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.
(2 x15= 30 Marks)

There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.
(2 x15= 30 Marks)

There shall be **Three questions** uniformly covering Modules 5 and 6, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 20 marks for all the subdivisions put together.
(2 x20= 40 Marks)

Course No	Course Name	L-T-P- Credits	Year of Introduction
CH203	PARTICLE TECHNOLOGY	3-1-0-4	2016

Prerequisite : Nil

Course Objectives

1. To impart the knowledge of mechanical operations employed in process industries
2. To develop understanding about size analysis, size reduction and solid handling adopted in process industries

Syllabus

Particle diameter and shape factor - particle size analysis - sieve analysis - particle size distribution - cumulative and differential methods of analysis - mean diameters - specific surface area and number of particles - sub-sieve analysis - pipette analysis - beaker decantation- elutriation - screening - effectiveness and capacity of screens and factors affecting them - types of industrial screens.

Principles of free and hindered settling - equal settling particles - classifiers - types of classifiers- mechanical and non-mechanical, pneumatic classifiers - principles of mineral beneficiation methods - jigging - Wilfley table - heavy media separation - magnetic and high-tension separation- froth flotation, principles, additives, and flotation cell arrangements batch and continuous thickening - Kynch theory - design of continuous thickener

filtration - theory of constant pressure and constant rate filtration - cake porosity and compressibility - filter aids - optimum filtration cycle - types of batch and continuous filters - washing of filter cakes - centrifugal methods of separation including centrifugal filtration - continuous centrifuge

Air separation methods-air separator - cyclone separation – electrostatic precipitation –Bag filters-Cottrell precipitator- scrubbing

Laws of comminution - mechanism and efficiency of size reduction - principles of important size reduction equipment - types and selection of equipment for all ranges - closed circuit and open circuit grinding - free crushing and choke feeding - wet and dry grinding

Mixing of granular solids and pastes - degree of mixing – mixers for non-cohesive and cohesive solids - storage and conveying of solids - silos, bins and hoppers - different types of conveyors - selection of conveyors

Expected Outcome

At the end of the course students will be able to

1. Determine particle size distribution of a given sample.
2. Select suitable size reduction equipment and estimate the energy requirements for a specified reduction in size of a given material.
3. Explain and analyse the concepts of various industrial operations such as Screening, Classification, Sedimentation, Filtration etc.

Text Books

1. McCabe W.L., Smith J.C. & Harriott P., Unit Operations in Chemical Engineering, McGraw Hill
2. Badger & Banchero, Introduction to Chemical Engineering, McGraw Hill

Reference Books

- Coulson J.M. & Richardson J.F., Chemical Engineering, Vol. II, ELBS, Pergamon Press
- Foust A.S. et al, Principles of Unit Operations, John Wiley
- Perry R.H., Chemical Engineers Handbook, McGraw Hill
- George Granger Brown, Unit Operations, Wiley

Course Plan

Module	Contents	Hours	Sem. exam marks
I	Particle diameter and shape factor - particle size analysis - sieve analysis - particle size distribution - cumulative and differential methods of analysis - mean diameters - specific surface area and number of particles - sub-sieve analysis - pipette analysis - beaker decantation- elutriation - screening - effectiveness and capacity of screens and factors affecting them - types of industrial screens.	8	15%
II	Principles of free and hindered settling - equal settling particles - classifiers - types of classifiers-mechanical and non-mechanical, pneumatic classifiers – principles of mineral beneficiation methods - jigging - Wilfley table - heavy media separation - magnetic and high-tension separation- froth flotation, principles, additives, and flotation cell arrangements batch and continuous thickening - Kynch theory - design of continuous thickener	8	15%
FIRST INTERNAL EXAMINATION			
III	Filtration - theory of constant pressure and constant rate filtration - cake porosity and compressibility - filter aids - optimum filtration cycle - types of batch and continuous filters -washing of filter cakes - centrifugal methods of separation including centrifugal filtration - continuous centrifuge	10	20%
IV	Air separation methods-air separator - cyclone separation – electrostatic precipitation –Bag filters-Cottrell precipitator- scrubbing and associated equipments used in process industries.	8	10%
SECOND INTERNAL EXAMINATION			
V	Laws of communition - mechanism and efficiency of size reduction - principles of important size reduction equipment - types and selection of equipment for all ranges - closed circuit and open circuit grinding - free crushing and choke feeding - wet and dry grinding	12	20%
VI	Mixing of granular solids and pastes - degree of mixing – mixers for non-cohesive and cohesive solids - storage and conveying of solids - silos, bins and hoppers - different types of conveyors - selection of conveyors	10	20%
END SEMESTER EXAM			

Evaluation Scheme

- **Internal Evaluation: Total Marks: 50**
  - (i) *Total Marks for Assignment/Seminar/Project/Case study or any other appropriate tool used for the evaluation of the course outcomes:* **10**
    A minimum of above two tools shall be used. If more than 2 tools are used, proportionate change shall be made in the marks so that the total contribution of marks for item (i) above remains at 10.
  - *(ii) Marks for Tests: Two tests each carrying 40% weightage shall be conducted with total contribution of* **40 marks**.

- **External Evaluation :** University Examination
  Maximum Marks : 100
  Exam Duration : 3 Hours

Question Paper Pattern:

There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.
(2 x15= 30 Marks)

There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.
(2 x15= 30 Marks)

There shall be **Three questions** uniformly covering Modules 5 and 6, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 20 marks for all the subdivisions put together.
(2 x20= 40 Marks)

Course code	Course Name	L-T-P-Credits	Year of Introduction
CH204	CHEMICAL ENGINEERING THERMODYNAMICS	3-1-0-4	2016

Prerequisite : Nil

Course Objectives

To understand the concepts and applications of chemical engineering thermodynamics

Syllabus

Basic Concepts and Definitions, Laws of Thermodynamics, Some applications of the Laws of Thermodynamics, Entropy, PVT behaviour of pure substances, Equations of State, Thermodynamic properties of pure fluids, Fugacity and Activity of Pure fluids, Properties of Solutions, Ideal and Non ideal solutions, Property change of mixing, Excess Properties, Gibbs Duhem equation, Phase equilibrium criteria, Phase rule for non-reacting system, Vapour Liquid Equilibria concepts, VLE diagrams, Activity coefficient models, Liquid-Liquid Equilibria, Chemical Reaction Equilibria, Equilibrium Constant, Phase rule for reacting system

Expected Outcome

At the end of the course the students will be able to

1. Apply the laws of thermodynamics to analyse chemical engineering problems
2. Compute the properties of ideal/real gases and mixtures/solutions
3. Analyse processes using mass, energy and entropy balances
4. Evaluate composition of vapor-liquid equilibrium for ideal and non-ideal systems
5. Determine equilibrium constant and mole fraction of reaction mixture under given conditions

Text books:

1. Smith J. M. & Van Ness H.V., Introduction to Chemical Engineering Thermodynamics, McGraw Hill
2. Narayanan K. V., A Textbook of Chemical Engineering Thermodynamics, 2nd Edn., Prentice-Hall of India, 2013

References:

- Stanley I. Sandler, Chemical and Engineering Thermodynamics, 2nd Edn., John Wiley & Sons, USA, 1989
- Kyle B.G., Chemical and Process Thermodynamics, Prentice-Hall of India
- Y.V.C. Rao, Chemical Engineering Thermodynamics, Universities Press

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Scope of Thermodynamics, Thermodynamic Systems-Closed, open and isolated system - intensive and extensive properties - path and state functions - reversible and irreversible process –Zeroth law of Thermodynamics- First Law of Thermodynamics- Energy Balance for Closed Systems-Limitations of First Law- Second Law of	9	15%

	Thermodynamics-Carnot's principles -Definition of Entropy-Calculation of entropy change in processes involving ideal gases-Definition of availability and exergy – entropy generation in steady flow processes-Third law of Thermodynamics-Energy balance of open systems-Flow through pipe, nozzles, compressors, throttling, refrigeration, liquefaction.		
II	P-V and P-T diagram of pure substances. Equations ofstate for real gases- van der Waal's, Redlich Kwong, Peng Robinson and Virial equations. Principle of corresponding states- generalized compressibility chart- Fundamental Property Relations-Maxwell's Equations- Clausius-Clapeyron equation - entropy-heat capacity relationships - equations for entropy, internal energy and enthalpy in terms of measurable quantities- Joule-Thomson coefficient – Gibbs Helmholtz equation- -fugacity and activity of pure fluids - selection of standard state - effect of temperature and pressure on fugacity and activity-residual properties-thermodynamic diagrams.	9	15%
FIRST INTERNAL EXAMINATION			
III	Definition of partial molar properties-chemical potential - definition - effect of temperature and pressure on fugacity-fugacity in solution - ideal solution - Lewis-Randall rule-Raoult's law - Henry's law - activity and activity coefficients in solutions - effect of temperature and pressure on activity coefficients - Gibbs-Duhem equations – criterion of phase equilibria - criterion of stability - phase equilibrium in single component systems - phase equilibria in multicomponent systems - phase rule for non-reacting systems - Duhem's theorem	9	15%
IV	Vapour-liquid equilibrium - phase diagram for binary solutions - VLE in ideal solutions - non-ideal solutions - positive and negativedeviation - azeotropes - VLE at low pressures-Application of activity coefficient equations in equilibrium calculations - activity coefficient models such as Wohl's equation - van Laar equation - Wilson equation -NRTL, UNIQUAC and UNIFAC models - calculation of activity coefficients using Gibbs - Duhem equations - consistency tests for equilibrium data - Redlich-Kister method -coexistence equation	9	15%
SECOND INTERNAL EXAMINATION			
V	Vapour-liquid equilibrium at high pressures – vaporization equilibrium constants - bubble point, dew point and flash	10	20%

	calculations in multi component systems- vapour-liquid equilibrium in partially miscible and immiscible systems - phase diagrams - principles of steam distillation – phase equilibrium considerations in steam distillation - liquid-liquid equilibrium - binary and ternary equilibrium diagrams - use of triangular diagrams for ternary equilibrium		
VI	Chemical reaction equilibria-extent of reaction-equilibrium constant - standard free energy change - feasibility of reaction -effect of temperature on equilibrium constant – evaluation of equilibrium constant - equilibrium conversion in gas-phase reactions - effect of pressure and other parameters on conversion - pressures of decomposition in gas-solid reaction - simultaneous reactions - phase-rule for reacting systems	10	20%
END SEMESTEREXAMINATION			

Evaluation Scheme

- **Internal Evaluation: Total Marks: 50**
  (i) *Total Marks for Assignment/Seminar/Project/Case study or any other appropriate tool used for the evaluation of the course outcomes:* **10**
  A minimum of above two tools shall be used. If more than 2 tools are used, proportionate change shall be made in the marks so that the total contribution of marks for item (i) above remains at 10.
  (ii) Marks for Tests: Two tests each carrying 40% weightage shall be conducted with total contribution of **40 marks**.

- **External Evaluation :** University Examination
  Maximum Marks : 100
  Exam Duration : 3 Hours

Question Paper Pattern:

There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.
(2 x15= 30 Marks)
There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.
(2 x15= 30 Marks)
There shall be **Three questions** uniformly covering Modules 5 and 6, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 20 marks for all the subdivisions put together.
(2 x20= 40 Marks)

Course No.	Course Name	L-T-P-Credits	Year of Introduction
CH205	FLUID AND PARTICLE MECHANICS-I	3-1-0-4	2016

Prerequisite: Nil

Course Objectives

To expose the students to the concepts of fluid mechanics that is relevant and used for applications in chemical engineering.

Syllabus

Fundamental Concepts: Continuum Hypothesis, Fluid Statics, Fluid Kinematics, Classification of Flow, Basic Equations of Fluid Flow, Laminar and Turbulent Flow of incompressible fluid in conduits, Pipe and tubing, Joints and fittings, Valves, Metering of Fluids.

Expected Outcome

At the end of the course the students will be able to

1. Summarize various properties of fluids and distinguish the different types of flow systems.
2. Summarize the fluid statics principles and examine the mathematical models for flow behaviour in different systems utilizing the principles of kinematics.
3. Analyze the basic fluid dynamic equations of change for isothermal systems
4. Explain the concepts of flow in boundary layers.
5. Select suitable flow measuring/metering devices and distinguish the different types of valves used in process industries

References Books:

- McCabe W.L. & Smith J.C., Unit Operations of Chemical Engg, McGraw Hill
- Streeter V.L., Fluid Mechanics, McGraw Hill
- An Introduction to Fluid Mechanics, Joseph Katz, Cambridge University Press
- Coulson J.M. & Richardson J.F., Chemical Engg. Vol. 1, Pergamon
- Foust, Wenzel, Clump, Maus& Anderson, Principles of Unit Operation
- Noel de Nerves, Fluid Mechanics for Chemical Engineers, McGraw Hill.
- Fluid Dynamics and Heat Transfer, Knudsen and Katz.

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Continuum hypothesis, Definition of fluid, Newton's law of viscosity. Physical properties of fluid: Density, specific weight, specific volume, specific gravity, viscosity, compressibility & elasticity, surface tension & capillarity. Variation of viscosity and density with temperature and pressure. Measurement of viscosity using Newton's law of viscosity (Coaxial cylinder viscometer). Rheology of fluids, Classification of fluids.	8	15%

II	Pascal's law, Hydrostatic equilibrium in gravity and centrifugal field. Barometric equation. Principles of continuous gravity decanter and centrifugal decanter. Lapse rate. Principles of Manometer-Simple manometer, Differential manometer, Inclined tube manometer. Buoyancy and Floatation: Buoyancy, Buoyant Force and Centre of Buoyancy. Metacentre and Metacentric Height. Stability of submerged and floating bodies.	8	15%
FIRST INTERNAL EXAMINATION			
III	Introduction to fluid flow: Flow field, Eulerain and Lagrangian approach, velocity potential, stream function, circulation and vorticity. Stream line, Path line, Streak line, Stream tube. Classification of flow: Steady & unsteady flow, Uniform & non uniform flow, Rotational & irrotational flow. Reynolds experiment, Reynolds number, Turbulance, Reynolds stress, Flow in boundary-layers, Boundary-layer formation in straight tubes, Boundary-layer separation and wake formation.	10	15%
IV	Basic equations of fluid flow: Continuity Equation, Macroscopic Momentum Balance (Navier-Stoke's equation), Bernoulli Equation, Kinetic energy correction factor, Correction for fluid friction, Pump work in Bernoullis equation.	8	15%
SECOND INTERNAL EXAMINATION			
V	Laminar flow of incompressible fluids in conduits and thin layers: Shear stress and Velocity distribution, Maximum and average velocity-Hagen Poiseuille equation-Definition of Friction factor on Reynolds number in laminar flow. Turbulent flow of incompressible fluids in pipes and conduits: Universal velocity distribution equation, Friction factor and Reynolds number relationship-Nikuradse and Karman equation-Blasius equation (derivation not required), Prandtl one seventh power law-Friction factor chart-Frction from changes in velocity or direction-Sudden expansion and contraction-Effect of fittings and valves. Flow of liquids in thin layers.	14	25%
VI	Pipe and tubing, Joints and fittings, Valves – Gate valves and globe valves, Plug cokes and ball valves, Check valves. General Description and Flow rate equation for Venturi; Orifice; Flow Nozzle; Pitot tube; Rectangular, Triangular & Trapezoidal weir; Rotameter.	8	15%
END SEMESTER EXAMINATION			

Evaluation Scheme

- **Internal Evaluation: Total Marks: 50**
  (i) *Total Marks for Assignment/Seminar/Project/Case study or any other appropriate tool used for the evaluation of the course outcomes:* **10**
  A minimum of above two tools shall be used. If more than 2 tools are used, proportionate change shall be made in the marks so that the total contribution of marks for item (i) above remains at 10.
  (ii) Marks for Tests: Two tests each carrying 40% weightage shall be conducted with total contribution of **40 marks***.*

- **External Evaluation :** University Examination
  Maximum Marks : 100
  Exam Duration : 3 Hours

Question Paper Pattern:

There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.
(2 x15= 30 Marks)

There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.
(2 x15= 30 Marks)

There shall be **Three questions** uniformly covering Modules 5 and 6, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 20 marks for all the subdivisions put together.
(2 x20= 40 Marks)

Course code	Course Name	L-T-P-Credits	Year of Introduction
CH206	FLUID AND PARTICLE MECHANICS-II	3-0-0-3	2016

Prerequisite : CH205 Fluid and particle mechanics -I

Course Objectives

To impart the knowledge of fluid mechanics and its applications in chemical engineering.

Syllabus

Flow Past Immersed Bodies, Fluidization, Pumps, Fans, Blowers, Compressors, Fundamentals of Compressible Fluids, Agitation and Mixing

Expected Outcome

At the end of the course the students will be able to:

1. Outline the fluid flow around immersed solids and calculate the pressure drop in fluidized beds and packed beds.
2. Examine the fluidization behaviour and write model equations for fluidized beds which are required for the design of gas-solid fluidized bed reactors.
3. Calculate the flow rates of compressible flows in fluid moving machinery.
4. Determine the effects of variable cross-sectional area on sub- and supersonic flows.
5. Select mixing equipment used in process industries

References Books:

- McCabe W.L. & Smith J.C., Unit Operations of Chemical Engg, McGraw Hill
- Streeter V.L., Fluid Mechanics, McGraw Hill
- Coulson J.M. & Richardson J.F., Chemical Engg. Vol. 1, Pergamon
- Foust, Wenzel, Clump, Maus& Anderson, Principles of Unit Operation
- 5.Noel de Nerves, Fluid Mechanics for Chemical Engineers, McGraw Hill.
- Kunii and Levenspiel, "Fluidization Engineering"

Module	Contents	Hours	Sem. Exam Marks
I	Flow past immersed bodies - Drag coefficient - Flow through packed bed - Ergun equation -Kozney-Carman equation - Blake Plummer equation - Design of packed beds - Motion of particles through fluids - Motion from gravitational and centrifugal fields - Terminal settling velocity - Approximate equation - Stoke's law - Intermediate law - Newton's law – Hindered settling	7	15%
II	Fluidization - The phenomenon of fluidization - Liquid-like behaviour of fluidized beds - Comparison with other contacting methods - Advantages and disadvantages of fluidized beds for industrial applications - fluidization quality. Pressure drop - vacuum - flow rate diagrams, minimum fluidizing velocity, effect of pressure and temperature on fluidized bed behaviour. The expanded bed - Flow patterns in fluidized beds - Design of fluidized beds.	7	15%

FIRST INTERNAL EXAMINATION			
III	General description, classification and application of Centrifugal, Reciprocating, Gear and Lobe Pumps. Various losses, Characteristic curves, NPSH, Cavitation, Specific speed, Priming of Centrifugal pumps. Fans and Blowers- classification, power consumption. Compressors – classification, Positive displacement compressors, reciprocating compressors, multistaging, power consumption, compressor output.	7	15%
IV	Compressible fluids - Mach number - Continuity equation - Total energy balance – Mechanical energy balance - Ideal gas equation - Equations for isentropic flow - Adiabatic frictional flow Isothermal flow - Measurement of compressible fluid flow.	7	15%
SECOND INTERNAL EXAMINATION			
V	Non-Newtonian fluids - Time dependent flow - Viscosity, rate of shear Vs. shear stress for non- Newtonian fluids - Agitation and mixing of liquids - Agitation equipments - Impellers, propellers, paddles, turbines, flow patterns in agitated vessels, standard turbine design, circulation, velocities and power consumption in agitated vessels - Flow number – velocity gradient and velocity patterns, power correlations, dimensionless groups, blending and mixing, mixer selection, scale-up of agitator design.	7	20%
VI	Mixing of solids and pastes - Mixers for pastes and plastic masses - change can mixers, kneaders, dispersers and masticators, mixer extruders, mixing rolls, Muller mixers, power requirements, mixing index, mixers for dry powders, mix index in blending granular solids.	7	20%
END SEMESTER EXAMINATION			

Evaluation Scheme

- **Internal Evaluation: Total Marks: 50**
  (i) *Total Marks for Assignment/Seminar/Project/Case study or any other appropriate tool used for the evaluation of the course outcomes:* **10**
  A minimum of above two tools shall be used. If more than 2 tools are used, proportionate change shall be made in the marks so that the total contribution of marks for item (i) above remains at 10.
  (ii) Marks for Tests: Two tests each carrying 40% weightage shall be conducted with total contribution of **40 marks**.

- **External Evaluation :** University Examination
  Maximum Marks : 100
  Exam Duration : 3 Hours

Question Paper Pattern:

There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.

(2 x15= 30 Marks)

There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.

(2 x15= 30 Marks)

There shall be **Three questions** uniformly covering Modules 5 and 6, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 20 marks for all the subdivisions put together.

(2 x20= 40 Marks)

Course No.	Course Name	L-T-P-Credits	Year of introduction
CH207	CHEMISTRY FOR PROCESS ENGINEERING- I	2-1-0-3	2016

Prerequisite : Nil

Course Objectives:

- To impart the knowledge of organic chemistry for Chemical engineering practice
- To illustrate the reactions in chemical processing.
- To familiarize the advanced synthetic reagents and mechanisms.
- To understand the importance of selected industrially used organic compounds

Syllabus:

Aromatic Compounds-Reactions and Synthetic Reagents-Bio-molecules-Industrially important organic compounds-Chemistry of Food and Drugs-Organic Photochemistry

Expected Outcome:

At the end of the course the students will be able to:

(i) Distinguish aromaticity and anti-aromaticity and explain the associated rules

(ii) Summarize the reactions of aromatic compounds and the related reaction and preparations.

(iii) Classify amino acids, proteins and carbohydrates along with the tests for their identification.

(iv) Summarize dyes, reactions involved and their synthesis

(v) Summarize fats and oils, insecticides, biodegradable polymers, polysaccharides, vitamins and drugs

(vi) Summarize the principle of photochemistry, mechanisms and reactions involved.

References:

1. Morrison & Boyd, Organic Chemistry, Prentice-Hall of India
2. Bah l& Bahl, Advanced Organic Chemistry, S. Chand
3. Finar, Organic Chemistry, Vol. I and II, ELBS
4. Sony, P.L., Organic Chemistry, S. Chand
5. Albert L. Lehninger; David L. Nelson; Michael M. Cox; David L. Nelson, *Lehninger*
6. Principles of Biochemistry, W H Freeman & Co
7. Tewari, Mehrotra and Vishnoi- Advanced Organic Chemistry

Module	Contents	Hours	End Sem. Marks
I	Aromaticity- Conditions of aromaticity- Huckel rule for aromaticity- Benzenoid and non-benzenoid (azulene, tropylium cation, Cyclopentadienyl ion, annulenes) compounds.	6	15%
	Anti-aromaticity and non-aromaticity. Aromaticity and basicity of heterocyclic compounds like furan, pyrrole, thiophene and pyridine.		
	Reactions of aromatic compounds- electrophilic ring substitution reactions with mechanism of aniline, benzoic		

	acid (Halogenation, Nitration, Sulphonation) and directive and activation effects of substituents.		
	Nucleophilic substitution reactions of aryl halides (addition-elimination mechanism, elimination-addition (benzyne) mechanism)		
II	Reaction intermediates- formation, structure, stability and important reactions- carbocation (S_N1, E1 reactions) – carbanion (aldol condensation, reaction of methyl lithium with ketone)	7	15%
	Free radical (chlorination of methane, addition of HBr to alkenes)- Carbenes -singlet and triplet- (cyclopropanation of carbenes		
	Rearrangement reactions with mechanism – pinacol-pinacolone, Beckmann, Fries, Claisen rearrangements.		
	Synthetic reagents- NBS (allylic bromination), OsO_4 (hydroxylation of alkenes), Crown ether (structures of 12-crown-4, 15-crown-5, 18-crown-6 and dibenzo-18-crown-6-application in phase transfer catalysis)		
FIRST INTERNAL EXAMINATION			
III	Amino acids-classification-synthesis (Gabriel phthalimide & Strecker reactions)-Zwitter ion formation-Action of heat on alpha, beta and gama amino acids.	7	20%
	Proteins- classification and biological function-Sanger's end group analysis- Tests of proteins (Biuret, xantho-proteic, Hopkins Cole, Ninhydrin tests)-Structure of proteins (primary-secondary and tertiary)- Denaturation of proteins.		
	Carbohydrates-classification-reactions of glucose & fructose (reduction and oxidation with mild and strong agents-osazone formation)-epimerisation-mutarotation of glucose and fructose- Anomers- Killiani synthesis for ascending the series - Ruff's method to descend the series- Conformation of alpha and beta glucose. Reducing and non-reducing sugars (glucose, fructose and sucrose-explanation with structure)		
IV	Dyes - colour and constitution – chromophores and auxochromes. Azodyes- synthesis and use of Congo Red. Triphenyl methane dyes -Synthesis and use of pararosaniline- Xanthene dye- Synthesis and use of Fluorescein.	8	20%
	Fats and oils- saponification - hydrogenation of oils (vanaspathi)- Soaps and detergents (cleansing action, types of detergents).		
	Biodegradable polymers- classification (agro-poylymers& bio-polyesters) - synthesis and applications of polylactide		

	(PLA), polyglycolide (PGA), polycaprolactone (PCL).		
	Insecticides-structures of – organochlorides - pentachlorophenol- pyrethroids- Transfluthrin- Organophosphates -Malathion. Artificial sweeteners- Structure and synthesis of Saccharine, Sucralose and Sorbitol.		
SECOND INTERNAL EXAMINATION			
V	Polysaccharides: Brief study of the chemistry – starch and cellulose- structure, function and hydrolysis by acids.	7	15%
	Vitamins-Classification- vitamin – C (Ascorbic acid) – function, structure and anti oxidant property. Vitamin A (Retinol)- structure and function. Vitamin B_3 (Nicotinic acid)- structure and function.		
	Enzymes-Definition-function- apoenzyme, cofactor (coenzyme), holoenzyme, - Classification based on chemical reactions, specificity, factors affecting the enzyme activity, enzyme inhibitors. Lipids- Classification and functions.		
	Drugs-Antipyretics/analgesiscs- synthesis of paracetamol and aspirin-Sedatives-synthesis of barbitone- Antibiotics-Different types (pencillin based, aminoglycoside based, Tetracyclin based- (sketetal structures only)- Prodrugs and its importance- Drug design & QSAR (elementary idea only)		
VI	Fundamentals-absorption of light –MOs, singlet and triplet states of molecules, Jablonski diagram-fluroscence and phosphorescence, sensitization and quenching.	7	15%
	Photochemistry of carbon-carbon double bond- cyclisation reactions of conjugated alkenes- [2+2] cycloadditions. Rearrangements- Cope and Claisen- Norrish type I and Norrish type II cleavages.		
	Photosenzitised reactions-photosynthesis (elementary idea only), bioluminescence in fire fly, chemiluminescence (reaction of luminal with H_2O_2)		
END SEMESTER EXAMINATION			

Evaluation Scheme

- **Internal Evaluation: Total Marks: 50**
  (i) *Total Marks for Assignment/Seminar/Project/Case study or any other appropriate tool used for the evaluation of the course outcomes:* **10**
  A minimum of above two tools shall be used. If more than 2 tools are used, proportionate change shall be made in the marks so that the total contribution of marks for item (i) above remains at 10.
  (ii) Marks for Tests: Two tests each carrying 40% weightage shall be conducted with total contribution of **40 marks**.

- **External Evaluation :** University Examination
  Maximum Marks : 100
  Exam Duration : 3 Hours

Question Paper Pattern:

There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.
(2 x15= 30 Marks)

There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.
(2 x15= 30 Marks)

There shall be **Three questions** uniformly covering Modules 5 and 6, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 20 marks for all the subdivisions put together.
(2 x20= 40 Marks)

Course code	Course Name	L-T-P-Credits	Year of Introduction
CH208	CHEMISTRY FOR PROCESS ENGINEERING -II	3-0-0-3	2016

Prerequisite: CH207 Chemistry for process engineering - I

Course Objectives

1. To impart the knowledge of analytical and physical chemistry relevant to the field application of Chemical Engineering
2. To comprehend the contemporary techniques in analytical and physical chemistry that are applied to many areas of chemical research

Syllabus

Electro-analytical chemistry, potentiometry, voltammetry, electrogravimetry, electrochemical sensors; Mass spectrometry, atomic absorption & emission spectroscopy and surface analysis techniques; Phase equilibria, principles of solvent extraction; electrolytic conductions and electrolytic processes; Adsorption and surface chemistry, emulsions and surfactants; Nuclear stability, radioactivity, analytical and medicinal applications of nuclear chemistry.

Expected Outcome

At the end of the course students will be able to:

(i) Describe basic principles of electrochemistry

(ii) Summarize spectroscopy, surface analysis techniques and solubility behaviour

(iii)Interpret phase equilibria and electrochemical equilibria towards different chemical engineering applications.

References:

1. D.A. Skoog, D.M. West, F.J. Holler, S.R. Crouch, Fundamentals of Analytical Chemistry, 8th edition, Saunders College Pub., 2007.
2. H.H. *Willard, L.L. Merritt Jr. J.A. Dean,* F. A. Settle *Jr*., 7th ed., Wadsworth Publishing Co., 1988.
3. G.R. Chatwal, S.K. Anand, Instrumental Methods of Chemical Analysis, 5th edition, Himalaya, 2007.
4. B. R. Puri, L.R. Sharma, M.S. Pathania, Principles of Physical Chemistry, Vishal Publishing Co., 2013.
5. J. Koryta, J. Dvorak, L. Kavan. Principles of electrochemistry, 2nd edition, John Wiley & Sons, Inc. 1993.
6. D. Harvey, Modern analytical chemistry, McGraw-Hill, Inc. 2000.
7. J. A. C. Broekaert, Analytical Atomic Spectrometry with Flames and Plasmas, Wiley-VCH, 2002.
8. P. Atkins, J. de Paula, Elements of Physical Chemistry, 5th edition, Oxford University Press, 2009.
9. P. J. Gellings, H. J. M. Bouwmeester (editors), The CRC handbook of solid state electrochemistry, CRC Press, Inc., 1996.
10. J. Wang, Analytical Electrochemistry, 2nd edition, Wiley-VCH, 2000.
11. W. Adamson, A. P. Gast, Physical Chemistry of Surfaces, 6th edition, Wiley-Interscience, 1997.

12. D. Myers, Surfaces, Interfaces, and Colloids, 2nd edition, Wiley-VCH, 1999.
13. W. D. Loveland, D. J. Morrissey, G. T. Seaborg, Modern nuclear chemistry, John Wiley & Sons, Inc., 2006.
14. G. Friedlander, J. W. Kennedy, E. S. Macias, J. M. Miller, Nuclear and radiochemistry, 3rd edition, John Wiley & Sons, Inc. 1981.

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	**Electro-analytical chemistry** Potentiometry – Principle, determination of equivalence points for acid–base, complexation, redox, and precipitation titrations. Voltammetry -Residual current, migration current, diffusion current (Ilkovic equation) and limiting current. Polarographic waves (anodic and cathodic), Half wave potentials. Dropping mercury electrode (DME). Anodic stripping voltammetry. Amperometry. Coulometric titrations. Electrogravimetry.	6	15%
II	**Spectroscopic and surface analysis technique** Principle, instrumentation and applications of mass spectrometry, atomic absorption spectroscopy (AAS), atomic emission spectroscopy (AES), X–ray photoelectron spectroscopy (XPS), auger electron spectroscopy (AES), scanning electron microscopy (SEM), scanning tunneling electron microscopy (STEM)and atomic force microscopy (AFM).	6	15%
FIRST INTERNAL EXAMINATION			
III	**Phase equilibria** Nernst distribution law (thermodynamic derivation), association and dissociation of solute, chemical combination of solute with solvent. Application of Nernst distribution law, principles of solvent extraction, Parke's process. Numerical problems of distribution law. Solubility of partially miscible liquids. Critical solution temperature. Phenol – water, triethylamine – water and nicotine – water systems. Distillation of immiscible liquids – steam distillation – applications	**7**	15%
IV	**Electrochemistry** Conductivity of electrolytes, Arrhenius theory of weak electrolytes, Kohlrausch law, Debye–Hückel theory (basics	**7**	15%

	only). Transport (transference) number,Hittorf's method. Concentration cells (with and without transference), Liquid junction potential. Cathodic hydrogen evolution - hydrogen overvoltage. Anodic oxygen evolution, Cathodic Oxygen reduction. Electrochemical sensors (Biosensors for glucose, ethanol and urea, gas sensors for Oxygen and CO_2).Electrochromism and electrochromic devices (e.g. tungsten oxide).		
SECOND INTERNAL EXAMINATION			
V	**Adsorption and Surface Chemistry** Adsorption Isotherms – Langmuir, Freundlich and BET equations (no derivation for BET). Determination of surface area using BET equation. Gibbs surface excess. Gibbs adsorption isotherm – derivation. Colloids – classification, preparation and purification. Protective colloids. Zeta potential, Donnan membrane equilibrium. Dorn effect. Emulsion – properties and applications. Surfactants - types and uses	8	20%
VI	**Nuclear and radiochemistry** Nuclear stability and radioactivity, types of radioactive decays. Binding energy and decay schemes, first order decay expressions. Consecutive decays, transient & secular equilibria. Nuclear reaction cross-section.Liquid drop model of nuclear fission and fissionability parameters. Neutron activation analysis. Medical isotopes and treatment. Tracers, isotope separation, dating techniques. Isotope effects.	8	20%
END SEMESTEREXAMINATION			

Evaluation Scheme

- **Internal Evaluation: Total Marks: 50**
  (i) *Total Marks for Assignment/Seminar/Project/Case study or any other appropriate tool used for the evaluation of the course outcomes:* **10**
  A minimum of above two tools shall be used. If more than 2 tools are used, proportionate change shall be made in the marks so that the total contribution of marks for item (i) above remains at 10.
  (ii) Marks for Tests: Two tests each carrying 40% weightage shall be conducted with total contribution of **40 marks**.

- **External Evaluation :** University Examination
  Maximum Marks : 100
  Exam Duration : 3 Hours

Question Paper Pattern:

There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.

(2 x15= 30 Marks)

There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.

(2 x15= 30 Marks)

There shall be **Three questions** uniformly covering Modules 5 and 6, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 20 marks for all the subdivisions put together.

(2 x20= 40 Marks)

Course code	Course Name	L-T-P-Credits	Year of introduction
CH231	CHEMISTRY LAB FOR PROCESS ENGINEERING- I	0-0-3-1	2016

Prerequisite: CH207 Chemistry for process engineering - I

Course Objectives

1. To provide knowledge of analysis, estimation and preparation of selected organic chemicals.
2. To accustom the students with the handling and analyzing chemicals.

List of Exercises / Experiments

1.**Analysis of simple organic compounds** (minimum 8 numbers)

2. **Preparations of organic compounds** (minimum 5 numbers)
   a) Preparation of benzanilide from aniline.
   b) Preparation of m-dinitrobenzene from nitrobenzene.
   c) Preparation of benzoic acid from ethyl benzoate.
   d) Preparation of glucosazone from glucose.
   e) Preparation of salicylic acid methyl salicylate.
   f) Preparation of aspirin from salicylic acid.

3. **Volumetric estimation of organic compounds**.
   a) Aromatic primary amine.
   b) Phenol.
   c) Glucose

4. **Colorimetric estimation of organic compounds**.
   a) Ascorbic acid
   b) Streptomycin

5. **Chromatography** - Identification of amino acids using paper chromatography

Expected outcome

At the end of the course, students will be able to

(i) Prepare, analyse and estimate selected organic chemicals experimentally.

(ii) Plan and perform experiments for the analysis

(iii) Demonstrate capacity to work in teams and exhibit knowledge of safety, health and environment by practicing laboratory ethics.

References:

- Srivastava T.N. & Kamboj P.C., Systematic Analytical Chemistry.
- F G Mann & B C Saunders, Practical Organic Chemistry, Dorling Kinderly PVT. Ltd.
- Beebet, Pharmacuetical Analysis.
- Vogel's Textbook of Practical Organic Chemistry, ELBS/Longman, 1989

Course no	Course Name	L-T-P-credits	Year of introduction
CH232	FLUID AND PARTICLE MECHANICS LAB	0-0-3-1	2016

Prerequisite: CH205 Fluid and particle mechanics - I

Course Objectives

To analyse and apply knowledge of fluid mechanics in realistic situations by performing experiments in flow measuring and fluid moving equipments

LIST OF EXERCISES/EXPERIMENTS (Minimum of 8 mandatory)

1. Experiments on Reynolds apparatus for determination of flow regime and construction of fanning friction factor vs. Reynolds No. plot
2. Determination of co efficient of discharge for orifice meter
3. Determination of co efficient of discharge for venturi meter
4. Determination of co-efficient of pitot tube and construction of velocity profile across the cross section of pipe.
5. Determination of co-efficient of discharge for different types of weirs.
6. Determination of pressure drop for flow through packed bed and verification of Ergun equation. Experiment on fluidization techniques and determination of
   (a) Minimum fluidization velocity;
   (b) Pressure drop profile
7. Determination of efficiency of a centrifugal pump.
8. Pipe line assembling and a layout drawing with standard symbols.
9. Calibration of a Rotameter
10. Determination of viscosity of Newtonian& non-Newtonian fluid by Falling Sphere method
11. Verification of Bernoulli's Theorem

Expected outcome

At the end of the course, the students will able to:

(i) Plan and perform experiments in flow measuring equipments and analyse the principles involved.

(ii) Plan and perform experiments in fluid moving machinery and analyse the principles involved.

(iii) Plan and perform experiments in solid-fluid systems and analyse the principles involved.

(iv) Demonstrate capacity to work in teams and exhibit knowledge of safety, health and environment by practicing laboratory ethics.

References

- McCabe W.L. & Smith J.C., Unit Operations of Chemical Engg, McGraw Hill
- Streeter V.L., Fluid Mechanics, McGraw Hill
- Coulson J.M. & Richardson J.F., Chemical Engg. Vol. 1, Pergamon
- Foust, Wenzel, Clump, Maus& Anderson, Principles of Unit Operation

Course code	Course Name	L-T-P-Credits	Year of introduction
CH233	CHEMICAL TECHNOLOGY AND ENVIRONMENTAL ENGINEERING LAB	0-0-3-1	2016

Prerequisite: Nil

Course objective

To apply and demonstrate the concepts of Chemical Technology and Environmental engineering.

List of Exercises / Experiments (Minimum 10 are mandatory)

1. Determine the Acid value of the given oil sample.
2. Determine the Iodine value of the given oil sample.
3. Determine the Saponification value of the given oil sample.
4. Determine the available chlorine in bleaching powder.
5. Preparation and analysis of soap.
6. Estimate the hardness of the given sample of water.
7. Estimate the dissolved oxygen in the given water sample.
8. Estimate the COD of the given water sample.
9. Estimate the BOD of the given water sample.
10. Estimate the total solids and dissolved solids content of the given waste water sample.
11. Determine the sucrose content in given sugar sample.
12. Determine the flash and fire point of the oil sample.
13. Analysis of oil and grease in waste water sample.
14. Determination of ammoniacal nitrogen.
15. Study of Equipments- Gas Chromatography, Flame photometer, Junkers Gas Calorimeter, Redwood viscometer, Digital pH meter, Spectrophotometer.

Expected outcome

(i) Analyse and estimate parameters for the raw materials and products of selected industrial chemicals.

(ii) Develop skills to use analytical and instrumental methods for measurement of parameters relevant to Chemical processing and environmental engineering

(iii) Plan and perform experiments for the analysis

(iii) Demonstrate capacity to work in teams and exhibit knowledge of safety, health and environment by practicing laboratory ethics.

Text books:

References:

- Vogels textbook of practical organic chemistry ELBS/Longman, 1989
- Standard Methods for the examination of water and waste water based on specified Codes.

Course code	Course name	L-T-P-credits	Year of Introduction
CH234	PARTICLE TECHNOLOGY LAB	0-0-3-1	2016

Prerequisite: CH203 Particle technology

Objective

1. To analyse and apply knowledge of size analysis and size reduction methods by performing experiments.
2. To impart knowledge of solid-solid and solid-fluid separation equipments and provide knowledge of their working and constructional features.

List of exercises/experiments (Minimum 10 are mandatory)

1. Sieve analysis -Determination of particle size distribution, mean diameters,
2. specific surface area and number of particles per unit mass
3. Determination of the effectiveness of the screen
4. Pipette analysis-Determination of particle size distribution, specific surface area and mean diameters
5. Beaker decantation- Determination of particle size distribution, specific surface area and mean diameters
6. Sedimentation – Determination of area of a thickener
7. Verification of the laws of crushing
8. Ball mill - Determination of the critical speed
9. Leaf filter- Determination of specific cake resistance and compressibility factor
10. Cyclone separator – Determination of collection efficiency
11. Free Settling- Determination of terminal settling velocity
12. Studies on Plate & frame filter press, Mineral jig, and Wilfley table
13. Studies on Continuous thickener, Rotary drum filter, Jaw crusher and Hammer mill

Expected outcome

At the end of the course, students will be able to

1. Plan and perform experiment using size reduction equipment and estimate the energy requirements for a specified reduction in size of a given material.
2. Plan and perform experiment using equipments used in industrial operations such as Screening, Classification, Sedimentation, Filtration etc.
3. Demonstrate capacity to work in teams and exhibit knowledge of safety, health and environment by practicing laboratory ethics.

References

- Unit Operations of chemical Engineering,Warren McCabe, Julian Smith and Peter Harriott , McGraw Hill publishers
- Introduction To Chemical Engineering ,J.T. Banchero and W.L. Badger , McGraw Hill Publishers
- Coulson and Richardson's Chemical Engineering volume 2, Particle Technology and Separation Process, Elsevier publishers.

Course code	Course Name	L-T-P - Credits	Year of Introduction
HS300	Principles of Management	3-0-0-3	2016

Prerequisite : Nil

Course Objectives

- To develop ability to critically analyse and evaluate a variety of management practices in the contemporary context;
- To understand and apply a variety of management and organisational theories in practice;
- To be able to mirror existing practices or to generate their own innovative management competencies, required for today's complex and global workplace;
- To be able to critically reflect on ethical theories and social responsibility ideologies to create sustainable organisations.

Syllabus

Definition, roles and functions of a manager, management and its science and art perspectives, management challenges and the concepts like, competitive advantage, entrepreneurship and innovation. Early contributors and their contributions to the field of management. Corporate Social Responsibility. Planning, Organizing, Staffing and HRD functions, Leading and Controlling. Decision making under certainty, uncertainty and risk, creative process and innovation involved in decision making.

Expected outcome.

A student who has undergone this course would be able to

i. manage people and organisations
ii. critically analyse and evaluate management theories and practices
iii. plan and make decisions for organisations
iv. do staffing and related HRD functions

Text Book:

Harold Koontz and Heinz Weihrich, *Essentials of Management*, McGraw Hill Companies, 10th Edition.

References:

1. Daft, *New era Management*, 11th Edition, Cengage Learning
2. Griffin, *Management Principles and Applications*, 10th Edition, Cengage Learning
3. Heinz Weirich, Mark V Cannice and Harold Koontz, *Management: a Global, Innovative and Entrepreneurial Perspective*, McGraw Hill Education, 14th Edition
4. Peter F Drucker, *The Practice of Management*, McGraw Hill, New York
5. Robbins and Coulter, *Management*, 13th Edition, 2016, Pearson Education

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Introduction to Management: definitions, managerial roles and functions; Science or Art perspectives- External environment-global, innovative and entrepreneurial perspectives of Management (3 Hrs.)– Managing people and organizations in the context of New Era- Managing for competitive advantage - the Challenges of Management (3 Hrs.)	6	15%

II	**Early Contributions and Ethics in Management**: Scientific Management- contributions of Taylor, Gilbreths, Human Relations approach-contributions of Mayo, McGregor's Theory, Ouchi's Theory Z (3 Hrs.) Systems Approach, the Contingency Approach, the Mckinsey 7-S Framework Corporate Social responsibility- Managerial Ethics. (3 Hrs)	6	15%
FIRST INTERNAL EXAMINATION			
III	**Planning:** Nature and importance of planning, -types of plans (3 Hrs.)- Steps in planning, Levels of planning - The Planning Process. – MBO (3 Hrs.).	6	15%
IV	**Organising for decision making:** Nature of organizing, organization levels and span of control in management Organisational design and structure –departmentation, line and staff concepts (3 Hrs.) Limitations of decision making- Evaluation and selecting from alternatives- programmed and non programmed decisions - decision under certainty, uncertainty and risk-creative process and innovation (3 Hrs.)	6	15%
SECOND INTERNAL EXAMINATION			
V	**Staffing and related HRD Functions:** definition, Empowerment, staff – delegation, decentralization and recentralisation of authority – Effective Organizing and culture-responsive organizations –Global and entrepreneurial organizing (3 Hrs.) Manager inventory chart-matching person with the job-system approach to selection (3 Hrs.) Job design-skills and personal characteristics needed in managers-selection process, techniques and instruments (3 Hrs.)	9	20%
VI	**Leading and Controlling:** Leading Vs Managing – Trait approach and Contingency approaches to leadership - Dimensions of Leadership (3 Hrs.) - Leadership Behavior and styles – Transactional and Transformational Leadership (3 Hrs.) Basic control process- control as a feedback system – Feed Forward Control – Requirements for effective control – control techniques – Overall controls and preventive controls – Global controlling (3 Hrs.)	9	20%
END SEMESTER EXAM			

Question Paper Pattern

Max. marks: 100, Time: 3 hours .
The question paper shall consist of three parts

Part A: 4 questions uniformly covering modules I and II. Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)
Part B : 4 questions uniformly covering modules III and IV. Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)
Part C: 6 questions uniformly covering modules V and VI. Each question carries 10 marks
Students will have to answer any four questions out of 6 (4X10 marks =40 marks)

Note: In all parts, each question can have a maximum of four sub questions, if needed.

Course code	Course Name	L-T-P-Credits	Year of Introduction
CH301	ENVIRONMENTAL ENGINEERING	3-1-0-4	2016

Prerequisite : Nil

Course Objectives

- To impart basic concepts of environmental engineering
- To understand about different types of pollution and its treatment

Syllabus

Introduction to environmental engineering. Water treatment methods. Classification and characteristics of wastewater. Wastewater sampling and its analysis. Wastewater treatment methods. Sludge treatment and disposal. Sewage - characteristics - treatment and disposal. Air pollution - sources and classification of air pollutants. Sampling and analysis of air pollutants.Noise pollution. Noise control methods

Expected Outcomes

The students will be able to

i. Recognize the environmental legislation and regulation aimed at protecting the environment from harmful actions.
ii. Know the different types of treatment processes for drinking water, municipal water and boiler feed water.
iii. Know the primary, secondary & tertiary treatment methods used for the waste water treatment.
iv. Design waste water treatment equipment such as activated sludge process and trickling filters.
v. Predict suitable treatment and disposal methods for industrial and hazardous wastes.
vi. Identify air and noise pollution sources and select control methods.

Text Books

1. Metcalf & Eddy, Wastewater Engg., Disposal & Reuse, McGraw Hill
2. Peavy H.S., Rose D.R.& Tchobanoglous G., Environmental Engineering, McGraw Hill
3. Rao C.S., Environmental Pollution Control Engineering, New age International Pub.
4. Rao M.N. & Rao H., Air Pollution, Tata McGraw Hill

Reference Books

1. Austin G.T. (Ed.), Shreve's Chemical Process Industries, McGraw Hill
2. Babbitt H.E., Sewage & Sewage Treatment, John Willey
3. Chemtech I, Chem. Eng. Curriculum Dev. Centre, IIT-Madras
4. Gopal Rao M. & Sittig M. (Eds.), Dryden's Outlines of Chemical Technology, Affiliated East West Press.
5. Mahajan S.P., Pollution Control in Process Industries, Tata McGraw Hill
6. Perkins H.C., Air Pollution, McGraw Hill
7. Sincero A.P. & Sincero G.A., Environmental Engineering-A Design Approach, Prentice Hall of India.

Course Plan			
Module	**Contents**	**Hours**	**Sem. exam marks**
I	Introduction to environmental engineering –environmental legislation and regulation. Water treatment - precipitation processes - alum treatment and lime soda softening. Municipal water conditioning - ion exchange processes Boiler feed water treatment - desalting	8	15%
II	Sources and classification of wastewater. Physical, chemical and biological characteristics of wastewater Types of water pollutants and their effects - water quality standards - Wastewater sampling and analysis - determination of organic matter - dissolved oxygen - biochemical oxygen demand - chemical oxygen demand - wastewater microbiology	8	15%
FIRST INTERNAL EXAMINATION			
III	Wastewater treatment methods - pretreatment - primary treatment - secondary treatment - tertiary treatment Screening, grit removal, oil removal and equalization - neutralization, coagulation, flocculation and sedimentation - clarifiers and clariflocculation Aerobic and anaerobic biological processes - activated sludge process - trickling filters - oxidation ditch - aeration lagoon - rotating biological contactors - aerobic fluidized bed bioreactors - Anaerobic digestion process - anaerobic filter - anaerobic contact process - anaerobic fluidized bed bioreactors - up flow anaerobic sludge blanket (UASB) - disinfections - chlorinating and ozonation - sand filters.	12	20%
IV	Sludge treatment and disposal - sludge thickening - sludge conditioning - sludge dewatering - sludge digestion and composting. Solid waste treatment - sources and classification - collection and disposal methods - open dumping - sanitary landfill - incineration – composting. Treatment of industrial waste - pulp and paper mill - textile mill - distillery - dairy - petroleum refinery - fertilizer industry Hazardous waste -types of hazardous waste - health effects - treatment methods.	12	20%

SECOND INTERNAL EXAMINATION			
V	Air pollution - sources and classification of air pollution. Effects of air pollution - global effects of air pollution - global warming and ozone depletion. - air pollution meterology - atmospheric dispersion - air pollution Sewage - characteristics - treatment and disposal from automobiles - sampling and analysis of air pollutants	8	15%
VI	Air pollution control methods and equipment - settling chambers - cyclone separators - fabric filters - electrostatic precipitators - wet scrubbers - control of gaseous emission - absorption by liquid and adsorption by solids Noise pollution - effects of noise on people. Noise control methods.	8	15%
END SEMESTER EXAM			

Question Paper Pattern:

Maximum Marks: 100 Exam Duration: 3 Hours

Part A: There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part B: There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 20 marks for all the subdivisions put together. (2 x20= 40 Marks)

Part C: There shall be **Three questions** uniformly covering Modules 5 and 6, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Course code	Course Name	L-T-P-Credits	Year of Introduction
CH302	PROCESS DYNAMICS AND CONTROL	3-1-0-4	2016

Prerequisite: Nil

Course Objectives

- To impart the basic concepts of mathematical modeling and Laplace transforms for dynamic study
- To impart fundamentals of controls for chemical processes like block diagram development & reduction, stability analysis, tuning etc.

Syllabus

Laplace transform and its properties –dynamics of first order systems – systems in series - dynamics of second order systems –closed loop systems – block diagram – types of controllers - Transient response of simple control systems-stability analysis- Frequency response methods- Controller tuning-industrial control system

Expected Outcome

At the end of the course the students will be able to

i. determine transfer function for simple chemical process systems
ii. develop control system block diagram and reduce a given block diagram to input/output transfer function model
iii. analyze the stability of open loop and closed loop systems
iv. tune the controller

References:

1. Albert C L & Coggan D A (Ed.)., Fundamentals of Industrial Control, ISA, 1992
2. Bhgade S.S, Nageshwar G.D., Process Dynamics and Control, PHI Learning Pvt. Ltd.
3. Ceaglske N.H., Automatic Process Control for Chemical Engineers, John Wiley & Sons, NY, 1956
4. Coughanewr D.P., Process System Analysis & Control, McGraw Hill
5. Eckman D.P., Principles of Industrial Process Control, John Wiley & Sons Inc, NY (1946)
6. Harriot P., Process Control, Tata McGraw Hill
7. Stephanopoulose G., Chemical Process Control, An Introduction to Theory & Practice, Prentice Hall of India
8. Tsai T.H., Lane J.W. & Lom C.S., Modern Control Techniques for the Processing Industries, CRC Press; 1 edition (April 15, 1986)

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Introduction to process dynamics and control - definition of terms - Laplace transform - transform of simple functions - derivatives and integral - properties of Laplace transforms - final value theorem - initial value theorem - transition of transforms and functions – examples - inversion by partial fraction - solution of differential equations - qualitative nature of solutions - linear open loop systems - first order systems - mercury thermometer,	10	15%

	liquid level and mixing processes - response of these towards different types of forcing functions		
II	Systems in series - interacting and non-interacting types and generalization of results. Linear open loop second order systems - mercury thermometer in a well and manometer - impulse and step response of under damped, critically damped and over damped system, their derivation	8	15%
FIRST INTERNAL EXAMINATION			
III	Controllers - types, basic principles and transfer functions - the flapper nozzle assembly - pneumatic & electronic controllers - PID, PI and PD (derivation excluded). Closed loop system – feedback control- servo and regulator problems - block diagram development - block diagram reduction	10	15%
IV	Transient response of simple control systems - step response and offset - introduction to stability of linear systems - Routh-Hurwitz criterion for stability - root locus technique - plotting the root locus diagram - transportation lag and its effect on root locus diagram	9	15%
SECOND INTERNAL EXAMINATION			
V	Introduction to frequency response - substitution rule – Nyquist diagram, Nyquist stability criteria. Bode diagram for first order systems - first order systems in series - second order systems - bode stability criterion, gain margin and phase margin	10	20%
VI	Controller tuning- Ziegler-Nichols method - reaction curve method - comparison of closed loop responses for different controller settings. Supervisory control and data acquisition (SCADA) – distributed control system (DCS)	9	20%
END SEMESTER EXAMINATION			

Question Paper Pattern

Maximum Marks: 100 Exam Duration: 3 Hours

Part A : There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part B: There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part C: There shall be **Three questions** uniformly covering Modules 5 and 6, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in eachmain question with a total of 20 marks for all the subdivisions put together. (2 x20= 40 Marks)

Course code	Course Name	L-T-P-Credits	Year of introduction
CH303	MASS TRANSFER OPERATIONS -I	3-0-0-3	2016

Prerequisite : Nil

Course Objectives

- To impart the basic concepts of mass transport
- To develop understanding about gas absorption, humidification, crystallization, adsorption and drying.

Syllabus

Molecular diffusion- Theories of mass transfer – interphase mass transfer -Gas-Liquid contacting equipments for mass transfer operations- Gas absorption- Adsorption- Humidification and dehumidification- Drying-dryers- Crystallization-crystalizers

Expected Outcome

The students will be able to

i. Explain the fundamentals of mass transfer operations
ii. Design cooling tower, dryer, crystallizer and absorption systems
iii. Summarize the quantitative requirements of materials for the above unit operations.

References:

1. Coulson J.M. & Richardson J.F., Chemical Engineering, Vol. I & II, ELBS, Pergamon Press
2. Foust A.S. et. al., Principles of Unit Operations, John Wiley
3. K. V. Narayanan and B. Lakshmikutty, Mass Transfer Theories and Applications, CBS Publishers
4. McCabe W.L., Smith J.C. & Harriott P., Unit Operations in Chemical Engineering, McGraw Hill
5. Rousseau R.W., Handbook of Separation Process Technology, John Wiley
6. Seader J.D.& Henley E.J Separation Process Principles, John Wiley & Sons
7. Treybal R.E., Mass Transfer Operations, McGraw Hill
8. Welty J.R., Wilson R.E. & Wicks C.E., Fundamentals of Momentum Heat and Mass Transfer, John Wiley

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Molecular diffusion - mass fluxes J_A and N_A - Fick's law - diffusivity and estimation - steady state diffusion of A through stagnant B and equimolar counter diffusion in binary gases, liquids and multi component gas mixtures. Mass transfer coefficients, dimensionless groups and dimensional analysis - analogy between mass, heat and momentum transfer. Elementary treatment of theories of mass transfer: penetration and surface renewal theories - interphase mass transfer - equilibrium - diffusion between phases - two-film theory - local and overall k-type coefficients.	8	20%

II	Gas-Liquid contacting equipments for mass transfer operations - single stage and multistage contact , tray towers, wetted wall columns, tray types and general features of tray designs (qualitative treatment), continuous contact equipment, venturi scrubbers, packed columns, packing materials and characteristics, general constructional details of packed columns, Factors affecting column performance-flooding, priming, coning, weeping, loading etc, comparison between plate and packed columns.	8	20%
FIRST INTERNAL EXAMINATION			
III	Gas absorption - Solubility of gases in liquid, choice of solvent, Material balance in counter current and concurrent absorption and stripping, L/G ratio, multistage operation, number of plates by graphical construction, Kremser equation, tray efficiency, design of packed columns, transfer unit and general graphical method, dilute solutions and simplified design methods	8	15%
IV	Adsorption, types of adsorption, properties of adsorbents, adsorption isotherm for single gases, vapours and dilute liquid solutions, Adsorption isotherms (equations and derivations only), Adsorption equipments, adsorption wave, rate of adsorption and breakthrough curve. Humidification and dehumidification, Use of humidity chart to find properties of air, Lewis relation, water cooling with air, types of cooling towers, spray chambers for air humidification, principles of gas dehumidification.	8	15%
SECOND INTERNAL EXAMINATION			
V	Drying, equilibrium moisture content, batch drying, rate of drying, cross-circulation drying, mechanism of moisture movement, continuous drying, parallel and counter current, material and enthalpy balances, rough estimate of size of rotary dryer based on heat-transfer units for drying at high temperature, industrial dryers for batch and continuous drying.	**5**	15%
VI	Crystallization, principles of crystallization, purity, yield, energy requirements, super saturation, nucleation, rate of nucleation, growth of crystals, growth coefficients, crystallisation equipment, MSMPR crystallizer.	**5**	15%
END SEMESTEREXAMINATION			

Question Paper Pattern

Maximum Marks: 100 Exam Duration: 3 Hours

Part A : There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 20 marks for all the subdivisions put together. (2 x20= 40 Marks)

Part B: There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part C: There shall be **Three questions** uniformly covering Module 5 and 6, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Course code	Course Name	L-T-P Credits	Year of Introduction
CH304	INORGANIC CHEMICAL TECHNOLOGY	3-0-0-3	2016

Prerequisite : Nil

Course Objectives

- To impart knowledge of various process engineering technologies and process flow sheeting methods
- To develop an understanding of the about unit process and unit operations in various industries.
- To enable the students to select the best process for a product among the alternative methods available in the process industry.

Syllabus

Introduction to chemical technology, Industrial gases and industrial acids, Fertilizers-ammonia manufacture, manufacture of nitrogenous fertilizers, phosphatic fertlizers, compounded and complex fertilizers, marine chemicals, electro thermal products, oil fats and waxes, soaps and detergents.

Expected Outcome

The student will be able to

i. identify unit operation and unit process that are employed in process plants
ii. develop process flow diagrams for manufacturing process.
iii. solve the engineering problems that may occur during various stages of production in process industries.

Text Books:

1. Austin G. T., Shreve's Chemical Process Industries 3/e, McGraw Hill, 1984.
2. Dryden C. E., Outline of Chemical Technology, 2/e, East West Publishers, 1997.
3. Shukla S. D. and G. N. Pandey, "A Text Book of Chemical Technology. Vikas Publishing House, 1986.

References:

1. Chemtech Vol. I – IV, Chemical Engineering Education Development Centre, Indian Institute of Technology, Madras, 1979.
2. Kirk-Othmer Encyclopaedia of Chemical Technology, John Wiley and Sons
3. Ullmann's Encyclopaedia of Industrial Chemistry, John Wiley and Sons

Course Plan

Module	Contents	Hours	Sem Exam Marks
I	Introduction to Chemical Technology, Sectors of Chemical Industry, Overview of Indian Chemical Industry. Industrial gases: Manufacture, properties and uses of hydrogen, oxygen, nitrogen, carbon dioxide Industrial acids: Hydrochloric acid manufacture by synthesis process. Manufacture of sulphur and sulphuric acid by DCDA process. phosphorus and phosphoric acid: wet process phosphoric acid, electric furnace phosphorus and phosphoric acid	8	15%

II	Manufacture of sodium chloride, sodium sulphate, sodium silicate, by products of salt industry Soda ash: Manufacture by Solvay process Chlorine and caustic soda: Manufacture by electrolytic process - Diaphragm cells, membrane cells, mercury cell, baking soda	6	15%
FIRST INTERNAL EXAM			
III	Glasses: Types, raw materials and methods of manufacture. Ceramics: Types, raw materials, processing methods - drying and firing of ceramic wares.	6	15%
IV	Surface coating industries: pigments, paints, varnishes, lacquers. Refractories: classification, manufacture and testing of refractories	6	15%
SECOND INTERNAL EXAM			
V	Fertilizers: Ammonia manufacture, manufacture of urea by once through process and total recycle process Phosphatic fertilizers - super phosphates. Manufacture of nitrogenous fertilizers - ammonium chloride, ammonium sulphate and urea Compound and complex fertilizers:- MAP and DAP, urea ammonium phosphate, NPK fertilizers.	9	20%
VI	Electrothermal products: Manufacture, properties and uses of graphite, fused alumina, silicon carbide, carbon disulphide. Cement: portland cement, constituents, types, raw materials and manufacturing processes.	7	20%
END SEMESTER EXAM			

Question Paper Pattern

Maximum Marks: 100 Exam Duration: 3 Hours

Part A: There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part B: There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part C: There shall be **Three questions** uniformly covering Modules 5 and 6, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 20 marks for all the subdivisions put together. (2 x20= 40 Marks)

Course code	Course Name	L-T-P-Credits	Year of Introduction
CH305	CHEMICAL REACTION ENGINEERING-I	3-0-0-3	2016

Prerequisite : CH204 Chemical engineering thermodynamics

Course Objectives

- To expose the students to the fundamental concepts of chemical kinetics and reactor design.

Syllabus

Reaction kinetics, rate laws, factors affecting rate law, analysis of rate equations by various methods. Ideal reactors, design aspects of single and multiple reactions, multiple reactor systems, pressure drop through reactors, simultaneous reactions and separations, kinetics of enzymatic reactions, bioreactors.

Expected Outcome

At the end of the course the students will be able to

1. Explain the principles of chemical kinetics and thermodynamics to find reaction rate.
2. Determine chemical kinetic parameters using various experimental methods.
3. Design and analyze problems related to isothermal operation of common types of chemical reactors
4. Extend reactor design principles to multiple reactions.
5. Determine rate laws for enzymatic reactions and hence design bioreactors.

Reference Books:

1. H, Scott Fogler, "Elements of Chemical Reaction Engineering", Prentice Hall of India.
2. K.G Denbigh& J.C.R Turner, 'Chemical Reactor Theory- An Introduction', 3rd Ed., Cambridge University Press
3. Levenspiel Octave , "Chemical Reaction Engineering", John Wiley & Son's.
4. Ronald W. Missen, Charles A. Mims, Bradley A. Saville, 'Introduction to Chemical Reaction Engineering and Kinetics', John Wiley & Sons
5. Smith J.M, "Chemical Engineering Kinetics," McGraw Hill.

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	An overview of chemical reaction engineering. Brief outline of reactor design procedure and types of industrial reactors. Classification of chemical reactions with examples. Basic concepts of chemical kinetics. Rate equations, rate constant, temperature dependency-Arrhenius law, collision theory, transition state theory, comparisons and predictions.	5	15%
II	Concentration dependency-non-elementary homogeneous reactions: Active intermediates, pseudo steady state hypothesis (PSSH), searching for a mechanism, General considerations, hydrogen bromide reaction, polymerisation - steps in free radical polymerization. Other examples of non-elementary reactions	6	15%

FIRST INTERNAL EXAMINATION			
III	Analysis of rate equations –Interpretation of batch reactor data: integral and differential method of rate analysis. Integral method; irreversible first order, second order and third order type reactions, zero order reactions, reversible reactions, autocatalytic reactions. Variable volume batch reactor. Differential method of rate analysis, method of half lives, method of initial rates, least square analysis.	10	15%
IV	Evaluation of laboratory reactors, Integral (fixed bed) reactor, stirred batch reactor, stirred contained solid reactor (SCSR), Differential reactors: Continuous stirred tank reactor (CSTR), Laminar flow reactor, stirred through transport reactor, recirculating transport reactor. Ideal reactors, concept of ideality, design equations for batch, tubular and stirred tank reactors. Space time and space velocity, steady state mixed flow, plug flow and laminar flow reactors.	4	15%
SECOND INTERNAL EXAMINATION			
V	Multiple reactor systems, Plug flow reactor in series and parallel, equal sized mixed reactors in series, mixed flow reactors of different sizes in series, determination of the best system for a given conversion. Advantages and limitations of series combinations. Recycle reactors, optimum recycle ratio, plug flow and mixed flow reactors for an autocatalytic reaction. Design for multiple reactions: Reactions in parallel, contacting patterns for reactions in parallel, quantitative treatment of product distribution and reactor size for reactions in parallel and series.	10	20%
VI	Pressure drop in reactors, accounting the pressure drop in the rate law, flow through a packed bed, pressure drop in pipes, simultaneous reactions and separations, Reactive distillation, membrane reactors, inert membrane reactor. Enzymatic reaction fundamental: Michaelis - Menten kinetics, batch reactor calculations for enzymatic reactions. Bioreactors-cell growth kinetics- Monod equation- batch and chemostat models.	7	20%
END SEMESTER EXAMINATION			

Question Paper Pattern

Maximum Marks: 100 Exam Duration: 3 Hours

Part A: There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part B: There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part C: There shall be **Three questions** uniformly covering Modules 5 and 6, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 20 marks for all the subdivisions put together. (2 x20= 40 Marks)

Course code	Course Name	L-T-P-Credits	Year of Introduction
CH306	MASS TRANSFER OPERATIONS II	3-0-0-3	2016

Prerequisite: CH303 Mass transfer operations - I

Course Objectives

- To impart the fundamental concepts of mass transfer operations such as distillation, liquid extraction, leaching and membrane separation processes.
- To develop understanding about design and analysis of distillation, extraction, leaching and membrane operation units.

Syllabus

Distillation – vapour-liquid equilibrium- enthalpy-composition diagrams -Distillation methods-flash distillation - differential distillation - steam distillation – fractionation-principles of rectification – material and energy balance - Design of fractionation columns - McCabe-Thiele method – number of plates- total reflux -minimum reflux - optimum reflux-cold reflux - open steam. Ponchon-Savarit method - feed plate location - minimum reflux conditions. Rectification in packed columns - azeotropic and extractive distillation. Liquid extraction - applications - distribution curve - single-stage and multistage operations – continuous contact extraction-Extraction equipments. Leaching- leaching equilibrium - working principles of leaching equipment. Constant underflow - variable underflow- single stage and multistage leaching - Membrane separation processes – classification of membranes - concentration polarization – ultrafiltration. Reverse osmosis – pervaporation – dialysis.

Expected Outcome

The students will be able to

i. Analyse chemical engineering operations involving mass transfer
ii. Design differential and stage wise separation processes

References:

1. Coulson J.M. & Richardson J.F., Chemical Engineering, Vol. II, ELBS, Pergamon
2. Foust A.S. et al, Principles of Unit Operations, John Wiley.
3. Geankoplis C.J., Transport Processes and Unit Operations, Prentice Hall India
4. K.V.Narayanan and B.Lakshmikutty.,Mass Transfer,Theory and Applications,CBS Publishers.
5. McCabe W.L., Smith J.C. & Harriott P., Unit Operations in Chemical Engineering, McGraw Hill.
6. Seader J.D.& Henley E.J Separation Process Principles Wiley India
7. Treybal R.E., Mass Transfer Operations, McGraw Hill.

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Distillation- boiling-point diagram and equilibrium curves - application of Raoult's law -relative volatility - enthalpy composition diagrams-Distillation methods- flash distillation - differential distillation - steam distillation - fractionation- plate columns for distillation - condensers – reboilers.	7	15%

II	Principles of rectification - material and energy balance -Design of fractionation columns by McCabe-Thiele method - basic assumptions - feed quality and feed line - number of plates -feed plate location –- total reflux -minimum reflux -optimum reflux- plate efficiency -cold reflux – open steam.	7	15%
FIRST INTERNAL EXAMINATION			
III	Ponchon-Savarit method– difference points and reflux ratio- number of plates- feed plate location- minimum reflux conditions Rectification in packed columns - height of packed towers - azeotropic and extractive distillation (qualitative treatment only).	7	15%
IV	Extraction - applications - ternary equilibria on triangular coordinate system - mixer rule -distribution curve - selectivity - choice of solvent - Single-stage and multistage extraction operations. calculations for immiscible systems and partially miscible systems.	7	15%
SECOND INTERNAL EXAMINATION			
V	Construction and working of mixer - settler cascades, sieve-tray columns, agitated towers, pulse columns and centrifugal extractors. Continuous contact extraction - design for insoluble liquids - simplification for dilute solutions. Leaching - factors affecting rate of leaching. Working principles of leaching equipment - Shank's system- thickeners, classifiers and moving bed leaching equipment.	7	20%
VI	Leaching equilibrium -constant underflow - variable underflow Single stage and multistage leaching. Membrane separation processes – classification – types of membranes: flat, spiral wound, hollow fibre - concentration polarization – ultrafiltration. reverse osmosis- – pervaporation -– dialysis effects of operating variables.	7	20%
END SEMESTEREXAMINATION			

Question Paper Pattern:

Maximum Marks: 100 Exam Duration: 3 Hours

Part A: There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part B: There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part C: There shall be **Three questions** uniformly covering Module 5 and 6, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 20 marks for all the subdivisions put together. (2 x20= 40 Marks)

Course code	Course Name	L-T-P-Credits	Year of Introduction
CH307	COMPUTER PROGRAMMING IN C++	2-1-0-3	2016

Prerequisite : Nil

Course Objectives

- To present the concept of object oriented programming
- To discuss the important elements of C++
- To write simple programs using C++

Syllabus

Introduction to OOP, Basics of C++ programming, Decision making and Looping Functions, Arrays and strings ,Classes and objects, Constructors and destructors, Overloading, Inheritance, Pointers, Polymorphism, Files and streams

Expected Outcome

After the successful completion of this course students will be able to

i. Know the basic concepts of OOP
ii. Develop problem solving skills
iii. Write and execute C++ programs using decision making and looping statements
iv. Apply the concept of functions, arrays, pointers, overloading, polymorphism, files, streams etc.

Text Books

1. E. Balaguruswamy, Object Oriented Programming in C++, TMH
2. Robert Lafore, Object Oriented Programming in C++, Galgotia Publishers

Reference Books

- Bjarne Stroustrup ,The C++ Programming Language, , Pearson Education

Course Plan

Module	Contents	Hours	Sem. exam marks
I	Introduction to OOP, Features of object oriented programming, Basics of C++ programming- Data types, operators, precedence of operators, control flow	7	15%
II	Decision Making (if, if…else, else… if, switch statements, conditional operators), Looping Statements (while, do… while, for), break, continue, goto statements.	7	15%
	FIRST INTERNAL EXAMINATION		
III	Functions, arrays and strings, operations on arrays, string manipulations. Classes and objects, constructors, destructors, objects as function arguments, inline functions, friend functions, friend classes, array of objects	7	15%
IV	Overloading, operator overloading, overloading unary operators, overloading binary operators, function overloading. Inheritance – single, multiple, multilevel, hierarchical and hybrid. Base class and derived class, public inheritance, private inheritance, constructors in derived class	7	15%

SECOND INTERNAL EXAMINATION			
V	Pointers, memory management, new and delete, pointers within a class, pointers to objects, array of pointers to objects, pointer to object members, pointer to derived class objects, pointers to pointers	7	20%
VI	Polymorphism, virtual function, pure virtual function, abstract classes, late binding, early binding. Files and streams, streams, predefined console streams, string I/O, object I/O, files, file modes, file pointers, file input/output, command line arguments, templates.	7	20%
END SEMESTER EXAM			

Question Paper Pattern:

Maximum Marks: 100 Exam Duration: 3 Hours

Part A: There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part B: There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part C: There shall be **Three questions** uniformly covering Modules 5 and 6, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 20 marks for all the subdivisions put together. (2 x20= 40 Marks)

Course code	Course Name	L-T-P-Credits	Year of Introduction
CH308	CHEMICAL REACTION ENGINEERING-II	3-0-0-3	2016

Prerequisite : CH305 Chemical reaction engineering - I

Course Objectives

- To expose the students to the concepts of non-ideal flow and flow models, kinetics and reactor design for heterogeneous reactions and design aspects of non-isothermal operations.

Syllabus

Non Ideal flow, RTD studies, Models for non-ideal flow. Kinetics and design of catalytic and non-catalytic heterogeneous reactions. Non-Isothermal reactor operation, Energy Balance, Adiabatic and non adiabatic operations.

Expected outcome

At the end of the course, students will be able to

i. Understand non ideal behaviour of chemical reactors.
ii. Set up and solve non ideal flow models using RTD studies.
iii. Analyze the kinetics and design aspects of catalytic and non-catalytic heterogeneous reactions.
iv. Set up and solve energy balances for non-isothermal operation of chemical reactors.
v. Design chemical reactors for non-isothermal operations.
vi. Develop an awareness of stability and safety of chemical reactors

References Books:

1. H Scott Fogler, “Elements of Chemical Reaction Engineering”, Prentice Hall of India.
2. James J Carberry, “Chemical &Catalytic Reaction Engineering”, Mc Graw Hill
3. K.G Denbigh& J.C.R Turner, ‘Chemical Reactor Theory- An Introduction’, Cambridge University Press
4. Lanny D Schmidt, ‘The Engineering of Chemical Reactions, ’Oxford University Press.
5. Levenspiel Octave , “Chemical Reaction Engineering”, John Wiley & Sons.
6. Ronald W. Missen, Charles A. Mims, Bradley A. Saville, ‘Introduction to Chemical Reaction Engineering and Kinetics’, John Wiley & Sons
7. Smith J.M, “Chemical Engineering Kinetics,” McGraw Hill.

Module	Contents	Hours	Sem. Exam Marks
I	Non-ideal Flow. Residence time distribution for chemical reactors: General characteristics - RTD functions. Measurement of the RTD - pulse input, step tracer input, integral relationships, mean residence time, other moments of the RTD, Normalized RTD function E(theta), Interval age distribution. RTD in ideal reactors: Batch and plug flow reactors, single CSTR, Laminar flow reactor,PFR /CSTR series reactor	6	15%

II	Reactor modelling with RTD - use of RTD to determine conversion. RTD models - segregation models, tanks in series model, the dispersion model. Conversion for the tanks-in-series model, fitting the dispersion model for small extents of dispersion and large extents of dispersion. Models for small deviations from plug flow and long tails. Mixing of fluids - self mixing of fluids - degree of segregation, early and late mixing of fluids	6	15%
FIRST INTERNAL EXAMINATION			
III	Catalyst and catalytic reactors: Catalysts, types of catalysts, catalytic properties, steps in a catalytic reaction, adsorption equilibrium constant, desorption, surface reaction, synthesizing rate law, rate limiting step, Langmuir-Hinshelwood approach. Development of design equations for ideal mixed batch reactor, plug flow tubular reactor and perfectly mixed continuous stirred tank reactor for heterogeneous systems. Heterogeneous data analysis for reactor design	7	15%
IV	Diffusion and reaction in porous catalysts- effective diffusivity, tortuosity-modelling of diffusion with reaction on a spherical catalysts. Thiele Modulus, internal effectiveness factor, Overall effectiveness factor. Estimation of diffusion and reaction limited regimes - Weisz - Prater criterion for internal diffusion, Mears criterion for external diffusion.	7	15%
SECOND INTERNAL EXAMINATION			
V	Fluid Particle Reactions (Non catalytic) Selection of a model: Unreacted core model for spherical particles of unchanging size, model development for diffusion through gas film, ash layer, and chemical reaction controls. Rate of reaction for shrinking spherical particles - chemical reaction controls, diffusion controls, application to design. Fluid-fluid reactions - Rate equations, Kinetic regimes for mass transfer and reactions, rate equation for instantaneous and fast and slow reactions,.	8	20%
VI	.Non isothermal reactor design - Temperature and pressure effects - single reactions : Heat of reaction from thermodynamic, heat of reaction and temperature, equilibrium constants from thermodynamics. General graphical design procedure, optimum temperature progression. Heat effects: adiabatic operations and non-adiabatic operations : Energy Balance, Non-isothermal continuous flow reactors at steady state, application to the CSTR, adiabatic tubular and batch reactor, steady state tubular reactor with heat exchange. Equilibrium Conversions, Adiabatic Equilibrium conversion, reactor staging. Multiple Steady States in CSTR.	8	20%
END SEMESTER EXAMINATION			

Question Paper Pattern

Maximum Marks: 100 Exam Duration: 3 Hours

Part A: There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part B: There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part C: There shall be **Three questions** uniformly covering Module 5 and 6, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 20 marks for all the subdivisions put together. (2 x20= 40 Marks)

Course code	Course Name	L-T-P-Credits	Year of Introduction
CH312	CHEMICAL ENGINEERING DESIGN -I	3-0-0-3	2016

Course Objectives

- To impart the basic concepts of chemical engineering drawing, mechanical design and process design of heat exchangers
- To develop understanding about P&ID, I&C drawing, design and heat exchangers

Syllabus

Introduction to chemical engineering drawing – P&ID of heat exchangers, distillation columns and stirred tank jacketed reactors with at least one control loop. Introduction to pressure vessels: stress variation. Mechanical design of pressure vessels and jacketed vessels. tall columns, column supports- skirt, bracket- saddle as per IS codes. Mechanical design of non standard flange- Design of storage tanks for Volatile and Non-volatile liquids. Process design and detailed drawing of double pipe heat exchanger and shell & tube heat exchangers for single phase streams. Process design of shell & tube condensers: Tubular horizontal & Tubular vertical for condensation of single vapours.

Expected outcome

At the end of the course, students will be able to

i. Demonstrate general P&ID symbols and I&C drawing used in chemical engineering practice
ii. Select and design suitable equipment for the given operation.

Text Books:

1. B.C Bhattacharya, Introduction to Chemical Equipment Design, CBS Publishers & Distributors, New Delhi.
2. D.Q.Kern, Process Heat Transfer, Tata Mc-GRAW HILL

1. .

References:

1. Badger & Bancharo, Introduction to Chemical Engineering, McGraw Hill
2. Bhatt N.D., Machine Drawing, Charotar Book Stall
3. E. Ludwig, Applied Process Design for Chemical & Petrochemical Plants, Vol I, II, III, Gulf Publication, London.
4. Harriot P., Process Control, Tata McGraw Hill
5. I.S.A. code (P&ID)
6. IS Codes.
7. J.M.Coulson & J.F.Richardson, Chemical Engineering, Vol.6, 3rd Edn, Butterworth-Heinemann, (Indian print)
8. M.V Joshi & Mahajan V.V., Process Equipment Design, 3rd Edn, Mac-Milan & Co. India.
9. McCabe W.L., Smith J.C., & Harriot P., Unit Operations in Chemical Engineering, McGrawHill.
10. Perry. R.H & Green.D.W., Chemical Engineers Handbook, 7th Edn, Mc- Graw Hill.
11. Rase & Barrow, Project Engineering of Process Plants, John Wiley

Module	Contents	Hours	Sem. Exam Marks
I	Introduction to chemical engineering drawing – P&ID of heat exchangers, distillation columns and stirred tank	21	50%

	jacketed reactors with at least one control loop. Introduction to pressure vessels: stress variation. Mechanical design of pressure vessels and jacketed vessels. tall columns, column supports- skirt, bracket- saddle as per IS codes. Mechanical design of non standard flange		
FIRST INTERNAL EXAMINATION			
II	Design of storage tanks for Volatile and Non-volatile liquids. Process design and detailed drawing of double pipe heat exchanger and shell & tube heat exchangers for single phase streams. Process design of shell & tube condensers: Tubular horizontal & Tubular vertical for condensation of single vapours.	21	50%
SECOND INTERNAL EXAMINATION			
END SEMESTER EXAMINATION			

Question paper pattern

Maximum marks : 100 Exam duration : 3 hours

There shall be 3 questions uniformly covering modules I & II each carrying 50 marks of which the student has to answer any 2 questions. At the most 4 subdivisions can be there in one main question with a total of 50 marks for all the subdivisions put together.
(2 x50= 100 Marks)

Course code	Course Name	L-T-P-Credits	Year of Introduction
CH331	HEAT TRANSFER OPERATIONS LAB	0-0-3-1	2016

Prerequisite : CH202 Process heat transfer

Course Objectives

- To understand the principles of various modes of heat transfer through experimentation

List of Experiments (Minimum of 10 experiments are mandatory)

1. Heat Transfer by Natural Convection
2. Thermal Conductivity of Metal Rod
3. Heat Transfer through Composite Wall
4. Parallel Flow / Counter Flow Heat Exchanger
5. Heat Transfer in Shell and Tube Heat Exchanger
6. Heat Transfer in fins
7. Unsteady state Heat Transfer
8. Heat Transfer in Agitated Vessels
9. Combined convection and radiation heat transfer
10. Radiation heat transfer
11. Film wise Condensation
12. Determination of Critical thickness of insulation
13. Any other experiments related to modes of heat transfer with and without change of phase

Expected outcome :

- The students will be able to find heat transfer properties and characteristics by conducting experiments

Course code	Course Name	L-T-P-Credits	Year of Introduction
CH332	MASS TRANSFER OPERATIONS LAB	0-0-3-1	2016

Prerequisite: CH303 Mass transfer operations -I

Course objectives

- To supplement the theory course on mass transfer operations

List of Experiments: (Minimum 10 experiments are mandatory)

1. Diffusion coefficient measurement
2. Wetted wall column- measurement of mass transfer coefficient.
3. Simple Distillation
4. Steam distillation
5. Distillation in packed columns, HETP.
6. Absorption in Packed bed columns
7. Surface evaporation – Free convection mass transfer.
8. Liquid extraction: Determination of ternery liquid – liquid equilibria.
9. Simple leaching
10. Cross current leaching
11. Counter current leaching.
12. Adsorption: Determination of adsorption isotherm.
13. Atmospheric batch drying.
14. Any other experiments related to mass transfer operations applicable in chemical engineering field.

Expected outcome

- The students will be able to conduct experiments to find characteristics of different mass transfer operations

Course code	Course Name	L-T-P-Credits	Year of Introduction
CH333	CHEMICAL REACTION ENGINEERING LAB	0-0-3-1	2016

Prerequisite: CH305 Chemical reaction engineering - I

Course Objective

- To expose the students to the fundamental concepts of chemical kinetics and reactor design through experimentation

List of Experiments

1. Isothermal Batch Reactor
2. Isothermal Plug Flow Reactor
3. Isothermal CSTR
4. Packed Bed Reactor
5. RTD Studies in a Packed Bed Reactor
6. RTD Studies in CSTR
7. RTD Studies in PFR
8. Combined Flow Reactor
9. UV Photo Reactor
10. Determination of activation energy
11. Kinetics of reactions
12. Any other experiments related to chemical reaction engineering applicable in chemical engineering field.

Expected Outcome

- The students will be able to determine chemical kinetic parameters using various experimental methods.

COURSE CODE	COURSE NAME	L-T-P-Credits	Year of Introduction
CH334	PROGRAMMING AND PROCESS SIMULATION LAB	0-0-3-1	2016

Prerequisite: CH307 Computer programming in C++

Course Objectives

- To develop the skill to model and simulate various unit operations and processes using commercial simulators
- To impart the ability to develop software programmes for simulating Chemical Engineering problems

SYLLABUS

(Minimum of 5 exercises from each part is compulsory)

Part A

1. Introduction to process simulation
2. Equations of state: solution of problems using MS Excel/ MATLAB (Scilab)/ Aspen Plus
3. Phase equilibrium: solution of problems using MS Excel / MATLAB (Scilab)/ Aspen Plus
4. Chemical Reaction equilibrium: solution of problems using MS Excel / MATLAB (Scilab)/ Aspen Plus
5. Mass Balances with Recycle Streams: solution of problems using MS Excel / MATLAB(Scilab)/ Aspen Plus
6. Simulation of Mass Transfer Equipments: solution of problems using MS Excel / MATLAB(Scilab)/ Aspen Plus
7. Chemical Reactors: solution of problems using MS Excel / MATLAB(Scilab)/ Aspen Plus
8. Transport Processes in One Dimension: solution of problems using MS Excel / MATLAB(Scilab)/ Aspen Plus
9. Process simulation of typical chemical plants using Aspen Plus/ HYSYS

Part B

Develop C++ programmes to implement the following numerical methods

Solution of

1. Nonlinear and transcendental equations
2. Linear Algebraic Equations, Set of equations
3. Methods for interpolation and extrapolation
4. Numerical Differentiation and Integration
5. Solution of Ordinary Linear Differential Equations
6. BVP Ordinary and Partial Differential Equations
7. Fitting Models to data

References:

1. Bruce.A.Finlayson, Introduction to Chemical Engineering Computing, Wiley Interscience.
2. Aspen Plus: Building and running a process model: Manual from Aspen Tech, US.
3. Mohd. Kamaruddin Abd Hamid, HYSYS: An introduction to Chemical Engineering Simulation, http://eprints.utm.my/3030/2

Course code	Course Name	L-T-P- Credits	Year of Introduction
CH361	ENERGY ENGINEERING	3-0-0-3	2016

Prerequisite : Nil

Course Objectives

- To familiarize the students with various conventional & non-conventional energy sources
- To develop understanding about energy harnessing methodology for sustainable development.

Syllabus

General classification of energy, world and Indian energy resources and energy consumption,. Conventional energy resources Solar energy Wind energy and applications. Ocean energy, tidal energy, geothermal energy. Biomass energy resources Fuel cells. Magneto hydro dynamic power generation Energy conservation in different chemical process plants- Energy Audit, electrical energy conservation in chemical Process plants

Expected Outcome

The students will be able to

i. Identify different sources of energy.
ii. Differentiate conventional and non conventional resources.
iii. Apply the knowledge on different energy harnessing technology to related practical problem.
iv. Aware importance of effective utilization of energy in process plants & daily life.

Text Books

1. Rao S. & Parulekar B.B., Energy Technology, Khanna Publishers.
2. Bansal N.K., Kleeman M. & Meliss M., Renewable Energy Sources & Conversion Tech., Tata McGraw Hill.
3. Goldmberg J., Johansson, Reddy A.K.N. & Williams R.H., Energy for a Sustainable World, John Wiley

References:

- Sukhatme S.P., Solar Energy, Tata McGraw Hill
- Mittal K.M., Non-Conventional Energy Systems, Wheeler Publications.
- Venkataswarlu D.I, Chemical Technology, S. Chand
- Pandey G.N., A Text Book on Energy System and Engineering, Vikas Publishing.
- Rai G.D., Non-Conventional Energy Sources, Khanna Publishers.

Course Plan

Module	Contents	Hours	Sem. exam marks
I	Energy, general classification of energy, world energy resources and energy consumption, Indian energy resources and energy consumption, energy Crisis, energy alternatives	6	15%
II	Conventional energy resources, Thermal, hydel and nuclear reactors, thermal, hydel and nuclear power plants, efficiency, merits and demerits of the above power plants, combustion processes, fluidized bed combustion.	6	15%

FIRST INTERNAL EXAMINATION			
III	Solar energy, solar thermal systems, flat plate collectors, focusing collectors, solar water heating, solar cooling, solar distillation, solar refrigeration, solar dryers, solar pond, solar thermal power generation, solar energy application in India, energy plantations. Wind energy, types of windmills, types of wind rotors, Darrieus rotor and Gravian rotor, wind electric power generation, wind power in India, economics of wind farm generation, wind power in India, economics of wind farm.	8	15%
IV	Ocean wave energy conversion, ocean thermal energy conversion, tidal energy conversion, geothermal energy. Biomass energy resources, thermochemical and biochemical methods of biomass conversion, combustion, gasification, pyrolysis, biogas	7	15%
SECOND INTERNAL EXAMINATION			
V	Fuel cells, alkaline fuel cell, phosphoric acid fuel cell, molten carbonate fuel cell, solid oxide fuel cell, solid polymer electrolyte fuel cell. magneto hydro dynamics, open cycle and closed cycle systems, magneto hydro dynamic power generation	7	20%
VI	Energy conservation in chemical process plants, energy audit energy saving in heat exchangers, distillation columns, dryers, ovens and furnaces and boilers, steam economy in chemical plants, energy conservation in petroleum, fertilizer and steel industry, cogeneration, pinch technology, recycling for energy saving, electrical energy conservation in chemical Process plants, environmental aspects of energy use.	8	20%
END SEMESTER EXAM			

Question Paper Pattern:

Maximum Marks: 100 Exam Duration: 3 Hours

Part A: There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part B: There shall be **Three questions** uniformly covering Module 3 and 4, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part C: There shall be **Three questions** uniformly covering Module 5 and 6, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 20 marks for all the subdivisions put together. (2 x20= 40 Marks)

Course code.	Course Name	L-T-P-Credits	Year of Introduction
CH362	NONCONVENTIONAL PETROLEUM RESOURCES	3-0-0-3	2016

Prerequisite : Nil

Course Objectives:

- To understand the geographic distribution of unconventional hydrocarbon resources
- To understand characterization of source and reservoir rocks
- To understand methodology to produce these reserves
- To understand environmental consequences of producing these reserves

Syllabus:

Non-conventional Oil, Shale gas, Coal Bed Methane (CBM), Gas Hydrates, Coal and Gas conversion to Oil, Environmental and Economic considerations of Non-conventional Petroleum Resources.

Expected Outcome:

The students will be able to

i. Apply the concepts related to exploration and development of Shale Gas Reservoirs.
ii. Apply the concepts related to exploration and development of Coal Bed Methane.
iii. Summarize and apply the concepts related to formation of gas hydrates.
iv. Recognize and apply different conversion processes for the production of hydrocarbons.
v. Demonstrate awareness related to environmental issues involved in the development of non-conventional hydrocarbon resources.

Reference Books:

1. Carrol John, 2003, Natural Gas Hydrates: A guide for engineers, Gulf Publications
2. Farooqi Ali, S M, Jones S A and Meldau R F, Practical Heavy Oil Recovery, SPE, 1997.
3. James T. Bartis, Frank Camm, David S. Ortiz, Producing Liquid Fuels from Coal, Prospects and Policy Issues. NETL, DOE, USA, 2008
4. Pramod Thakur, Steve Schatzel and Kashy Aminian, (Editors), 2014, Coal Bed Methane: From Prospects to Pipeline, Elsevier,
5. Rafiqul Islam, M, 2014, Unconventional Gas Reservoirs: Evaluation, Appraisal, and Development, Gulf Professional Publishing
6. Warner, H.R., 2009, Emerging and Peripheral Technologies, Society of Petroleum Engineers, Handbook, Volume VI

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Non-Conventional Oil: Introduction, geology of Heavy oil, extra heavy oil, Tar Sand and bituminous oil shales, their origin and occurrence worldwide, resources, reservoir characteristics, new production technologies.	6	15%
II	Shale Gas: Introduction and present status of shale gas. Formation and properties of shale gas. Drilling and completion	8	15%

	of shale gas. Uses and applications of shale gas. Environmental issues in shale gas exploration. Future prospects of shale gas.		
FIRST INTERNAL EXAM			
III	Coal Bed Methane (CBM): Formation and properties of coal bed methane. Thermodynamics of coal bed methane. Exploration and Evaluation of CBM. Hydro-fracturing of coal seam. Production installation and surface facilities. Well operations and production equipment.	8	20%
IV	Gas Hydrates: Introduction and present status of gas hydrates. Formation and properties of gas hydrates. Thermodynamics of gas hydrates. Drilling and completion of gas hydrates wells. Gas hydrates accumulation in porous media. Gas extraction from gas hydrates. Uses and applications of gas hydrates.	7	20%
SECOND INTERNAL EXAM			
V	Coal and Gas Conversion to Oil: Introduction, classification and principles, pyrolysis, theoretical aspect of processes involved in conversion. Technological development of direct conversion and indirect processes and sustainability of conversions.	7	15%
VI	Environmental and Economic Considerations: Environmental considerations of non-conventional oil and gas. Treating and disposing produced water. Economics of development	6	15%
END SEMESTER EXAM			

Question Paper Pattern:

Maximum Marks: 100 Exam Duration: 3 Hours

Part A: There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part B: There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 20 marks for all the subdivisions put together. (2 x20= 40 Marks)

Part C: There shall be **Three questions** uniformly covering Modules 5 and 6, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Course code	Course Name	L-T-P-Credits	Year of Introduction
CH363	PRINCIPLES OF NANOMATERIALS AND NANOTECHNOLOGY	3-0-0-3	2016

Prerequisite : Nil

Course Objectives

- To introduce the fundamental principles of nanotechnology and nanomaterials
- To understand the various methods of characterization and synthesis of nanomaterials
- To know the applications of nanotechnology and nanomaterials.

Syllabus

Introduction to nanotechnology- Classification of nanomaterials - Supramolecular Chemistry- Types of Nanomachines and nanotechnology- Atomic structure molecules and phase Energy-Molecular and Atomic size-surfaces and dimensional space- Instrumentation for nanoscale characterization - Methods of Synthesis of Nanometerials - Biologically-Inspired Nanotechnology- Molecular nanoscale engineered devices, Kinetically confined synthesis of nano-particles.

Expected Outcomes

The students will be able to:

i. Identify different instruments for Nano scale characterization.
ii. Explain various methods of synthesis of Nano materials
iii. Summarize various applications of nanomaterials.
iv. List the important properties of nanostructured materials.
v. Outline various manufacturing techniques of Nano scale materials.

References:

1. Bhushan, Handbook of Nanotechnology, Springer–Springer,2007
2. Carl C. Koch. Noyes, Nano-structured materials: Processing, properties and Potential Applications, William Andrew Publishing New York.
3. Challa Kumar, Nanodevices for Life Sciences, Vol 4,WILEY-VCH, 2006
4. Challa Kumar, Nanomaterials for Cancer Diagnosis and Therapy, Vol 6 and 7, WILEY-VCH
5. Challa Kumar, Nanomaterials for Medical Diagnosis and Therapy, Vol 10, WILEY VCH
6. Challa Kumar, Tissue, Cell And Organ Engineering, Vol 9, WILEY-VCH, 2006
7. Christof M. Niemeyer and Chad A. Mirkin, Nanobiotechnology: Concepts, Applications and Perspectives, Wiley-VCH; 1 edition, 2004
8. David S. Goodsell, Bionanotechnology, Lessons from Nature, Wiley-Liss, 2004.
9. Fujita H, Micromachines as Tools for Nanotechnology, Springer Verlag, 2003
10. Gero Decher and Joseph B. Schlenoff, Multilayer Thin Films, Wiley-VCH Verlag GmbH and Co. KGaA, 2003
11. Guozhong A.O, Nano structure and nano-materials, Imperial College Press, London
12. Hari Singh Nalwa, “Nanostructured Materials and Nanotechnology”, Academic Press, 2002
13. Jacob Israelachvil, Intermolecular and Surface Forces, Academic Press, London, 1992.
14. Jean-Marie Lehn, Supramolecular Chemistry, Wiley VCH, 1995
15. Jonathan Steed & Jerry Atwood, Supramolecular Chemistry, John Wiley & Sons, 2004
16. Kenneth J. Klabunde, Nanoscale Materials in Chemistry, John Wiley & Sons, Inc., 2001
17. Mark J. Schulz, Mannur J. Sundaresan, Ajit D. Kelkar, Nanoengineering of Structural, Functional and Smart Materials, CRC Press

18. Nicholas A.Kotov , Nanoparticles Assemblies and Superstructures, 2006, CRC Press.
19. Niemeyer C.M and Mirkin C.A, Nanobiotechnology Concepts, Applications and Perspectives 2004, Wiley VCH Verlag GMBH and Co.
20. Poole P, Jr and Frauk J. Owens, Introduction to Nano technology, Charles P, Wiley Interscience, New Jersey, 2003.
21. Pradeep.T, Nano: The Essentials, Tata McGraw-Hill Publishing Company Ltd, 2007.
22. Ralph et al, (Eds), Nanoscale Technology in Biological Systems, 2005, CRC Press.
23. Rao C.N.R., Muller A., Chutham A.K, The Chemistry of Nanoparticles Synthesis, Properties and Applications, Vol 1 and Vol 2, WILEY-VCH
24. William A. Goddard III, Donald W Brenner, Sergey E. Lyshevski, Gerald J. Iafrate, Handbook of Nanoscience, Engineering, and Technology, CRC Press Taylor and Francis Group, 2007

Module	Content	Hours	Sem. Exam Marks
I	Introduction to Nanotechnology, its emergence and challenges Classification of nano-materials: Zero, one, two and three dimensional nano-structured materials Supramolecular Chemistry: Definition and examples of the main intermolecular forces used in supramolecular chemistry. Self-assembly processes in organic systems. Main supramolecular structures. Types of Nanomachines and nanotechnology- Atomic structure of molecules and phase Energy-Molecular and Atomic size-surfaces and dimensional space-Top down and bottom up.	7	15%
II	Instrumentation for nanoscale characterization: Basic characterization techniques; Electron microscopy; Atomic force microscopy; Photon correlation spectroscopy The measurable properties and resolution limits of each technique, with an emphasis on measurements in the nanometer range. Methods of Synthesis of Nanomaterials: Bottom-up (building from molecular level) and top-down (breakdown of microcrystalline materials) approaches.	8	15%
FIRST INTERNAL EXAMINATION			
III	Biologically-Inspired Nanotechnology: basic biological concepts and principles that may lead to the development of technologies for nano engineering systems. Coverage will be given to how life has evolved sophisticatedly Molecular nanoscale engineered devices, and discuss how these nanoscale biotechnologies are far more elaborate in their functions than most products made by humans. Synthesis of nano-particles through homogenous and heterogeneous nucleation Kinetically confined synthesis of nano-particles: Synthesis of nano-wire, rod, tubes and thin films.	7	15%

IV	Special nano-materials: carbon, carbon fullerenes and carbon, nano-tubes, nano and microporous materials, core shell structure and nano-composites. Electrical, magnetic, optical, thermal and mechanical properties of nano-structured materials	7	15%
SECOND INTERNAL EXAMINATION			
V	Manufacturing of nanoscale materials: Chemical vapor deposition of carbon nano tubes, Plasma deposition of ultra-thin functional films on nano materials. Structural nano composites, carbon nano fiber and carbon nano tube/polymer composite fibers and films Nano scale intelligent materials	6	20%
VI	Applications: Solar energy conversion and catalysis, Molecular electronics and printed electronics Nanoelectronics, Polymers with a special architecture, Liquid crystalline systems, Linear and nonlinear optical and electro-optical properties, Applications in displays and other devices, Advanced organic materials for data storage, Photonics, Plasmonics, Chemical and biosensors, Nanomedicine and Nanobiotechnology.	7	20%
END SEMESTER EXAMINATION			

Question Paper Pattern:

Maximum Marks: 100 Exam Duration: 3 Hours

Part A: There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part B: There shall be **Three questions** uniformly covering Module 3 and 4, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part C: There shall be **Three questions** uniformly covering Module 5 and 6, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 20 marks for all the subdivisions put together. (2 x20= 40 Marks)

Course code	Course Name	L-T-P - credits	Year of Introduction
CH364	BIOPROCESS ENGINEERING	3-0-0-3	2016

Prerequisite: Nil

Course objectives:

- To understand industrial fermentation and design an industrial fermenter.
- To distinguish between primary and secondary metabolites
- To know the process technologies for commercial production of products
- To identify the engineering problems associated with the manufacture of products using bioreactors.
- To summarize the application of enzymes in industries.
- To explain the role of microorganisms in bioremediation and biopesticides.

Syllabus

A historical overview of industrial fermentation process – traditional and modern biotechnology- Isolation, preservation and improvement of industrial micro-organisms- Production and purification of primary metabolites - Production of secondary metabolites- Production and purification of enzymes and other by products- Production of bio-fertilizers- bio-pesticides- Bio-preservatives, biopolymers- Bioremediation- Production modern biotechnology products- Products of plant and animal cell culture- Isolation and purification of commercially important enzymes

Expected Outcome

At the end of the course, students will be able to

i. design an industrial fermenter.
ii. distinguish between primary and secondary metabolites
iii. identify the process technologies for commercial production of products and the engineering problems associated.
iv. summarize the application of enzymes in industries.
v. visualise the role of microorganisms in bioremediation and biopesticides..

Reference Books

- Casida Jr, L.E, Industrial Microbioloy, New Age International (P) Ltd.
- Jackson, A.T, Process engineering in biotechnology, Prentice Hall.
- Murrey Moo and Young, Comprehensive Biotechnology, Pergamon.
- Palmer T, Enzymes: Biochemistry, Biotechnology, Clinical chemistry, Horwood publishing Colphon.
- Presscott, Dunn, Industrial Microbiology, Agrobios (India).
- Wulf Cruger and Anneliese Crueger, Biotechnology: A Textbook of Industrial Microbiology, Panima Publishing Corporation.

Course Plan

Module	Contents	Hours	Sem. Exam marks
I	A historical overview of industrial fermentation process – traditional and modern biotechnology -industrially useful microorganisms. Process flow sheeting – block diagrams with industrial pictorial representation for various equipments.	2	15%

	Isolation, preservation and improvement of industrial micro-organisms for overproduction of primary and secondary metabolites. Medium requirements for fermentation process,. Examples of simple and complex media. Basic design of the fermenter, overview of fermentation processes.	4	
II	Production and purification of primary metabolites : Industrial processes for the manufacture of the following products :Organic acids-citric acid, lactic acid itaconic acid and acetic acid .Production of amino acids - commercially important amino acids; alcohols:- ethanol, acetone and butanol	7	15%
FIRST INTERNAL EXAM			
III	Production of secondary metabolites :- Industrial production processes for various classes of secondary metabolites: antibiotics: beta-lactams-penicillin and cephalosporin; aminoglycosides-streptomycin, kanamycin; macrolideserythromycin, quinines, aromatics; commercially important vitamins and steroids	6	15%
IV	Production and purification of enzymes and other byproducts: Microbial production of industrial enzymes: proteases, amylases, lipases and cellulases. Production of biofertilizers- manufacture, formulation and utilization, biopesticides:-. Important biopesticides- Bt-toxin, Kasugamycin, Beauverin, Devine and Collego	7	15%
SECOND INTERNAL EXAM			
V	Biopreservatives, biopolymers- Xanthan gum and PHB, single cell protein. Beverages:- production of beverages, production of baker's yeast, milk products. Bioremediation-microbes in mining, ore leaching, oil recovery, waste water treatment, biodegradation of non cellulose and cellulosic wastes for environmental conservation. Production of recombinant proteins having therapeutic and diagnostic applications, production of vaccines. Production of monoclonal antibodies.	8	20%
VI	Products of plant and animal cell culture. Enzymes: Isolation and purification of commercially important enzymes. Extraction of enzymes, preparation of crude enzymes, purification and characterization of enzymes from plant, animal and microbial sources. Application of enzymes in industry, analytical purposes and medical therapy.	8	20%
END SEMESTER EXAM			

Question Paper Pattern

Maximum Marks: 100 Exam Duration: 3 Hours

Part A: There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part B: There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part C: There shall be **Three questions** uniformly covering Module 5 and 6, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 20 marks for all the subdivisions put together. (2 x20= 40 Marks)

Course code	Course Name	L-T-P-Credits	Year of introduction
CH365	POLYMER TECHNOLOGY	3-0-0-3	2016

Prerequisite : Nil

Course Objectives

- To Impart the basic concepts of polymer technology
- To develop understanding about polymer as an engineering material
- To understand the techniques of polymer processing

Syllabus

Introduction to polymers- classification-kinetics of polymerisation – addition polymerization – free radical polymerization – anionic and cationic polymerization – different types of copolymers. Methods of polymerization – bulk, solution, suspension and emulsion polymerization. Molecular weight of polymers – experimental methods for molecular weight determination –molecular weight distribution curve. Factors affecting polymer properties – types of polymer degradation. Important thermoplastics & thermosetting plastics – properties of polymers – stress strain behaviour of elastomers – viscoelasticity – measurement of rheological properties – melt flow index – capillary rheometers. Processing methods - effect of additives used – compounding methods. Moulding techniques for plastics – injection moulding – compression moulding –calendaring – blow moulding – extrusion – thermoforming – spinning methods for fibres – vulcanization of rubber – general study of elastomer processing methods. Introduction to nano-composites.

Expected Outcome

The student will be able to:

i. Classify the types and mechanisms of polymerization
ii. Summarize the classes, properties and engineering uses/applications of different polymeric materials.
iii. Explain the processing methods and moulding techniques
iv. Describe the elastomer processing methods and vulcanization of rubber..

References:

1. Billmeyer F.W., Text book of polymer science, John Wiley.
2. Gowariker V.R. Polymer Science, New Age.
3. Premamoy Ghosh., Polymer Science and Technology, Tata Mc Graw Hill.
4. Rodrigues F., Principles of polymer systems, Tata Mc Graw Hill
5. Shah V.H., Handbook of plastic testing technology, Wiley, 1998

Course Plan			
Module	**Contents**	**Hours**	**Sem. Exam Marks**
I	Introduction to polymers-monomer, functionality, classification of polymer based on source, structure, application, thermal behaviour, mode of polymerization. Kinetics of polymerisation – addition polymerization – free radical polymerization – anionic and cationic polymerization.	7	15%
II	Molecular weight of polymers – weight average and number average molecular weight – sedimentation and viscosity average molecular weights. Experimental methods for molecular weight determination – end group analysis, light scattering method – viscometry (Ostwald viscometer) intrinsic viscosity. Molecular weight distribution curve.	7	15%
FIRST INTERNAL EXAMINATION			
III	Copolymerisation-Different types of copolymers – Characteristic features. Methods of polymerization – bulk, solution, suspension and emulsion polymerization. Factors affecting polymer properties – crystallinity – orientation treatment – solubility of polymers – glass transition temperature – types of polymer degradation – effect of reinforcement on the properties.	7	15%
IV	Thermoplastics – ABS – acrylics – cellulose acetate – fluoropolymers (PTFE) – nylons – polycarbonate – PVC – PE– PP – PS – polyurethanes. Thermosetting plastics – epoxy – phenol formaldehyde – urea formaldehyde – melamine formaldehyde – polyesters – silicones – (raw materials, properties and applications).Properties of polymers – rheology- viscous flow – apparent viscosity – rubber like elasticity – stress strain behaviour of elastomers – viscoelasticity – stress relaxation and creep – measurement of rheological properties – melt flow index (MFI) – capillary rheometers .	7	15%
SECOND INTERNAL EXAMINATION			
V	Addictives for polymer processing - effect of additives used – plasticizers – colourants – heat stabilizers - antioxidants – ultraviolet absorbers – antistatic agents – flame retardants – blowing agents – lubricants and fillers – brief description of compounding methods.	7	20%

VI	Moulding techniques for plastics – injection moulding – compression moulding – calendaring – blow moulding – extrusion – thermoforming – wet, dry and melt spinning methods for fibres – vulcanization of rubber – general study of elastomer processing methods. Introduction to nano composites.	7	20%
END SEMESTEREXAMINATION			

Question Paper Pattern:

Maximum Marks: 100 Exam Duration: 3 Hours

Part A : There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part B: There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part C: There shall be **Three questions** uniformly covering Modules 5 and 6, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in ache main question with a total of 20 marks for all the subdivisions put together. (2 x20= 40 Marks)

Course code	Course Name	L-T-P-Credits	Year of Introduction
CH366	CORROSION ENGINEERING	3-0-0-3	2016

Course Objectives

- This course is intended to impart knowledge on the importance of corrosion and its prevention and control in process industries.

Syllabus

Importance and principles of corrosion, types of corrosion, testing and monitoring of corrosion, prevention of corrosion, corrosion control in different engineering materials, corrosion control in various industries

Expected Outcome

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

i. identify different types of corrosion
ii. demonstrate various corrosion testing techniques
iii. explain various corrosion prevention techniques
iv. select the appropriate corrosion control technique for different engineering materials
v. know the corrosion control techniques used in various industries

Text Books

1. Fontana M. G., Corrosion Engineering, , Tata McGraw Hill, 3rd Edition, 2005.
2. Jones D. A, Principles and Prevention of Corrosion,., Prentice-Hall, Inc., 2nd Edition, 1996.

Reference Books

- Scully J. C, The Fundamentals of Corrosion,., 2nd Ed., Pergamon Press.
- Stansbury E. E. and Buchanan, R. A, Fundamentals of Electrochemical Corrosion, , ASM International.
- Uhlig H. H. and Revie R. W , Corrosion and Corrosion Control, 3rd Ed., John Wiley & Sons.

Course Plan

Module	Contents	Hours	Sem. exam marks
I	Definition and importance of corrosion, Principles of corrosion phenomenon: Corrosion rate expressions, Electrochemical aspects, Environmental effects, Metallurgical and other aspects.	7	15%
II	Different forms of corrosion: Galvanic or two metal corrosion, Crevice corrosion, Pitting, Intergranular corrosion, Selective leaching, Erosion corrosion, Stress corrosion, Hydrogen damage.	7	15%
	FIRST INTERNAL EXAMINATION		
III	Corrosion testing and monitoring: Non-electrochemical and electrochemical methods: potentiostat, Tafel extrapolation, linear polarization, galvanostat,	7	15%

	impedance spectroscopy, thermogravimetric technique, salt spray test, weight change measurements.		
IV	Corrosion prevention: Design and coatings, inhibitors and surface engineering, cathodic protection and anodic protection.	7	15%
SECOND INTERNAL EXAMINATION			
V	Corrosion and its control in different engineering materials: concrete structures, duplex, super duplex stainless steels, ceramics, composites and polymers.	7	20%
VI	Corrosion and its control in industries: Power, Process, Petrochemical, ship building, marine and fertilizer industries. Corrosion auditing in industries, Corrosion map of India.	7	20%
END SEMESTER EXAM			

Question Paper Pattern

Maximum marks : 100 **Exam. Duration 3 hours**

Part A: There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part B: There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part C: There shall be **Three questions** uniformly covering Modules 5 and 6, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 20 marks for all the subdivisions put together. (2 x20= 40 Marks)

Course code	Course Name	L-T-P-Credits	Year of Introduction
CH367	NUMERICAL METHODS FOR PROCESS ENGINEERS	3-0-0-3	2016

Prerequisite : Nil

Course Objectives

- To impart the basic concepts of numerical analysis
- To develop understanding about numerical techniques for solution of engineering problems

Syllabus

Errors in numerical calculations. Numerical solution of polynomial and transcendental equations - iteration based on second degree equation-Solution of system of linear algebraic equations. Direct methods, Solution of system of nonlinear equations by Newton-Raphson method, Power method for the determination of Eigen values-Polynomial interpolation- Numerical differentiation, Numerical integration. Numerical solution of ordinary differential equations (IVP problems for ODE). Solution of boundary value problems in ordinary differential equations. Solution to PDE's

Expected Outcome

After successful completion of the course the students will be able to

i. Understand basic concepts of error, convergence etc.in numerical methods
ii. Choose and apply appropriate numerical schemes to solve various chemical engineering problems.
iii. Solve system of equations using different numerical methods
iv. Use suitable interpolation methods to deal with the data in hand.
v. Understand and use various numerical schemes used for solving ODE (IVP& BVP) and PDE.

References:

1. Ajay K. Ray, Mathematical Methods in Chemical & Environmental Engineering, Thomson-Learning
2. Froberg C.E., Introduction to Numerical Analysis, Addison Wesley
3. Gerald C.F., Applied Numerical Analysis, Addison Wesley
4. Hildebrand F.B., Introduction to Numerical Analysis, T.M.H.
5. James M.L., Smith C.M. & Wolford J.C., Applied Numerical Methods for Digital Computation, Harper & Row
6. Mathew J.H., Numerical Methods for Mathematics, Science and Engineering, P.H.I

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Errors in numerical calculations,Sources of errors, significant digits and numerical instability - numerical solution of polynomial and transcendental equations - bisection method - method of false position - Newton-Raphson method - fixed-point iteration - rate of convergence of these methods - iteration based on second degree equation - the Muller's method - Chebyshev method - Graeffe's root squaring method for polynomial equations - Bairstow's method for quadratic factors in the case of polynomial equations	7	15%

II	Solutions of system of linear algebraic equations. Direct methods - gauss and gauss - Jordan methods - Crout's reduction method - error analysis - iterative methods - Jacobi's iteration - Gauss-seidel iteration - the relaxation method - convergence analysis - solution of system of nonlinear equations by Newton-Raphson method - power method for the determination of Eigen values - convergence of power method	7	15%
FIRST INTERNAL EXAMINATION			
III	Polynomial interpolation. Lagrange's interpolation polynomial - divided differences Newton's divided difference interpolation polynomial - error of interpolation - finite difference operators - Gregory – Newton forward and backward interpolations - Stirling's interpolation formula -	7	15%
IV	Numerical differentiation - differential formulas in the case of equally spaced points - numerical integration - trapezoidal and Simpson's rules - Gaussian integration - errors of integration formulas	7	15%
SECOND INTERNAL EXAMINATION			
V	Numerical solution of ordinary differential equations. The Taylor series method - Euler and modified Euler methods - Runge–Kutta methods (2nd order and 4th order only) - multistep methods - Milne's predictor - corrector formulas - Adam-Bashforth & Adam-Moulton formulas	7	20%
VI	Solution of boundary value problems in ordinary differential equations - finite difference methods for solving two dimensional Laplace's equation for a rectangular region - finite difference method of solving heat equation and wave equation with given initial and boundary conditions	7	20%
END SEMESTEREXAMINATION			

Question Paper Pattern:

Maximum Marks: 100 Exam Duration: 3 Hours

Part A: There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part B: There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part C: There shall be **Three questions** uniformly covering Modules 5 and 6, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 20 marks for all the subdivisions put together. (2 x20= 40 Marks)

Course No.	Course Name	L-T-P-Credits	Year of Introduction
CH368	COMPUTATIONAL FLUID DYNAMICS	3-0-0-3	2016

Prerequisite: Nil

Course Objectives

- To impart the expertise in computational flow modelling and solution of model equations.

Syllabus

Introduction to computational modelling of flows, Numerical methods for CFD, Application of numerical methods to selected model equations, Solution of Navier Stokes equation, Turbulence modelling, Introduction to reactive and multiphase flow modelling.

Expected Outcome

On completion of this course, students will have the

i. Ability to formulate simplified models of complex fluid flow systems by applying knowledge of mathematics and science.
ii. Ability to apply various numerical techniques in solving fluid flow models.
iii. Ability to assess the accuracy of numerical solutions by comparison to known solutions of simple test problems

References:

1. Anderson, D. A, Tanneheil, J. C. and Pletcher, R. H., "Computational Fluid Mechanics and Heat transfer", Hemisphere, New York, 1984.
2. Anderson, John David, "Computational Fluid Dynamics: The Basics with Applications". McGraw Hill, 1995.
3. Chung, T.J. "Computational Fluid Dynamics". Second Edition, Cambridge University press, Cambridge, UK, 2010.
4. Ferziger, J. H and Peric, M., "Computational methods for Fluid Dynamics". Third edition, Springer-Verlag, Berlin, 2003.
5. Patankar, Suhas, V., Numerical Heat Transfer and Fluid Flow, McGraw Hill, Washington, 1980
6. Ranade, V., Computational Flow Modelling for Chemical Reaction Engineering, Academic Press, 2002.
7. Versteeg, H. K. and Malalasekara, W." Introduction to Computational Fluid Dynamics: The Finite Volume Method". Second Edition (Indian Reprint) Pearson Education, 2008.

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Introduction to Computational Modelling of Flows:– Index notation of vectors and tensors Control volume-Reynolds Transport Theorem Governing equations - Non dimensional forms-Phenomenological models Boundary conditions-Classification	6	15%
II	Numerical methods for CFD:-Classification of PDEs Basic discretization methods- Mesh- iterative methods Stability, convergence and consistency of numerical schemes, Von-Neumann analysis for stability, Courant-Friedrich-Lewi criterion	6	15%

FIRST INTERNAL EXAMINATION			
III	Application of numerical methods to selected model equations: Wave equation, Heat equation, Laplace's equation, Burgers' equation First order, Second order and higher order upwind, Lax Wendroff, MacCormack methods.	6	15%
IV	Solution of the Navier- Stokes equations: Discretization of convective, viscous, pressure and body force terms- conservation properties- Structured and unstructured grids- Staggered and collocated grids, SIMPLE, PISO and PROJECTION algorithms	6	15%
SECOND INTERNAL EXAMINATION			
V	Turbulence Modelling: The Turbulence Problem, Algebraic and Differential Models, Direct Numerical Simulation, Turbulent viscosity models RANS models, Large Eddy Simulation	9	20%
VI	Introduction to Reactive and Multiphase Flow Modelling: Reactor modelling (RTD Studies),Combustion Modelling Multiphase Flow modelling - Fluid/Fluid, Fluid/Solid	9	20%
END SEMESTEREXAMINATION			

Question Paper Pattern

Maximum Marks: 100 Exam Duration: 3 Hours

Part A : There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part B: There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part C: There shall be **Three questions** uniformly covering Modules 5 and 6, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 20 marks for all the subdivisions put together. (2 x20= 40 Marks)

Course code	Course Name	L-T-P-Credits	Year of Introduction
CH369	OPERATIONS RESEARCH	3-0-0-3	2016

Prerequisite : Nil

Course Objectives:

- To impart the scope, objectives, phases, models & limitations of operations research.
- To decide whether a problem can be solved using operations research.

Syllabus:

Introduction to Operations Research, Formulation of Linear Programming Problems, Graphical Solution and the Simplex Algorithm, Duality and Sensitivity Analysis, Transportation and Assignment Problems, Queuing theory, Replacement models, Scheduling on Machines, Network models and Project networks, Game theory and Decision theory.

Expected Outcome:

Upon completion of the subject, students will be able to:

i. Recognize the importance and value of Operations Research and mathematical modeling in solving practical problems in industry.
ii. Identify and develop operational research models from the verbal description of the real system
iii. Formulate a managerial decision problem into a mathematical model.

Reference Books:

1. G.Srinivasan, "Operations Research: Principles and Applications", PHI.
2. Hamdy A. Taha, “Operations Research: An Introduction”, Pearson.
3. Hillier and Lieberman, “Introduction to Operations Research”, TMH, 2001.
4. Paneer Selvam, “Operations Research”, 2nd edition, Prentice Hall of India

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	**Operations Research (OR):** Origin, nature and impact of OR. Development of OR as a branch of knowledge since World War II. Fields of applications of OR. Phases of OR study. **Linear Programming (LP)**: Introduction, LP and allocation of resources, LP definition, Linearity requirement, expressing LP problems, Limitations or constraints, Maximization and Minimization problem formulations.	6	15%
II	**Linear Programming** – Introduction To Graphical Linear Programming, Maximization and Minimization solution. Simplex method definition, formulating the Simplex model. LP – Simplex Method for Maximizing and minimizing, example containing mixed constraints. Duality Theory, The Primal Vs. Dual Solutions. Sensitivity Analysis - Changes in Objective Function, Changes in RHS and related sample problems.	7	15%
FIRST INTERNAL EXAMINATION			
III	**Transportation Problem:** Introduction to Transportation models: Formulation. Balanced and unbalanced transportation models. Initial solution to transportation problems – North West Corner method, Least Cost method and VAM method.	7	15%

	Optimality test – Stepping Stone and MODI method. **Assignment Problem** – problem formulation, illustration and Hungarian method for solution. Unbalanced assignment problem.		
IV	**Queuing theory:** Queuing theory, Queuing models, Assumptions, Queuing Costs, Queuing Terminology, Elements of Queues: Kendall – Lee Notation**,** Birth and death processes. Introduction to Single server and multiple server models**.** **Replacement models**: Replacement – Replacement in anticipation of failure, Individual and Group replacement. **Scheduling on Machines:** Two-job Two-machine problem, Johnson's algorithm.	8	15%
SECOND INTERNAL EXAMINATION			
V	**Network Models:** Construction of Network – Rules & Precautions, Shortest Path Method: Dijkstra's Algorithm and problems. Minimum Spanning Tree problems: Kruskal's and PRIM's algorithm and problems. Maximum Flow Problems**.** **Project Network:** CPM & PERT Networks. Obtaining of Critical Path. Time estimates for activities. Probability of completion of project. Determination of floats.	8	20%
VI	**Game theory:** Practical applications of game theory, Two-person zero-sum games, solving simple games, mixed strategy, Graphical solution, Solving by Linear Programming. **Decision Theory:** Statistical decision theory, Decision making with and without experimentation, Decision Trees, Utility theory.	6	20%
END SEMESTER EXAMINATION			

Question Paper Pattern:

Maximum Marks: 100 Exam Duration: 3 Hours

Part A :There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part B: There shall be **Three questions** uniformly covering Module 3 and 4, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part C: There shall be **Three questions** uniformly covering Module 5 and 6, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 20 marks for all the subdivisions put together. (2 x20= 40 Marks)

Course code	Course Name	L-T-P-Credits	Year of Introduction
CH371	NOVEL SEPARATION PROCESS	3-0-0 3	2016

Prerequisite: Nil

Course Objectives

- To identify the multiple factors influencing the choice of separation techniques.
- To be able to qualitatively and quantitatively address the fundamental aspects of separation processes.

Syllabus

Overview of Separation Processes - Characteristics and selection- Membrane processes - Type and choice of membranes- Membrane filtration- Reverse Osmosis- Dialysis- Models for membrane separations – Surfactant based separation techniques - Microemulsion / Macroemulsions- Hydrotopes - Solvent ablation- Adsorption - Adsorbents, Adsorption equilibrium- Interacting Adsorption systems - Adsorption-Desorption operations - Basics of Ion exchange- Ion movement theory- Applications - Mass transfer in ion exchange systems. Chromatographic separations - selective adsorption of biological macromolecules- Simulated countercurrent techniques - Comparison with other separation methods.

Expected Outcome

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

i. Explain the separation by Membrane process
ii. Explain the separation by adsorption and select suitable adsorbent for recovery of solute and solve the related problems.
iii. Explain the treatment of process liquids by ion exchange process and it's applications.
iv. Explain the treatment of process liquids by Chromatographic Separations and it's applications.

Text Books

1. Seader, J D, and Ernest J Henley. *Separation Process Principles*. New York, Wiley, 1998.
2. Marcel Mulder, "Basic Principles of Membrane Technology", 2 Ed., Springer Publications, 2007
3. King C. J.; "Separation Processes"; Tata McGraw–Hill Publishing Co. Ltd., 1982.
4. Wankat, P. C. "Rate- Controlled Separations", Springer, 1994.

References

1. Nunes S P, Peinemann K V, "Membrane Technology in the chemical industry", 2nd Edition, Wiley-VCH, 2006.
2. Rautanbach and Albrecht R., "Membrane Process", John Wiley and Sons.1989.
3. Crespo. J G, Bodekes K W, "Membrane Processes in separation and Purification", Kluwer Academic Publications, Netherland, 1994.
4. Geankoplis C J "Transport processes and Unit Operations", 4th Edition, PHI, New Delhi, 2006.
5. Philip Schweitzer; "Handbook of Separation Techniques for Chemical Engineers", Third Edition, Tata McGraw Hill New York, 1997.

Course Plan			
Module	**Contents**	**Hours**	**Sem. exam marks**
I	**Overview of Separation Processes and their Selection :** Characteristics and selection of separation process: Importance and variety of separation, economic significance, inherent separation factor, selection, factors influencing the choice of separation process, solvent selection , selection of equipment. Recent advances in separation techniques based on size, surface proper ties, ionic properties and other special characteristics of substances, Rate based versus equilibrium separation processes, Selection of separation process, Energy requirements of separation processes.	7	15%
II	**Membrane processes:** Introduction, Type and choice of membranes, Plate and frame, tubular, spiral wound and hollow fibre membrane reactors and their relative merits, Membrane filtration, Microfiltration, Ultrafiltration, Reverse Osmosis, Dialysis, Models for membrane separations.	7	15%
FIRST INTERNAL EXAMINATION			
III	**Surfactant Based Separation Techniques:** Basic principles, classifications, Surfactants at Inter phases and in bulk, Foam fractionation, Foam flotation, Adsorptive bubble separations, Ion flotation, Micro emulsion /Macro emulsions, Hydrotopes, Solvent ablation.	7	15%
IV	**Adsorption:** Adsorbents, Adsorption equilibrium, Interacting Adsorption systems: Interacting solutes, Adiabatic adsorbers, velocity effects. Adsorption-Desorption operations: Thermal desorption of gases, Activated carbon solute recovery, Processing liquid using thermal regeneration, Pressure swing and vacuum swing adsorption, Regeneration with purge and desorbent.	7	15%
SECOND INTERNAL EXAMINATION			
V	**ION EXCHANGE:** Basics of Ion exchange, Ion exchange resins, Binary ion exchange equilibrium, Ion movement theory, Applications, Applications without exchange: Ion exclusion, Mass transfer in ion exchange systems.	7	20%
VI	**Chromatographic Separations:** Introduction, types of chromatography, Elution chromatography: Principles and Retention theory, Band broadening and separation efficiency, Types of chromatography, Large scale elution (cyclic/batch) chromatography, Selective adsorption of biological macromolecules, Simulated countercurrent techniques, Comparison with other separation methods.	7	20%
END SEMESTER EXAMINATION			

Question Paper Pattern

Maximum Marks: 100 Exam Duration: 3 Hours

Part A: There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part B: There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part C: There shall be **Three questions** uniformly covering Modules 5 and 6, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 20 marks for all the subdivisions put together. (2 x20= 40 Marks)

Course code	Course Name	L-T-P-Credits	Year of Introduction
CH372	CATALYST SCIENCE AND CATALYTIC PROCESSES	3-0-0-3	2016

Prerequisite: Nil

Course Objectives

- To impart the principles, preparatory methods and industrial application of catalyst
- To make aware Chemistry of catalyst, Catalyst characterisation, Catalyst preparation, Industrial catalysis, Catalyst deactivation, Modern trends in catalysis.

Syllabus

Theory of Catalysis, Homogeneous catalysis, Heterogeneous catalysis, Biocatalyst, Preparatory methods, Catalyst characterization, Industrial catalysis, Catalyst activation and deactivation, Modern trends in catalysis.

Expected Outcome

The students will be able to

i. apply the basic concepts and theory for characterisation of catalysts
ii. select catalyst for various unit processes.
iii. know the various catalytic processes in industry.

Text books:

- Smith, J.M, Chemical Engineering Kinetics, McGraw Hill

Reference books:

1. B. Viswanathan, S. Sivasanker, A. V. Ramaswamy, Catalysis: Principles and Applications, Academic Press
2. Diazo Kunii, and Octave Levenspiel, Fluidization Engineering, Butterworth-Heinemann
3. Emmett, P.H , Catalysis Vol I and II, Reinhold Corp, New York, 1954
4. Fogler H.S., Elements of Chemical Reaction Engineering, Prentice Hall of India
5. Hill C.G., An Introduction to Chemical Engineering Kinetics & Reactor Design, John Wiley
6. Levenspiel O., Chemical Reaction Engineering, John Wiley
7. R. A. Van Santen, Piet W. N. M. Van Leeuwen, Jacob A. Moulijn, Bruce A. Averill, Catalysis: An Integrated Approach , Elsevier
8. Thomas and Thomas , Introduction to Heterogeneous Catalysis, Academic Press, London, 1967

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Catalysis. General characteristics of catalysis. Classification of Catalyst, Thermodynamics of adsorption, Physical adsorption and chemisorptions. Adsorption isotherms. Catalyst selectivity.	6	15%
II	Catalyst preparative methods – Precipitation and co precipitation, Sol gel process, Flame hydrolysis, Supported catalyst from CVD and related techniques, preparation and	8	15%

	structure of supports, Synthesis of aluminosilicate zeolites.		
FIRST INTERNAL EXAMINATION			
III	Catalyst Characterisation- surface area measurements, BET theory, Pore size distribution, Porosimetry, Chemisorption techniques, Static and dynamic methods, Crystallography and surface analysis techniques – XRD, NMR.	7	15%
IV	Industrial catalysis – Homogeneous, Heterogeneous, Biocatalysts, Transition metal catalyst, Organo metallic catalyst, Dual function catalyst, Zeolite, Powder and pellet catalyst and their typical industrial applications.	7	15%
SECOND INTERNAL EXAMINATION			
V	Deactivation of catalyst – classification of catalyst deactivation processes, poisoning of catalysts, poisoning of metallic catalysts, poisoning of non metallic catalysts, poisoning of bifunctional catalysts, coke formation on catalysts, metal deposition on catalysts ,sintering of catalysts. Regeneration of deactivated catalyst.	**8**	20%
VI	Modern trends in catalysis – Phase transfer catalysis, electro catalysis, Nano catalysis, Polymer supported catalysis, Bio catalysis, Photo catalysis (Types, uses and industrial application).	**6**	20%
END SEMESTEREXAMINATION			

Question Paper Pattern

Maximum Marks: 100 Exam Duration: 3 Hours

Part A : There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part B: There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part C: There shall be **Three questions** uniformly covering Modules 5 and 6, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 20 marks for all the subdivisions put together. (2 x20= 40 Marks)

Course code	Course Name	L-T-P-Credits	Year of Introduction
CH374	PROCESS DESIGN FOR POLLUTION CONTROL	3-0-0-3	2016

Prerequisite : CH301 Environmental engineering

Course Objectives:

- To impart knowledge in various pollution prevention and control techniques

Syllabus

Environmental regulations, definition of pollutant, types of pollution, process design of water pollution control equipments, process design of water pollution control equipments, process design of air pollution control equipments, bio medical waste

Expected Outcome

The students will be able to

i. understand the importance of protection and improvement of the environment
ii. to monitor and design air ,water& biomedical pollution control systems
iii. to select and use suitable waste treatment technique

Text Books

1. Freeman.H.M, "Industrial Pollution Prevention Hand Book", McGraw Hill,1995
2. Ray T.K., " Air Pollution Control in Industries", Volume I, TBI, New Delhi

Reference Books

1. C S Rao, Environmental Pollution Control Engineering, New age International
2. C. C. Lee, Shun Dar Lin, Handbook of Environmental Engineering Calculations, Second Edition, McGraw Hill
3. S.P.Mahajan Pollution Control in process industries, Tata McGraw Hill, 1990
4. Connwell & Devis, Introduction to Environmental Engineering, TMH.
5. Frank R. Spellman, Handbook of Water and Wastewater Treatment Plant Operations, CRC Press
6. Metcalf & Eddy, Wastewater Engg. TMH
7. S.J.Arceivala, Wastewater treatment for pollution control, TMH

Course Plan

Module	Contents	Hours	Sem. exam marks
I	Prevention vs control of industrial pollution, Environment policies and Regulations to encourage pollution prevention, Environment friendly chemical processes, Regulations for clean environment and implications for industries	7	15%
II	Definition of pollutant, types of pollution; Air, Water, Land, noise- adverse effects of pollutants eco system and human health - need for effluent treatment and toxicity, control. Water standards for portable, agricultural and left-off streams- air standards for cities, industrial areas, resorts.	8	15%
	FIRST INTERNAL EXAMINATION		
III	Design of Equalization Tank, Sedimentation tank, Oil and grease removal unit, aerator and settling tank of an Activated sludge process, Trickling filter, secondary clarifier, Design of Rotating Biological Contactor.	8	20%
IV	Design of Oxidation pond and Oxidation Ditch,Anaerobic	8	20%

	Filter,Two step Anaerobic Digestion System ,Design of Sludge Digester and Sludge Thickener,Air stripping tower		
SECOND INTERNAL EXAMINATION			
V	Process design of cyclone seperators ,fabric filters and Electrostatic precipitators, Baghouses ,gravity settler ,SO_2 Scrubbers.	6	15%
VI	Characterization of medical waste- Bio-medical wastes, biomedical waste categories. Environmental pollution, Treatment methods. Process design of Incinerator, Microwave.	5	15%
END SEMESTER EXAMINATION			

Question Paper Pattern

Maximum Marks: 100 Exam Duration: 3 Hours

Part A : There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part B: There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 20 marks for all the subdivisions put together. (2 x20= 40 Marks)

Part C: There shall be **Three questions** uniformly covering Modules 5 and 6, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Course code	Course Name	L-T-P - Credits	Year of Introduction
**341	DESIGN PROJECT	0-1-2-2	2016

Prerequisite : Nil

Course Objectives

- To understand the engineering aspects of design with reference to simple products
- To foster innovation in design of products, processes or systems
- To develop design that add value to products and solve technical problems

Course Plan

Study : Take minimum three simple products, processes or techniques in the area of specialisation, study, analyse and present them. The analysis shall be focused on functionality, strength, material, manufacture/construction, quality, reliability, aesthetics, ergonomics, safety, maintenance, handling, sustainability, cost etc. whichever are applicable. Each student in the group has to present individually; choosing different products, processes or techniques.

Design: The project team shall identify an innovative product, process or technology and proceed with detailed design. At the end, the team has to document it properly and present and defend it. The design is expected to concentrate on functionality, design for strength is not expected.

Note : The one hour/week allotted for tutorial shall be used for discussions and presentations. The project team (not exceeding four) can be students from different branches, if the design problem is multidisciplinary.

Expected outcome.

The students will be able to

i. Think innovatively on the development of components, products, processes or technologies in the engineering field
ii. Analyse the problem requirements and arrive workable design solutions

Reference:

Michael Luchs, Scott Swan, Abbie Griffin, 2015. Design Thinking. 405 pages, John Wiley & Sons, Inc

Evaluation

First evaluation (Immediately after first internal examination) 20 marks
Second evaluation (Immediately after second internal examination) 20 marks
Final evaluation (Last week of the semester) 60 marks

Note: All the three evaluations are mandatory for course completion and for awarding the final grade.

Course code	Course Name	L-T-P - Credits	Year of Introduction
**352	Comprehensive Examination	0-1-1-2	2016
Prerequisite : Nil			

Course Objectives

- To assess the comprehensive knowledge gained in basic courses relevant to the branch of study
- To comprehend the questions asked and answer them with confidence.

Assessment

Oral examination – To be conducted by the college (@ three students/hour) covering all the courses up to and including V semester– 50 marks

Written examination - To be conducted by the Dept. on the date announced by the University– common to all students of the same branch – objective type (1 hour duration)– 50 multiple choice questions (4 choices) of 1 mark each covering the six common courses of S1&S2 and six branch specific courses listed – questions are set by the University - no negative marks – 50 marks.

Note: Both oral and written examinations are mandatory. But separate minimum marks is not insisted for pass. If a students does not complete any of the two assessments, grade I shall be awarded and the final grade shall be given only after the completion of both the assessments.

The two hours allotted for the course may be used by the students for discussion, practice and for oral assessment.

Expected outcome.

- The students will be confident in discussing the fundamental aspects of any engineering problem/situation and give answers in dealing with them

Course code	Course Name	L-T-P-Credits	Year of Introduction
CH401	TRANSPORT PHENOMENA IN PROCESSES	3-1-0-4	2016

Prerequisite: Nil

Course Objectives

- To impart the knowledge in transport of momentum, heat and mass transport and provide insight into the dependence of temperature and pressure on the transport coefficients.
- To derive simple shell balances to formulate basic conservation equations of transport processes for solving selected engineering problems which can be solved analytically.
- To give basic axioms of conservations namely conservation of momentum, energy and mass.

Syllabus

Introduction to transport phenomena, Basics of Vector and tensor calculus, Mechanisms of momentum transport, Shell momentum balances, 1-D problems on velocity distribution in laminar flow, Equations of change for isothermal systems, Applications of equations of change to solve 1-D problems on velocity distribution in laminar flow. Mechanisms of energy transport, Shell energy balances, 1-D problems on temperature distribution in solids and in laminar flow, equations of change for non-isothermal systems, Applications of equations of change to solve 1-D problems on temperature distribution in solids and in laminar flow. Mechanisms of mass transport, Shell mass balances, Applications of shell mass balances to solve 1-D problems on concentration distributions in solids and in laminar flow, Equations of change for multi-component systems, 1-D problems on concentration distributions in solids and in laminar flow, Methods of solution of momentum, heat and mass transfer problems with more than one independent variable.

Expected Outcomes.

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

i. Apply the governing equations of transport of momentum, heat and mass transport in solving engineering problems
ii. Analyse the dependence of temperature and pressure on the transport coefficients.
iii. Derive simple shell balances to formulate basic conservation equations of transport processes and obtain analytical solutions of selected simple engineering problems.
iv. Interpret the basic axioms of conservations namely conservation of momentum, energy and mass and obtain analytical solutions of selected simple engineering problems.

Text Book

- Bird R.B., Stewart W.C and Lightfoot F.N, *Transport phenomena*, John Wiley & Sons.

References:

1. **Theodore L**, *Transport Phenomena for Engineers* by, International text book Company, U.S.A
2. **Geankoplis**, *Transport processes and unit operations*, 3rd, , PHI, 1997.
3. **Welty, Wicks and Wilson,** Fundamentals of Heat, Momentum and Mass Transfer, John Wiley.
4. **John C Slattery,** *Momentum, Energy and Mass transfer in continua*, McGraw Hill, Co.

5. **Robert S. Brodkey and Harry C Hersing,** *Transport Phenomena a Unified approach,* McGraw Hill Book Co.
6. **Bennet C U** and **Myers J E,** *Momentum, Heat and Mass Transfer,* Tata McGraw Hill Publishing Co.

Course Plan

Module	Contents	Hours	Sem. exam marks
I	Viscosity and the mechanisms of momentum transfer: Newton's law of viscosity, molecular momentum transport, generalization of Newton's law of viscosity, pressure and temperature dependence of viscosity of gases and liquids, prediction of viscosity of gases: Rigid sphere model and rigorous models, prediction of transport coefficients of liquids. Numerical problems Shell momentum balances and velocity distributions in laminar flow: shell momentum balances and boundary conditions, flow of a falling film along a flat surface and on the surface of cylinders, flow of a Newtonian fluid in between two slits formed by two flat plates, flow through a circular tube, flow through annulus, and flow of two adjacent immiscible fluids. Flow of a Bingham fluid through a cylinder- Buckingham-Reiner Equation.	12	20%
II	General transport equation for momentum, derivation of continuity equation, Analysis of equation of motion in rectangular coordinates, Navier Stoke's equation and Euler equation with significance of each terms, transport equation in curvilinear coordinates, application of transport equations to solve steady flow problems:- flow through a tube, tangential annular flow, rotating liquid, cone and plate viscometer. Velocity distributions in turbulent flow: comparisons of laminar and turbulent flows, time-smoothed equations of change for incompressible fluids, and the time- smoothed velocity profile near a wall.	10	20%
FIRST INTERNAL EXAMINATION			
II	**Energy Transport:** Thermal conductivity and the mechanism of energy transport- prediction of thermal conductivity of gases, effect of temperature and pressure on thermal conductivity of gases, relationship between thermal conductivity and viscosity of gases. Thermal conductivity of solids, relationship between thermal and electrical conductivity of solids, Numerical problems. Shell energy balance:- Boundary conditions, application of shell balances to heat conduction problems with electric, nuclear and viscous heat sources and other similar heat conduction problems, use of shell heat balances in variable thermal conductivity systems to derive temperature and heat flux profiles, fixed bed flow reactor, cooling fins with insulated	10	15%

	tip condition, heat transfer by free between two vertical plates and forced convection for flow through pipes with heat transfer at constant wall heat flux.		
IV	Equations of energy in rectangular coordinates, energy equations in curvilinear coordinates, application to steady state heat transfer problems:- tangential flow in annulus with viscous heat generation, free convection from vertical plate, flow of non-isothermal film and transpiration cooling.	8	15%
SECOND INTERNAL EXAMINATION			
V	**Diffusivity and the Mechanism of Mass Transport**: Definition of concentrations, velocities and mass/molar fluxes, Interrelationship between fluxes. Fick's law of diffusion, kinetic theory of diffusion in gases at low density, theory of ordinary diffusion in liquids. Prediction of diffusivity of gases	8	15%
VI	Analogies between heat, mass and momentum transfer, Derivation of equation of continuity for binary mixtures in rectangular coordinates in mass and molar units, general study of equation of continuity in curvilinear coordinates (derivation not desired). Application to combined heat and mass transfer, thermal and pressure diffusion. Solution of mass transport problems for binary systems with analytical solutions.	8	15%
END SEMESTER EXAM			

Question Paper Pattern:

Maximum Marks : 100 Exam Duration: 3 Hours

Part A: There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 20 marks for all the subdivisions put together.

(2 x 20= 40 Marks)

Part B: There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.

(2 x15= 30 Marks)

Part C: There shall be **Three questions** uniformly covering Modules 5 and 6, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.

(2 x15= 30 Marks)

Course code	Course Name	L-T-P-Credits	Year of Introduction
CH402	PROJECT ENGINEERING AND PROCESS PLANT ECONOMICS	3-0-0-3	2016

Prerequisite : Nil

Course Objectives

- To impart the basic concepts of project engineering and economics

Syllabus

Scope of project engineering - the role of project engineer, process engineering - flow diagrams - plot plans - engineering design and drafting, Planning and scheduling of projects, safety in plant design - plant constructions, start up and commissioning,

Time value of money and equivalence - equations used in economic analysis, methods of calculating depreciation, cost estimation techniques, profitability analysis, break-even analysis, inflation, principles of accounting, profit and loss account, balance sheet account, ethics for engineers

Expected Outcome

At the end of the course the students will be able to

i. use efficient tools for planning, scheduling and commissioning of projects.

ii. use different tools of economic analysis for comparing different projects and in decision making.

References

1. Ernest E. Ludwig, Applied project engineering and management, Gulf Pub. Co., (1988)
2. Jelen F.C., Cost and Optimisation Engineering, McGraw Hill
3. Peters & Timmerhaus, Plant Design & Economics for Chemical Engineering, McGraw Hill
4. Rase & Barrow, Project Engineering of Process Plants, John Wiley
5. Schweyer, Process Engineering Economics, McGraw Hill

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Classification of Projects, Scope of project engineering - the role of project engineer - R & D - TEFR - plant location and site selection - preliminary data for construction projects - process engineering - flow diagrams - plot plans - engineering design and drafting	7	15%
II	Planning and scheduling of projects - bar chart and network techniques - procurement operations - office procedures - contracts and contractors - project financing - statutory sanctions,	7	15%
	FIRST INTERNAL EXAMINATION		
III	Scope of piping engineering, pipe sizing technique, Codes and standards, Piping design, thermal insulation and buildings, safety in plant design - plant constructions, start up and commissioning	6	15%

IV	Time value of money and equivalence - equations used in economic analysis - compound interest and continuous interest, unacost - capitalized cost, depreciation and taxes - nature of depreciation - methods of determining depreciation - straight line - sinking fund - declining balances - double declining balance - sum of years digits and units of production methods	6	15%
SECOND INTERNAL EXAMINATION			
V	Cost indices - material cost indices - labour cost indices - William's sixteenth factor - location index – Cost estimation - equipments for process plants - types of cost estimates - order of magnitude estimate - study estimate - preliminary estimate - definitive estimate - detailed estimate - techniques of cost estimates - conference techniques - comparison techniques graphic relationship - tabular relationship - unit rate techniques - lang factor method - hand factor method - Chilton method - miller method - Peter's and Timmerhaus ratio factor method principles of accounting - accounting definition - trial balance - balance sheet - profit and loss accounts - financial ratios related to balance sheet and profit and loss account, canons of ethics of engineers	7	20%
VI	Profitability analysis - mathematical methods for profitability evaluation - payout time - payout time with interest - return on average investment - DCF rate of return - net present value - net present value index - break even analysis - variable cost and fixed cost - economic production chart for 100% capacity and dumping - non-linear economic production chart Inflation, una-burden, displacement vs replacement ,	9	20%
END SEMESTEREXAMINATION			

Question Paper Pattern:

Maximum Marks: 100 Exam Duration: 3 Hours

Part A : There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part B: There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part C: There shall be **Three questions** uniformly covering Modules 5 and 6, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 20 marks for all the subdivisions put together. (2 x20= 40 Marks)

Course code	Course Name	L-T-P-Credits	Year of Introduction
CH403	PROCESS INSTRUMENTATION	3-0-0-3	2016

Prerequisite : Nil

Course Objectives

- To study about different instruments and techniques used in chemical industry for measurement of various process variables and understand the theory behind them.
- To understand the range of applicability and characteristics of these instruments.

Syllabus

Applications of measurement instrumentation, functional description of measuring instruments, performance characteristics of instruments. Temperature measurement; Thermal expansion methods, thermoelectric sensors, electrical resistance sensors, radiation thermometer. Pressure measurement; Measurement of low pressure and high-pressure by different methods. Flow measurement of fluids and solids. Level measurement in open vessels; Humidity measurement; Moisture content measurement using thermal method. Composition analysis; liquids using spectroscopic analysis, solids by X-Ray diffraction and Gas analysis by thermal conductivity, polarography & chromatography. developments of P&I, diagram for flow systems, level, PH control temp control, Heat exchangers, Distillation column, reaction system etc.

Expected Outcome

- On completion of this course the students will be able to explain and sketch various measuring instruments used for pressure, temperature, flow, level and composition used in chemical industry and their applicability, static and dynamic characteristics

Text Book:

- Jain R K, Mechanical and Industrial measurements, Khanna publishers.

References:

1. Ernest O Doeblin, Measurement systems, Application and Design, McGraw Hill.
2. Patranabis D, Principles of Industrial Instrumentation, Tata- McGraw Hill.

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Introduction-definition of instrumentation-concept of an instrument Basic principles of measurements - Classification methods of measurements - Direct and indirect measurements, various elements in a measuring instrument - Sensing element, transducing element manipulating element and functioning element etc- Principles of working with a suitable example, static and dynamic characteristics of measuring instrument, accuracy, reproducibility, sensitivity, static error, dead zone, dynamic error, fidelity lag, speed of response etc.	8	15%
II	Temperature measurements, temperature scales, basic principles and working of thermometers, mercury in glass thermometers, bimetallic thermometers resistance	6	15%

	thermometers, thermocouples, optical pyrometers, radiation pyrometers, ranges of different types of temperature measuring instruments, sources of errors and precautions to be taken in temperature measurements.		
FIRST INTERNAL EXAMINATION			
III	Pressure measurement - Principles of working of manometers, various types of manometers - McLeod gauge, Knudsen gauge, radioactive vacuum gauge, Bourdon gauge, bellows, diaphragm, electrical pressure transducers, piezoelectric manometers, thermal conductivity gauges- ionization gauge high pressure measuring instruments. Level measurement-direct type and indirect type. Differential pressure method for pressurized vessels. Conductivity meters. Solid level detectors.	8	20%
IV	Flow measurements - Liquid and gas flow measurements, ways of measuring liquids and gas flow, direct volume measurements, quantity meters, gas meters, magnetic flow meters, heat input flow meters, elbow flow meters, impact meters, variable area meters, rotameters, cylinder and piston type - Liquid flow velocity, turbine meters, open channel flow measurements, wires notches, head meters, pitot tube, orifice meters venturi meters, theory and working flow measurements, electrical transducers, turbine type flow meters strain gauge flow meters mass flow meter, measuring flow of dry materials.	8	20%
SECOND INTERNAL EXAMINATION			
V	Moisture content and humidity definition, moisture content determination by thermal drying. Instruments for measuring humidity like hygrometer, psychrometer, dew point apparatus. pH measurement using calomel electrode. thermo gravimetric analysis	6	15%
VI	Composition analysis using spectroscopic methods like absorption, emission and mass spectrometers. Analysis of solids by X-ray diffraction. Gas analysis by thermal conductivity, polarography & chromatography. Developments of P&I, diagram for flow systems, level, PH control temp control, Heat exchangers, Distillation column, reaction system etc	6	15%
END SEMESTEREXAMINATION			

Question Paper Pattern

Maximum marks : 100 Exam Duration ; 3 hours

Part A: There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part B: There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 20 marks for all the subdivisions put together. (2 x20= 40 Marks)

Part C: There shall be **Three questions** uniformly covering Modules 5 and 6, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Course code	Course Name	L-T-P-Credits	Year of Introduction
CH404	SAFETY ENGINEERING IN PROCESS PLANTS	3-0-0- 3	2016

Prerequisite : Nil

Course Objectives:

- To impart the basic concepts of industrial safety.
- To develop understanding about safety practices in industries and emergency procedures.
- To understand about chemical hazards and risks.

Syllabus

Introduction to safety, accidents, safety data sheet, work permit system. Hazards-classification and consequence of hazards. Prevention and identification techniques of hazards. Safety audits, analysis and inspections. Fire, fire fighting techniques. Case study of safety provisions in factories**.**

Expected Outcome

The students will be able to

i. Implement safety in processes.
ii. Analyze the chemical hazards in plants.
iii. Analyze the Process Reliability and Human Errors.

Text Books

1. Bhaskara Rao- "Safety in Process Plant Industries" Khanna Publications.
2. Daniel Crowl- " Chemical Process Safety" 3rd edition, Pearson Publications
3. R.K.Jain & Sunil S Rao, Industrial Safety, Health and Environment Management Systems, Khanna Publishers

Reference Books:

1. Encyclopedia of Occupational Health & Safety, International labour Office, Geneva
2. Frank P. Lees- "Loss Prevention in Process Industries" ,Vol.1,2&3,Second Edn, Butterworth-Heinemann.1996
3. Grialdi, J. V., and Simonds, R.H., Safety Management, AITBS Publishers & Distributors, New Delhi
4. Guidelines for Hazard Evaluation Procedure. Centre for Chemical Process Safety.AICHE,1992
5. K.V. Raghavan and A. A. Khan : Methodologies in Hazard Identification and Assessment Manual by CLRI, December 1990.
6. Kumar, A., Chemical Process Synthetics and Engineering Design, Tata McGraw Hill, New Delhi
7. Ralph King, Safety in the Process Industries, Butterworth-Heinemann
8. Slote, L., Handbook of occupational safety & Health, John Wiley & Sons, New York.
9. V.C Marshal : Major Chemical Hazards – Ellis Harwood Ltd., Chichester, U.K. 1987.
10. Wells. G. L, Safety in Process Plant Design, George Godwin Ltd, London.

Course Plan			
Module	**Contents**	**Hours**	**Sem. exam marks**
I	Introduction to safety: Concept and importance of industrial safety. Fundamental safety tenets. Safety in the site selection and lay out. Accidents- Classification Cost of accidents. Key safe practices in chemical industry for accident prevention programme. Material safety data sheet. Work permit system	7	15%
II	Chemical hazards classification. Consequence of chemical hazards. Physical hazards- Atmospheric contaminants, Sound, Light, Radiation, Pressure, Temperature. Electrical hazards- electric shock, flash over, lightning Strokes. Mechanical hazards. Environmental hazards.	7	15%
FIRST INTERNAL EXAMINATION			
III	Prevention techniques for hazards. Hazard area classification. Safety in transportation of hazardous chemicals by road-HAZCHEM CODE, TREM CARD Relief system and Detectors. T.L.V, STEL, TLV-C, IDLH, UFL, LFL. Hazard identification techniques- Dow index and Toxicity index	7	15%
IV	Safety Inspections, safety Audits, Job- safety Analysis, Hazard Survey and analysis, HAZOP, Fault tree analysis, failure mode and effect analysis, Event tree analysis, examples. Consequence of chemical hazards. Probit equations, FN curves, Risk-individual risk, societal risk.	7	15%
SECOND INTERNAL EXAMINATION			
V	Hazards due to Fire-Pool fire, Jet fire, Flash fire, Explosion-UVCE, BLEVE, Toxic release, Runaway Reaction. Fire pyramid. Types of fire extinguishers and its handling. Types of built in extinguishing systems. Fixed fire protection systems. Firefighting techniques. Flame proof equipments.	7	20%
VI	Emergency planning-onsite and offsite emergency planning, Mock drill. Health hazards due to Chemical exposure. Safety provisions in the Factories Act, Salient features of Petroleum Act. The concept of inherent safety.	7	20%
END SEMESTER EXAM			

Question Paper Pattern

Maximum Marks: 100 Exam Duration: 3 Hours

Part A: There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.
(2 x15= 30 Marks)

Part B: There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.
(2 x15= 30 Marks)

Part C: There shall be **Three questions** uniformly covering Modules 5 and 6, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 20 marks for all the subdivisions put together.
(2 x20= 40 Marks)

Course code	Course Name	L-T-P-Credits	Year of Introduction
CH405	CHEMICAL ENGINEERING DESIGN II	3-0-0-3	2016

Prerequisite : CH312 Chemical engineering design - I

Course Objectives

- To impart the basic concepts of process design of evaporators, distillation, absorption and stripping columns, extraction columns, dryers and cooling towers.

Syllabus

Process design and detailed drawing of: Evaporators- Standard short tube, Standard long tube and forced circulation evaporators. Multiple effect evaporators. Process design and drawing of Cooling Towers, Rotary Dryers

Process design of steady state isothermal binary component distillation columns. Detailed drawing of distillation column and its accessories. Process design of steady state isothermal absorption and stripping column-detailed drawing. Process design and drawing of sieve tray single solvent extraction columns

Expected outcome

At the end of the course, students will be able to

i. Select and design suitable equipment for the given operation.
ii. Design evaporators and distillation columns.

Text Books:

1. R.E.Treybal, Mass Transfer Operations, McGraw Hill.
2. D.Q. Kern, Process Heat Transfer, Tata McGraw Hill.

References:

1. B.C Bhattacharya, Introduction to Chemical Equipment Design, CBS Publishers & Distributors, New Delhi.
2. Badger & Bancharo, Introduction to Chemical Engineering, McGraw Hill
3. E. Ludwig, Applied Process Design for Chemical & Petrochemical Plants, Vol I, II, II, Gulf Publication, London.
4. IS Codes.
5. J.M.Coulson & J.F.Richardson, Chemical Engineering, Vol.6, 3rd Edn, Butterworth-Heinemann, (Indian print)
6. M.V Joshi & Mahajan V.V., Process Equipment Design, 3rd Edn, Mac-Milan & Co. India.
7. McCabe W.L., Smith J.C., & Harriot P., Unit Operations In Chemical Engineering, McGraw Hill.
8. Perry. R.H & Green.D.W., Chemical Engineers Handbook, 7th Edn, McGraw hill.
9. Rase & Barrow, Project Engineering of Process Plants, John Wiley

Module	Contents	Hours	Sem. Exam Marks
I	Process design and detailed drawing of: Evaporators- Standard short tube, Standard long tube and forced circulation evaporators. Multiple effect evaporators. Process design and drawing of Cooling Towers, Rotary Dryers	21	50%
	FIRST INTERNAL EXAMINATION		
II	Process design of steady state isothermal binary component distillation columns. Detailed drawing of distillation column	21	50%

	and its accessories. Process design of steady state isothermal absorption and stripping column-detailed drawing. Process design and drawing of sieve tray single solvent extraction columns		
SECOND INTERNAL EXAMINATION			
END SEMESTER EXAMINATION			

Question paper pattern

Maximum marks : 100 Exam duration : 3 hours

There shall be 3 questions uniformly covering modules I & II each carrying 50 marks of which the student has to answer any 2 questions. At the most 4 subdivisions can be there in one main question with a total of 50 marks for all the subdivisions put together.
(2 x50= 100 Marks)

Course code	Course Name	L-T-P - Credits	Year of Introduction
CH407	BIOCHEMICAL ENGINEERING	3-0-0-3	2016

Prerequisite : Nil

Course Objectives

1. To understand different types of cells and classification of kingdom protistae.
2. To interpret kinetics of enzyme catalyzed reactions
3. To compare different types of fermentation cycles and growth phases.
4. To know different metabolic pathways and transport across cell membrane
5. To analyze Heat and mass transfer effects in bioprocess and bioreactors.

Syllabus

Cell theory , structure of cells-protist kingdom- Kinetics of Enzyme catalyzed reactions- Michaelis – Menten equation, Substrate concentration dependence of enzyme catalysed reactions- substrate activation and inhibition- competitive and uncompetitive inhibition- Enzyme specificity- Immobilized enzyme technology- Applications of enzymes - Metabolic pathways and energetics of the cell- Transport across cell membranes- Measuring and monitoring of growth process- Fermentation schemes- Transport phenomena in Bio process system- bio-chemical reactors

Expected Outcome

The students will be able to

i. Understand the fundamental aspects of Biochemical Engineering
ii. Develop the kinetics of enzyme catalyzed reactions and transport processes
iii. Explain the metabolic pathways and energetic of the cell.

Reference Books

1. James E. Baileay and David F. Ollis., “Bio-chemical Engineering Fundamentals”. Mc Graw Hill International Editions.
2. D G Rao., “Introduction to Biochemical Engineering”, Tata Mc Graw Hill.
3. Michael L Shuler and Frikret Khargi., “Bioprocess Engineering Basic Concepts” PHI Publications.

Course Plan

Module	Contents	Hours	Sem. Exam marks
I	Micro Biology, Cell theory, Structure of cells, cell fractionation, protist kingdom and their distinguishing characteristics.	2	15%
	Chemicals of life*:* repetitive and non repetitive bio polymers - lipids, sugars and polysaccharides, nucleotides RNA and DNA, amino acids and proteins. Protein structure,	4	15%
II	Kinetics of Enzyme catalyzed reactions: simple enzyme kinetics with oneor two substrates, Michaelis - Menten Kinetics, Evaluation of parameters in Michaelis – Menten equation, Substrate concentration dependence of enzyme catalysed reactions: substrate activation and inhibition, Modulation and regulation of enzyme activity - competitive and uncompetitive inhibition, other influences on enzyme activity	7	15%

FIRST INTERNAL EXAMINATION			
III	Enzyme specificity and enzyme specificity hypotheses, Enzymes of industrial importance. Isolation of crude enzyme - Koji technique - Enzyme purification. Immobilized enzyme technology: enzyme immobilization,medical and analytical applications of immobilized enzymes. Applications of hydrolytic enzymes: esterases, carbohydrases, proteolytic enzymes, pectic enzymes and additional applications. Medical application of enzymes.	6	20%
IV	Metabolic pathways and energetics of the cell: Metabolic reaction coupling : ATP, ADP and NAD. Oxidation and reduction- Coupling via NAD. Embden-Meyerhof pathway (EMP), Pentose phosphate cycle - Entner Doudorff (ED) pathway, Respiration - TCA cycle. Transport across cell membranes - passive transport, active transport and facilitated diffusion.	7	20%
SECOND INTERNAL EXAMINATION			
V	Measuring and monitoring of growth process (Hemacytometer, colony count and turbidity methods). Batch cultivation - growth cycle (lag, exponential, stationary and death phase). Fermentation schemes - Gaden's classifiation (type I, II and type III) and Deindoerfer classification	8	15%
VI	Transport phenomena in Bio process system-Gas-liquid mass transfer in cellular system - basic mass transfer and concepts - rates of metabolic oxygen utilization – determination of oxygen transfer rates-mass transfer across free falling or raising bubble and free surface with or without agitation in heat transfer. Microbial heat generation and correlation, bio-chemical reactors, types of reactors for sterilization.	8	15%
END SEMESTER EXAMINATION			

Question Paper Pattern:

Maximum Marks: 100 Exam Duration: 3 Hours

Part A : There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part B: There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 20 marks for all the subdivisions put together. (2 x20= 40 Marks)

Part C: There shall be **Three questions** uniformly covering Modules 5 and 6, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Course code	Course Name	L-T-P-Credits	Year of Introduction
CH409	ORGANIC CHEMICAL TECHNOLOGY	3-0-0-3	2016

Prerequisite : Nil

Course Objectives

- To expose conversion of raw materials into useful organic products.
- To impart unit operations and unit processes employed in the manufacture of organic products.
- To familiarize the manufacturing processes of natural organic products and synthetic organic chemicals.

Syllabus

Food Processing, Soaps And Detergents, Synthetic Organic Chemical Industries

Expected Outcome

The students will be able to

i. understand the manufacturing of various inorganic and organic chemicals
ii. identify various process parameters and to prepare process flow diagrams.
iii. apply the concepts of unit operation and unit processes in the design of process plants

References:

1. G.N. Pandey, A Textbook of Chemical Technology, Vol.II, Vikas Publishing House.
2. George T. Austin, Shreve's Chemical Process Industries, McGraw-Hill International Editions,
3. Gopala Rao M. and Marshall Sittig, Dryden's Outlines of Chemical Technology, Edited by Affiliated East - West Press
4. Moulijn J. K., Makkee M. and van Diepen A,. "Chemical Process Technology", Wiley.

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Natural products Industries I: general study of food processing-food by products - leather- gelatin – adhesives - vegetable oils-animal fats and oils –waxes.	7	15%
II	Natural products Industries II: sugar. starches and related products-industrial alcohol by fermentation-absolute alcohol-beers, wines and liquors.	6	15%
	FIRST INTERNAL EXAMINATION		
III	Natural products Industries III- soaps and detergents-gycerine-pulp and paper: Raw materials, pulping processes, recovery of chemicals, stock preparation and papermaking.	8	15%
IV	Synthetic Organic Chemical Industries I: Manufacturing processes of formaldehyde-methanol-chloromethanes-trichloroethylene-perchloroethylene-vinyl chloride-acetaldehyde-acetone-vinyl acetate	6	15%

SECOND INTERNAL EXAMINATION			
V	Synthetic Organic Chemical Industries II: Manufacturing processes of cumene-acylonitrile-isoprene-butadiene-phenol-styrene-phthalic anhydride-maleic anhydride-nitrobenzene-aniline	8	20%
VI	Synthetic Organic Chemical Industries III: general study of dyes and intermediates-pesticides-pharmaceuticals-biotechnology	7	20%
END SEMESTEREXAMINATION			

Question Paper Pattern:

Maximum Marks: 100 Exam Duration: 3 Hours

Part A: There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.
(2 x15= 30 Marks)

Part B: There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.
(2 x15= 30 Marks)

Part C: There shall be **Three questions** uniformly covering Modules 5 and 6, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 20 marks for all the subdivisions put together.
(2 x20= 40 Marks)

Course code	Course Name	L-T-P-Credits	Year of Introduction
CH431	PROCESS CONTROL LAB	0-0-3-1	2016

Prerequisite : CH302 Process Dynamics and Control

Course Objectives

- To study experimentally the dynamics of various systems and analyze common control systems

List of Exercises / Experiments (Minimum of 12 mandatory)

1. Calibration of thermocouple
2. Dynamics of thermocouple
3. Dynamics of thermometer
4. Dynamics of thermometer with thermo well
5. Dynamics of manometer
6. Dynamics of liquid level system - single tank
7. Dynamics of liquid level system - non-interacting tanks in series
8. Dynamics of liquid level system - interacting tanks in series
9. Control of level process system
10. Control of flow process system
11. Dynamics of mixing process
12. Control of temperature process system
13. Control of pressure process system
14. Comparative study of P, PI and PID controllers for temperature process system
15. Study of Electro-pneumatic converter
16. Control valve characteristics
17. Any other experiments related to process control applicable in chemical engineering field

Expected Outcome

At the end of the course the students will be able to:

i. Determine the dynamics and dynamic parameters of temperature, level and pressure systems
ii. Compare different types of controllers such as P,PI and PID
iii. Determine the characteristics of control valve

References:

1. Albert C.L. & Coggen D.A., Fundamentals of Industrial Control, ISA
2. Ceaglske N.H., Automatic Process Control for Chemical Engineers
3. Coughanewr D.P., Process System Analysis & Control, McGraw Hill
4. Eckman D.P., Principles of Industrial Process Control
5. Harriot P., Process Control, Tata McGraw Hill
6. Stephanopoulose G., Chemical Process Control- An Introduction to Theory & Practice, Prentice Hall of India
7. Tsai T.H., Lane J.W. & Lom C.S., Modern Control Techniques for the Processing Industries, Marcel Dekker

Course code	Course Name	L-T-P-Credits	Year of Introduction
CH461	PETROLEUM REFINERY ENGINEERING	3-0-0-3	2016

Prerequisite : Nil

Course Objectives

- To study the origin and formation of Petroleum , the principles and process of petroleum refinery operation, and the transportation & storage of Petroleum
- To know testing methods of petroleum products.

Syllabus

Origin and formation of Petroleum, Drilling operations, Evaluation and Characterization of crude. Transportation & Storage of Petroleum, pre-treatment of Crude, Atmospheric distillation &Vacuum distillation of crude, Arrangement of tower, Cracking, Reforming, Isomerisation, Alkylation, Polymerization. Treatment techniques for Petroleum products, Lube oil treatment. Analysis of petroleum products. .

Expected Outcome

The students will be able to

i. understand the basic concepts of Primary and Secondary petroleum processing
ii. evaluate and characterize of crude oil.
iii. Know about the storage and transportation of Petroleum products

Text books:

1. Baskara Rao B.K, Modern Petroleum Refinery Process, Oxford& IBM
2. Dr.Ram Prasad, Petroleum Refining Technology, Khanna Publishers

References:

1. Austin G.T, Shreves Chemical Process Industries, McGraw Hill
2. Dr.Kochu Baby Manjooran S, Modern Petroleum Chemistry, Kannatheri Publication, Cochin
3. Gopala Rao M & Sitting M, Drydens Outline of Chemical Technology, Affiliated East West Press
4. I D Mall, Petrochemical Process technology, Macmillan
5. Nelson W.L, Petroleum Refinery Engineering, McGraw Hill

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Origin and formation of petroleum. Exploration, Drilling and Secondary recovery methods of crude. Storage and transportation of crude and products. Status of Petroleum industry in India. Composition of crude-Evaluation of oil stock.	7	15%
II	Petroleum processing-Dehydration and desalting of crude-Furnace-Distillation of crude- Arrangement of tower, Atmospheric and Vacuum distillation unit.	7	15%
	FIRST INTERNAL EXAMINATION		
III	Thermal Conversion process. Thermal cracking-Mechanism of Thermal cracking - Visbreaking-Coking – Delayed coking, Fluid coking and Flexi coking.	6	15%

IV	Catalytic conversion process-Catalytic cracking-Types of Catalyst-Types of reaction-Mechanism of Catalytic cracking. Catalytic reforming-Reforming reaction-Catalyst-Process description. Process description and application of Hydro cracking, Polymerization, Alkylation, Isomerisation	8	15%
SECOND INTERNAL EXAMINATION			
V	Treatment techniques. Production and treatment of L.P.G. Treatment of Kerosene- Edeleanu process. Treatment of Lube-Sulphuric acid treatment, Clay treatment, Phenol extraction. Dewaxing methods. Hydrotreating Process.	8	20%
VI	Properties, test methods and uses of Refinery products such as L.P.G, Gasoline, Jet fuel, Kerosene, Diesel fuel, Lubricating oil, Waxes, Bitumen and Carbon Black.	6	20%
END SEMESTEREXAMINATION			

Question Paper Pattern:

Maximum Marks: 100 Exam Duration: 3 Hours

Part A: There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.
(2 x15= 30 Marks)

Part B: There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.
(2 x15= 30 Marks)

Part C: There shall be **Three questions** uniformly covering Modules 5 and 6, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 20 marks for all the subdivisions put together.
(2 x20= 40 Marks)

Course code	Course Name	L-T-P Credits	Year of Introduction
CH462	NATURAL GAS ENGINEERING	3-0-0-3	2016

Prerequisite : Nil

Course Objective

- To know about the properties of natural gas.
- To understand salient features of a gas reservoir.
- To be able to develop systems for natural gas production.

Syllabus

Introduction to Natural Gas, origin of natural gas, other sources of gaseous fluids. Gas Reservoir Performance and Gas flow measurement, Methods of measurements, Gas compression, Types of Compressors Heat and Mass Transfer Principles and Applications in Natural Gas Engineering, natural gas processing, Gas Gathering, Transport and Storage, Transmission of Natural Gas, Unconventional gas, LNG: Production and Utilization

Expected Outcome:

The students will be able to

i. Explain natural gas processing
ii. Describe gas compression, gas gathering and transport installation
iii. Perform trouble shooting of natural gas pipelines

Reference Books

1. "Gas Processes Suppliers Handbook", USA, 1980.
2. Beggs, D, H, Gas Production Operations. Edition Technip. 1984
3. Ikoku, Chi, "Natural Gas Production Engineering", John Wiley and Sons, 1984.
4. Katz D.L.et al., Natural Gas Engineering (Production & storage), McGraw-Hill, Singapore.
5. Kumar Sanjay, "Gas Production Engineering", Gulf Publishing Company, TX, USA, 1987.
6. Lee, J, Wattenbarger, R. A., "Gas Reservoir Engineering", Society of Petroleum Engineers, TX, USA, 1996.

Course Plan

Module	Content	Hours	Sem. Exam mark
I	Introduction to Natural Gas, origin of natural gas, other sources of gaseous fluids. Phase behaviour fundamentals, qualitative and quantitative phase behaviour, vapour- liquid equilibrium. Equation of state, critical pressure and temperature determination. Gas compressibility, viscosity and thermal conductivity, formation volume factor.	5	15%
II	Fundamentals of gas flow in conduits, fundamentals of fluid flow in porous media, inflow performance curves, outflow performance. Gas flow measurement, fundamentals, Methods of measurements, Orifice meters equation, turbine meters, Selection, Recording charts, Uncertainties in flow.	6	15%
	FIRST INTERNAL EXAM		
III	Types of Compressors, Selection, Thermodynamics of Compressors, Compression calculations. Heat and Mass	7	15%

	Transfer Principles and Applications in Natural Gas Engineering, Use of Mollier Diagrams.		
IV	Gas liquid separations, dehydration processes, absorption and adsorption by gas permeation. Desulfurization processes, solid bed sweetening process, physical and chemical absorption processes, Acid gas removal. Integrating natural gas processing.	8	15%
SECOND INTERNAL EXAM			
V	Gas Gathering, Transport and Storage: Gas Gathering System. Steady Flow in Simple Pipeline System, Steady State and non Steady State Flow in Pipelines, Solution for Transient Flow. Transmission of Natural Gas, Specifications. Underground Storage and Conservation of Natural Gas.	8	20%
VI	Unconventional gas**:** Coal Bed Methane, Natural Gas Hydrate, Basin Centered Gas, Tight Gas Sands, Shale Gas. Current Technology for Shale Gas and Tight Gas Exploration and Production. LNG: Production and Utilization Issue and Challenges to Enhance Supply of Natural Gas.	8	20%

Question Paper Pattern

Maximum Marks: 100 Exam Duration: 3 Hours

Part A: There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.
(2 x15= 30 Marks)

Part B: There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.
(2 x15= 30 Marks)

Part C: There shall be **Three questions** uniformly covering Modules 5 and 6, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 20 marks for all the subdivisions put together.
(2 x20= 40 Marks)

Course code	Course Name	L-T-P-Credits	Year of Introduction
CH463	ENZYME ENGINEERING	3-0-0-3	2016

Prerequisite: Nil

Course Objectives

- To impart the basic concepts of enzymes and the reactors involved in free and immobilized enzyme system
- To understand the kinetics and physicochemical characteristics of enzymes

Syllabus

Classification of enzymes, Commercial application of enzymes Production and purification of crude enzymes.. Mechanism of Enzyme action, Simple enzyme kinetics. Michaelis-Menten kinetics. Types of inhibition. Influences of pH, temperature, fluid forces, chemical agents and irradiation on enzyme activity. Enzyme immobilization. Advantages and disadvantages of different immobilization techniques. Application of immobilized enzyme systems. Mass transfer effects in immobilized enzyme systems. Batch and Continuous Operation of a stirred reactor. Immobilized enzyme reaction in a CSTR and plug flow reactor. Enzyme biosensors, design of enzyme electrodes and their application in industry.

Expected Outcome

Students will be able to:

i. Classify enzymes along with their applications in different fields
ii. Analyse the kinetics of enzymes and apply the same in the design of reactors
iii. Outline the types and methods of immobilization of enzymes
iv. Summarize the various types of enzyme reaction systems and reactors

References:

1. Gerharts, W, Enzymes in industry – Production and application.
2. James E Bailey & David F Ollis “Biochemical Engineering Fundamentals” McGraw Hill
3. Pauline M Doran “BiopriocessEngg. Principles” – Academic press
4. Taylor, R.F.(Ed.) “Protein Immobilization – Fundamentals and applications”. Wiley online Library.
5. Zubay G, Biochemistry, Maxwell Macmillan International Education

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Classification of enzymes, commercial application of enzymes in food, pharmaceutical and other industries. Enzymes for analytical and diagnostic applications. Production and purification of crude enzymes. Extracts from plant, animal and microbial sources	7	15%
II	Mechanism of Enzyme action, Concept of active site, enzyme-substrate complex and enzyme action, Simple enzyme kinetics with one substrate. Michaelis - Menten kinetics. Evaluation of parameters in the Michaelis - Menten kinetics Equation. Types of inhibition. Influences of pH, temperature, fluid forces, chemical agents and irradiation on enzyme activity	7	15%

FIRST INTERNAL EXAMINATION			
III	Enzyme immobilization. Physical and chemical techniques for enzyme immobilization adsorption, matrix entrapment, encapsulation, cross – linking, covalent binding. Advantages and disadvantages of different immobilization techniques. Application of immobilized enzyme systems	7	15%
IV	Mass transfer effects in immobilized enzyme systems. Analysis of film and pore diffusion effects on kinetics of immobilized enzyme reactions.	7	15%
SECOND INTERNAL EXAMINATION			
V	Batch Operation of a stirred reactor Time course for batch enzyme reaction. Continuous operation in a stirred tank reactor. Immobilized enzyme reaction in a CSTR and plug flow reactor.	7	20%
VI	Enzyme biosensors, application of enzymes in analysis, design of enzyme electrodes and their application in industry, health care and environment	7	20%
END SEMESTEREXAMINATION			

Question Paper Pattern

Maximum Marks: 100 Exam Duration: 3 Hours

Part A: There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.
(2 x15= 30 Marks)

Part B: There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.
(2 x15= 30 Marks)

Part C: There shall be **Three questions** uniformly covering Modules 5 and 6, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 20 marks for all the subdivisions put together.
(2 x20= 40 Marks)

Course code	Course Name	L-T-P-Credits	Year of Introduction
CH464	WATER AND WASTEWATER ENGINEERING	3-0-0-3	2016

Prerequisite : Nil

Course Objectives

- To have an increased awareness among students on issues in areas of water pollution.
- To establish a clear understanding of the role and impact of various aspects of engineering and engineering decisions on water pollution

Syllabus

Water Engineering- water sources, water demand, water quality standards, water conservation methods.

Water Engineering- wastewater Treatment analysis- Preliminary and Primary Treatment Methods, Biological and Advanced Treatment Methods, Wastewater Engineering -Sludge Treatment and Disposal.

Case studies on Wastewater Treatment Methods in various industries.

Expected Outcome

The student will be able to

i. Understand the different types of water pollution problems and their solutions
ii. Work in the area of water and wastewater engineering for research and education

Text Books:

1. Eckenfelder W.W, “Industrial Water Pollution Control”, Mc Graw Hill, 2000
2. M. N Rao &A.K Dutta, “ Wastewater treatment”, PHI Publication
3. Mark.J.Hammer & Mark.J.Hammer Jr ., Water and Wastewater Technology, Prentice Hall of India. Ltd.
4. Metcalf and Eddy Inc: “Wastewater engineering”, Tata Mc Graw Hill, New Delhi
5. Qasim S, “Water Works Engineering”, Prentice Hall Publication, New Delhi
6. S.K Garg ,”Wastewater engineering” , Khanna publication

Reference Books:

1. Areadio P Sincen & Gregoria A Sincen, Environmental Engineering- A Design Approach, Prentce Hall of India Ltd.
2. Duggal, K.N.,Elements of Public Health Engineering, S.Chand & Co.,New Delhi.
3. Mackenzie L Davis & David A Cornwell, Introduction to Environmental Engineering, Mc Graw Hill.
4. Peavy,Rowe & Tchobanoglous “Environmental Engineering”, Mc Graw Hill, New Delhi.
5. Ragwala, Water supply and sanitary Engineering, Charotar Publishing House,Anand,India
6. W.Wesley Eckenfelder,Jr, Principles of water quality management, CBI Publishing Company,Inc.

Course Plan			
Module	**Contents**	**Hours**	**Sem. exam marks**
I	Water resources- Rainfall and runoff, ground water and surface waters. Quantity of water-Domestic water needs, Industrial demand, Institutional demand and Fire fighting demand. Quality of water- Impurities in water and their importance, water borne diseases. Water Analysis-Physical, Chemical and Biological analysis.	7	15%
II	Water quality standards for drinking water, mineral water, boiler feed water and swimming pools. Water recycling and reuse, rain water harvesting. Water pollution control and water management.	6	15%
FIRST INTERNAL EXAM			
III	Wastewater flows and characteristics, wastewater collection systems, estimation and variation of wastewater flows. Treated wastewater reclamation and reuse, wastewater preliminary, primary, secondary and tertiary treatment processes. Screens, grit chamber & their design, sedimentation, coagulation, flocculation.	6	15%
IV	Theory of activated sludge process, extended aeration systems, trickling filters, aerated lagoons, stabilization ponds, oxidation ditches etc. concept of anaerobic contact process, anaerobic filter, anaerobic fixed film reactor, fluidized bed and expanded bed reactors and up flow anaerobic sludge blanket (UASB) reactor. Ddisinfections ,chlorinating and ozonation , sand filters, activated carbon, adsorption, ion exchange , reverse osmosis	8	15%
SECOND INTERNAL EXAM			
V	Sludge treatment and disposal: Design of sludge management facilities, sludge thickening, sludge digestion, biogas generation, sludge dewatering. Upgrading existing plants, ultimate residue disposal, and recent advances.	6	20%
VI	Case studies: Study on process flow sheets, wastewater characteristics, waste generation points, treatment scheme suggested for the following industries: Distillery, Paper/pulp industry, Tanneries, Sugar, Textile, Steel and Oil refinery.	9	20%
END SEMESTER EXAM			

Question Paper Pattern

Maximum Marks: 100 Exam Duration: 3 Hours

Part A: There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.
(2 x15= 30 Marks)

Part B: There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.
(2 x15= 30 Marks)

Part C: There shall be **Three questions** uniformly covering Modules 5 and 6, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 20 marks for all the subdivisions put together.
(2 x20= 40 Marks)

Course code	Course Name	L-T-P-Credits	Year of Introduction
CH465	PROCESS OPTIMIZATION	3-0-0-3	2016

Prerequisite : Nil

Course Objectives

- To identify and formulate different types of optimization problems
- To solve various multivariable optimization problems
- To apply different optimization techniques in process design.

Syllabus

Nature and essential features of optimization problems, formulation of optimization problems, convex and concave functions, numerical methods for one dimensional optimization problems, numerical methods for unconstrained multivariable optimization, nonlinear programming with constraints, application of optimization techniques in process design

Expected Outcome

The students completing this course will be able to:

i. analyze & solve practical chemical engineering optimization problems
ii. apply the knowledge of optimization to design problems

Text Books

1. Beightler C.S., Phillips D.T. & Wilde D.J., Foundations of Optimization, Prentice Hall of India
2. Beveridge G.S.G. & Schechter R.S., Optimiszation: Theory & Practice, McGraw Hill
3. Edgar T.F. & Himmelblau D.M., Optimization of Chemical Processes, McGraw Hill
4. Rao S.S., Optimization: Theory and Applications, Wiley Eastern

Reference Books

1. J. Nocedal and S. J. Wright, Numerical Optimization, Springer Verlag.
2. M.C. Joshi and K. M. Moudgalya, Optimization: Theory and Practice, Narosa Publishing.

Course Plan

Module	Contents	Hours	Sem. exam marks
I	Nature and organisation of optimisation problems - scope and hierarchy of optimisation -typical applications of optimisation - essential features of optimisation problems – objective function - investment costs and operating costs in objective function - optimising profitability - constraints - internal and external constraints	7	15%
II	Formulation of optimisation problems -typical examples - nature of functions and their representation - continuous functions - discrete functions - unimodal functions - convex and concave functions - necessary and sufficient conditions for optimum of unconstrained functions	7	15%

FIRST INTERNAL EXAMINATION			
III	Numerical methods for unconstrained functions - one dimensional search - gradient-free search with fixed step size - gradient search with acceleration - Newton's method - Quasi-Newton method - dichotomous search -fibonacci search - golden-section method – quadratic interpolation	8	20%
IV	Numerical methods for unconstrained multivariable optimisation – univariate search - Powell's method - method of steepest descent - Fletcher-Reeves conjugate - gradient method - Newton's method Linear programming - basic concepts in linear programming - graphical interpretation -simplex method - apparent difficulties in the simplex method - two-phase simplex method	8	20%
SECOND INTERNAL EXAMINATION			
V	Nonlinear programming with constraints - equality constraints - method of direct substitution Lagrange multiplier method - use of lagrange multipliers for inequality constraints – Kuhntucker conditions for local optimality Complex method, - Rosen's gradient projection method	6	15%
VI	Optimising recovery of waste heat - optimisation of evaporator design - optimum diameter for pipe for transportation of fluid - optimisation of liquid - liquid extraction process - optimal design and operation of staged distillation columns - optimum residence time for isothermal batch reactor - linear programming to optimize reactor operations	6	15%
END SEMESTER EXAMINATION			

Question Paper Pattern

Maximum Marks: 100 Exam Duration: 3 Hours

Part A: There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part B: There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 20 marks for all the subdivisions put together. (2 x20= 40 Marks)

Part C: There shall be **Three questions** uniformly covering Modules 5 and 6, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Course code	Course Name	L-T-P-Credits	Year of Introduction
CH466	COMPOSITE MATERIALS	3-0-0-3	2016

Prerequisite: Nil

Course Objectives

- To impart the basic concepts of composite materials

Syllabus

General Characteristics of Composites, Basic Materials, Processing/Manufacturing, Composite Micromechanics, Composite Mechanics Theory, Failure And Strength Design, Composite Behaviour And Applications

Expected Outcome

At the end of the course the students will be able to

i. Demonstrate understanding of fundamentals in materials, manufacturing, mechanics, design, and repair of composites;
ii. Identify advantages and disadvantages of composites with respect to metals; and
iii. Apply the knowledge acquired to the design and manufacturing of high-performance composite structures.

References:

1. G. Piatti, Advances in composite materials, , (1978), Applied Science Publishers Ltd., London.
2. D. Hull, An Introduction to Composite Materials, Cambridge University Press, Cambridge.
3. G.Lubin, Handbook of composites, Van Nostrand, New York, 1982.
4. K.K. Chawala, Ceramic matrix composites, , 1st ed., (1993) Chapman & Hall, London.
5. K.K.Chawla, Composite Materials, 2nd ed., (1987) Springer-Verlag, New York
6. Katz.H.S. & J.V. Milewski, Handbook of Fillers and Reinforcement for plastics- Van Nostrand, New York.
7. M.O.W. Richardson (Ed)Polymer Engineering Composites. Applied Science Publishers, London.
8. Mohr.J.G.et al, SPI handbook of Technology and Engineering of reinforced Plastics/Composites, Van Nostrand, New York.
9. P. M. Ajayan, L. S. Schadler, P. V. Braun , Nanocomposite Science and Technology, , (2003), Wiley-VCH Verlag GmbH Co. KGaA, Weinheim.
10. V.V. Vasiliev and E.V. Morozov, Mechanics and Analysis of Composite Materials, , (2001), Elsevier Science Ltd, The Boulevard, Langford Lane, Kidlington, Oxford OX5 lGB, UK.

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	General characteristics of composites, advantages and disadvantages, advantages of using composites in high performance structures application trends. Composite applications in aircraft, space, transportation, energy,	7	15%

	electronics, sports and medical industries. Characteristics of fibers, matrices, interface bonding, adhesives microstructure of composites, the function of the fiber and matrix in a composite. Thermoplastic and thermoset matrix composites. Composite products and their unique properties. The strengthening mechanism that makes composites stronger. Environmental effects to design of composite structures.		
II	**Processing/Manufacturing:** Traditional and novel approaches process fundamentals. Fundamental physics in composite manufacturing, manufacturing processes for polymeric composites. Typical defects introduced in manufacturing and the methods utilized to minimize these defects. Common terminology in composites manufacturing. Special tooling considerations required for composite manufacturing.	7	15%
FIRST INTERNAL EXAMINATION			
III	**Composite Micromechanics** Basic concepts, stiffness, strength, thermal and moisture expansion. Anisotropic and isotropic materials, tailored specific strengths. The cause of discontinuous stresses in composites and how it differs from metals.	7	15%
IV.	**Composite Mechanics Theory** Laminate theory; macromechanical behavior of a ply, out-of-plane effects. Hooke's Law to unidirectional composites. The stress-strainrelations of a unidirectional composite subjected to mechanical, thermal and moisture loads. Stress/strain/curvature of a laminate under constant axial forces and bending moments. The unusual behaviors which may occur in laminates such as bending/stretching coupling and stretching-shear coupling. The use of a specific layup orientation based on the loading conditions and CLT. The role of lamina and their arrangement in a laminate.	7	15%
SECOND INTERNAL EXAMINATION			
V	**Failure and Strength Design:** Failure criteria, Laminate Strength, Stress Concentrations. The service life (fatigue) and environmental (damage/corrosion) effects on metallic vs. composite structures. Key damage mode for composites and composite damage tolerance capabilities.	7	20%
VI	**Composite Behavior and Applications:** How do actual composites for aerospace, automotive, sporting goods, high temperature applications behave? Problem areas, long-term performance, influence of structural geometries the Advantages and disadvantages of composites with respect to Product Lifecycle Management. General considerations and	7	20%

	process involved in composite structural design. Typical in-service damage types for composites. Non-destructive inspection techniques for detecting damage in composites. Basic types of composite repair and their benefits.		
END SEMESTEREXAMINATION			

Question Paper Pattern

Maximum Marks: 100 Exam Duration: 3 Hours

Part A: There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.
(2 x15= 30 Marks)

Part B: There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.
(2 x15= 30 Marks)

Part C: There shall be **Three questions** uniformly covering Modules 5 and 6, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 20 marks for all the subdivisions put together.
(2 x20= 40 Marks)

Course code	Course Name	L-T-P-Credits	Year of Introduction
CH467	PROCESS MODELING AND SIMULATION	3-0-0-3	2016

Prerequisite : Nil

Course Objectives

- To give student an understanding of Process Modelling and Simulation

Syllabus

Definitions And Classification Of Modelling, Fundamental Laws Of Chemical Engineering, Mathematical Models For Chemical Engineering Systems, Continuous Flow Tanks, Mixing Vessels, Steam Jacketed Vessel, Batch Distillation, Gas Flow System, Simulation Of Gravity Flow Tank, CSTR In Series, Non-Isothermal CSTR, Binary Distillation Column, Batch Reactor, Jacketed Tubular Reactor, Countercurrent Liquid-Liquid Heat Exchanger

Expected Outcome

- The students will be able to develop mathematical models of Chemical engineering processes and do simulation.

References:

1. Amiya K.Jana, Computer Process Modelling and Computer Simulation, Prentice Hall of India
2. Biquette W.B., Process Dynamics - Modeling Analysis and Simulation, Prentice Hall of India
3. Franks R.G.E., Mathematical Modeling in Chemical Engineering, John Wiley
4. John Ingham et.al., Chemical Engineering Dynamics - Modeling with PC Simulation, VCH Publishers
5. Luyben W.L., Process Modeling, Simulation and Control for Chemical Engineers, Mc Graw Hill International Edition

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Definitions of Modelling, uses of Mathematical modelling, -classification of modelling techniques- -basic modelling principles	7	15%
II	Fundamental laws of chemical engineering: Energy equations, continuity equation, equation of motion, transport equations, equations of state, equilibrium states and chemical kinetics-examples	7	15%
	FIRST INTERNAL EXAMINATION		
III	Mathematical models for chemical engineering systems: continuous flow tanks- Mathematical models for mixing vessel- mixing with reaction - reversible reaction	7	20%
IV	Steam jacketed vessel-boiling of single component liquid-open and closed vessel- batch distillation Gas flow system-hydraulic transients between two reservoirs	7	20%

SECOND INTERNAL EXAMINATION			
V	Reaction kinetics-general modeling scheme-batch reactor-ideal binary distillation column Distributed system: jacketed tubular reactor - countercurrent liquid-liquid heat exchanger	7	15%
VI	Simulation of gravity flow tank- CSTR in series - non-isothermal CSTR- binary distillation column	7	15%
END SEMESTER EXAMINATION			

Question Paper Pattern

Maximum Marks: 100 Exam Duration: 3 Hours

Part A: There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.
(2 x15= 30 Marks)

Part B: There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 20 marks for all the subdivisions put together.
(2 x20= 40 Marks)

Part C: There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.
(2 x15= 30 Marks)

Course code	Course Name	L-T-P-Credits	Year of Introduction
CH468	FOOD PROCESSING AND TECHNOLOGY	3-0-0-3	2016

Prerequisite : Nil

Course Objectives

- To familiarize the food industry
- To identify the world and Indian food scenario
- To introduce various food preservation techniques
- To familiarize various food sources and their processing techniques

Syllabus

General aspects of food industry, world and Indian food needs, various food constituents and additives, food deteriorative factors and their control, Preliminary processing methods, food conversion techniques and equipment used. Food quality control and nutritive aspects, Various food preservation techniques such as dehydration, sterilization and pasteurization, fermentation, cold treatment, irradiation, microwave etc. Production of various food materials and its processing - cereals, pulses, vegetables, spices, fats and oils. Food industries - Diary products, meat, poultry and fish products. Beverage Industry- Soft and Alcoholic. Treatment and disposal of food processing wastes

Expected Outcome

The students will be able to apply

i. The various food processing and preservation techniques and the equipment and technology required.
ii. To familiarise various food industries and food quality aspects

Reference Books

1. B.Sivasankar, Food Processing and Preservation, PHI Learning Pvt. Ltd
2. Badger, W.L, Banchero, J.T., Introduction to Chemical Engineering, McGraw Hill
3. Food Industry Wastes: Disposal and Recovery; Herzka A & Booth RG; 1981, Applied Science Pub Ltd.
4. Hall C.W, Farall A.W & Rippen A.L, Encyclopedia of Food Engineering, Van Nostrand, Reinhold, New York.
5. Heid J.L & Joslyn M.A, Fundamentals of Food Processing Operations, AVI Pub.
6. Unit Operations of Chemical Engineering: McCabe, Smith & Harriot, TMH, 5th edition
7. V. Sathe, A First Course in Food Analysis, New Age International Pvt. Ltd. 1999
8. Waston E.L., Elements of Food Engineering, Van Nostrand, Reinhold, New York.

Course Plan			
Module	**Contents**	**Hours**	**Sem. exam marks**
I	General aspects of food industry World and Indian food needs Various food constituents and additives Food deteriorative factors and their control	7	15%
II	Preliminary processing methods Food conversion techniques and equipment used Food quality control and nutritive aspects	7	15%
FIRST INTERNAL EXAMINATION			
III	Hot and cold preservation techniques Irradiation and microwave heating Fermentation and Pickling, packing methods	7	15%
IV	Production and processing of cereals, pulses, Production and processing of vegetables, spices fats and oils	8	15%
SECOND INTERNAL EXAMINATION			
V	Food industries - Diary products, meat, poultry and fish products	6	20%
VI	Beverage Industry- Soft and Alcoholic. Treatment and disposal of food processing wastes	7	20%
END SEMESTER EXAM			

Question Paper Pattern

Maximum Marks: 100 Exam Duration: 3 Hours

Part A: There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part B: There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part C: There shall be **Three questions** uniformly covering Modules 5 and 6, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 20 marks for all the subdivisions put together. (2 x20= 40 Marks)

Course code	Course Name	L-T-P Credits	Year of Introduction
CH469	MATHEMATICAL METHODS IN PROCESS ENGINEERING	3-0-0-3	2016

Prerequisite : Nil

Course objectives:

1. To introduce different kinds of modelling equations in chemical engineering**.**
2. To gain the ability to solve the above equations of linear or nonlinear algebraic, ordinary differential equations and partial differential equations.
3. To appreciate the conditions of uniqueness of solutions of linear and nonlinear equations.
4. To study the effect of system parameters on stability of nonlinear systems.

Syllabus:

Introduction to modelling and simulation, vectors, matrices, Eigen values and Eigen vectors, solution methods for finite dimensional space (Algebraic Equations & Ordinary Differential Equations), solution methods for infinite dimensional space (Partial Differential Equations), Uniqueness conditions for Linear and Nonlinear Systems, Linear Stability and Limit Cycles Bifurcation Theory.

Expected outcome:

The students will be able to

i. Comprehend the behaviour of chemical engineering system from model equations.
ii. Understand the basis for each mathematical technique to solve the model equations
iii. Follow the models and simulation methods to analyse chemical engineering problems.
iv. Acquire the ability to use the simulation packages with a good understanding of mathematics behind it.

Text book:

- S. Pushpavanam, “Mathematical Methods in Chemical Engineering”, Prentice Hall of India Pvt. Ltd., 1998.

Reference books:

1. Gilbert Strang, “Linear Algebra and Applications”, Holden Day Publishers.
2. Irvin Kreyszig, “Advanced Engineering Mathematics”**,** New Age International (Pvt) Ltd., New Delhi.
3. T. K. V. Iyengar, B. Krishna Gandhi et al. “Mathematical Methods”, S. Chand and Company.

Course plan

Module	Contents	Hours	Sem. Exam Marks
I	Introduction to: Modelling, types of modelling, linear and non-linear equations, homogeneous and heterogeneous equations, simulation and types of simulation, mathematical methods: Numerical and analytical methods, examples for modelling equations in chemical engineering for: linear and nonlinear - algebraic, ordinary differential equation and partial differential equation.	5	15%

II	Vectors, vector spaces, Metrics, Norms, Inner products, Linear dependence anddimension. Gram- Schmidt Orthonormalisation. Matrices, Eigen values, Eigen vectors, Fredholm alternative. Applications to Chemical Engineering: Linear algebraic equations.	8	15%
FIRST INTERNAL EXAMINATION			
III	Applications to Chemical Engineering: Systems of first order homogeneous Ordinary Differential Equations (ODE) (IVP). First order non homogeneous ODE (IVP). Partial differential Equations: Classification of Second order partial differential equations. Linearity and superposition. Sturm- Louiville Theory	8	15%
IV	Infinite dimensional spaces, Eigen value problems, Classical Eigen value problems, Fourier Series, Rayleigh's Quotient. Separation of variables and Fourier Transforms: Rectangular Cartesian Coordinates. Cylindrical coordinates, Spherical coordinates, Fourier series and finite Fourier Transforms. Laplace Transform. Green's Function: Ordinary Differential Equations.	8	15%
SECOND INTERNAL EXAMINATION			
V	Uniqueness conditions for Linear and Nonlinear Systems. Maximum principle, Energy methods, Fredholm alternative, Monotone iteration method. Steady State Characteristics of Nonlinear Dynamical Systems: Dynamic systems, Steady state, Continuation methods.	7	20%
VI	Linear Stability and Limit Cycles: Linear Stability of Dynamical Systems. Bifurcation Theory, Maps. Secondary bifurcation and chaos:	6	20%
END SEMESTER EXAM			

Question Paper Pattern:

Maximum Marks: 100 Exam Duration: 3 Hours

Part A: There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part B: There shall be **Three questions** uniformly covering Module 3 and 4, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part C: There shall be **Three questions** uniformly covering Module 5 and 6, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 20 marks for all the subdivisions put together. (2 x20= 40 Marks)

Course No.	Course Name	L-T-P-Credits	Year of Introduction
CH471	SOLID WASTE MANAGEMENT	3-0-0-3	2016

Prerequisite : Nil

Course Objectives

- To impart the basic concepts of solid waste management
- To develop understanding about recovery, reuse and disposal of solid waste.

Syllabus

Sources of solid waste, types of solid wastes, Properties of solid wastes, generation rates of solid wastes, factors affecting generation rates, collection and storage of solid wastes, collection systems and routing of solid waste collection systems, recovery and reuse, disposal methods of solid wastes, design and operation of solid waste disposal systems, recovery, recycle and reuse of solid wastes and solid waste management practices in India.

Expected Outcome

The students will be able to

i. Explain municipal solid waste management systems with respect to its physical, chemical and biological properties.
ii. Select appropriate method for solid waste collection, transportation, redistribution and disposal.
iii. Develop an optimum route for solid waste collection and transportation
iv. Manage industrial and hazardous solid wastes.
v. Compare disposal methods of MSW by applying specific criteria.

Text Book

P.Aarne Vesilind and William Worrell, Solid waste Engineering, Cengage Learning

Reference Books

1. Frank Kreith, George Tchobanoglous, Handbook of Solid Waste Management, McGraw Hill Publishers.
2. Gerard Kiely, Environmental Engineering, McGraw Hill
3. Howard S.Peavy, Donald R.Rowe, George Tchobanoglous, Environmental Engineering, Mc Graw Hill
4. Nicholas P. Cheremisinoff, Handbook of Solid Waste Management and Waste Minimization Technologies , Elsevier

Course Plan

Module	Contents	Hours	Sem. exam marks
I	Solid wastes-Sources, nature and characteristics - types of solid waste, Residential, Commercial ,Hazardous wastes, and Industrial wastes, Properties of Solid wastes, Waste generation, Sampling and analysis, Characteristics of solid wastes - Energy content, Chemical content, Estimation of chemical composition of of a solid waste sample	6	15%
II	Changing nature of solid wastes and its impact on solid waste management, Generation rates - Estimation of solid waste	7	15%

	quantities - Factors affecting generation rates , Collection of solid waste, On-site storage methods-containers, their type, size and location.		
FIRST INTERNAL EXAMINATION			
III	Collection systems-Vehicles, Types of collection system –HCS, SCS , Determination of vehicle and labor requirements, Collection routing, route balancing and transfer stations, Transfer methods Processing methods.	8	15%
IV	Recovery and reuse of materials and energy, Disposal methods such as sanitary landfill –methods, leachate in landfills – control of leachate movement , Gas movement – control.	8	15%
SECOND INTERNAL EXAMINATION			
V	Design and operation of landfills, Landfarming, Deep well injection,etc. Composting, Factors affecting composting, Aerobic composting and anaerobic Digestion, Design principles. Incineration, Municipal incinerators, Grates, Furnances, Design principles, Pyrolysis of solid waste.	7	20%
VI	Recovery, Recycle and Reuse-Material and Energy recovery operations. Overview of solid waste management practices in India. Industrial and Hazardous solid waste management, Integrated Waste Management (IWM)	6	20%
END SEMESTER EXAM			

Question Paper Pattern

Maximum Marks: 100 Exam Duration: 3 Hours

Part A: There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.
(2 x15= 30 Marks)

Part B: There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.
(2 x15= 30 Marks)

Part C: There shall be **Three questions** uniformly covering Modules 5 and 6, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 20 marks for all the subdivisions put together.
(2 x20= 40 Marks)

Course code	Course Name	L-T-P-Credits	Year of Introduction
CH472	PROCESS INTEGRATION	3-0-0-3	2016

Prerequisite : NIL

Course Objectives

1. To impart the knowledge of systematic methods for the material and energy integration of chemical process industries.
2. To enable students to apply various techniques for process integration in order to conserve material and energy requirement in chemical process industries.

Syllabus

Process Integration and its Building Blocks, Heat Exchanger Networking, Targeting of Heat Exchanger Network, Integration of Reactor systems, Integration of Distillation systems, Mass Exchanger Network Synthesis

Expected Outcome

- The students will be able to apply various techniques for process integration in order to conserve material and energy requirement in chemical process industries

References:

1. James M. Douglas, Conceptual Design of Chemical Process, McGraw Hill, New York, 1988.
2. Kemp I.C, Pinch Analysis and Process Integration - A user guide on process integration for efficient use of energy, , 2nd Edition, Butterworth – Heinneman, 2006.
3. Linnhoff, B. Townsend D.W., Boland D., Hewitt G.F., Thomas, B.E.A., Guy, A. R. and Marsland, R. H., "A User's guide on process integration for the efficient use of energy", Inst. of Chemical Engineers, London (1982).
4. Mahmoud. M., El – Hawalgi, Process Integration -, Elsevier, 2006.
5. Robin Smith, Chemical Process Design and Integration, John Wiley and Sons. Ltd., New Delhi, 2005.
6. Uday. V. Shenoy, Heat Exchanger Network Synthesis, , Gulf Publishing Co, USA, 1995
7. Warren D. Seider, J. D. Seader and Daniel R. Lewin, Product & Process Design Principles, Wiley Publication.

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	**Process Integration and its Building Blocks** Definition of Process Integration, Areas of application and techniques available for Process Integration, Role of thermodynamic laws.	7	15%
II	**Heat Exchanger Networking** Heat Exchanger Networking, Composite curve method, Problem table algorithm, Grand composite curve	7	15%

FIRST INTERNAL EXAMINATION			
III	**Targeting of Heat Exchanger Network** Energy targeting, Area targeting, Number of units targeting, Shell targeting, cost targeting.	7	15%
IV	**Integration of Reactor systems** Choice of Idealized reactor model and reactor performance. Reactor configurations: Temperature Control, Choice of Reactors. Heat Integration characteristics of reactors	7	15%
SECOND INTERNAL EXAMINATION			
V	**Integration of Distillation systems** Distillation sequencing, Heat Integration characteristics of Distillation column, appropriate placement of distillation column, various configurations for heat integration of distillation column.	**7**	20%
VI	**Mass Exchanger Network Synthesis** Mass Exchanger Network, Minimum Mass Separating Agents (MSA), Mass exchange networks for minimum external MSA. Minimum Number of Mass Exchangers	**7**	20%
END SEMESTEREXAMINATION			

Question Paper Pattern

Maximum Marks: 100 Exam Duration: 3 Hours

Part A: There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.
(2 x15= 30 Marks)

Part B: There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.
(2 x15= 30 Marks)

Part C: There shall be **Three questions** uniformly covering Modules 5 and 6, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 20 marks for all the subdivisions put together.
(2 x20= 40 Marks)

Course code	Course Name	L-T-P - Credits	Year of Introduction
**451	Seminar and Project Preliminary	0-1-4-2	2016
Prerequisite : Nil			

Course Objectives

- To develop skills in doing literature survey, technical presentation and report preparation.
- To enable project identification and execution of preliminary works on final semester project

Course Plan

Seminar: Each student shall identify a topic of current relevance in his/her branch of engineering, get approval of faculty concerned, collect sufficient literature on the topic, study it thoroughly, prepare own report and present in the class.

Project preliminary:

Identify suitable project relevant to the branch of study. Form project team (not exceeding four students). The students can do the project individually also. Identify a project supervisor. Present the project proposal before the assessment board (excluding the external expert) and get it approved by the board.

The preliminary work to be completed: (1) Literature survey (2) Formulation of objectives (3) Formulation of hypothesis/design/methodology (4) Formulation of work plan (5) Seeking funds (6) Preparation of preliminary report

Note: The same project should be continued in the eighth semester by the same project team.

Expected outcome.

The students will be able to

i. Analyse a current topic of professional interest and present it before an audience
ii. Identify an engineering problem, analyse it and propose a work plan to solve it.

Evaluation

Seminar : **50 marks**

(Distribution of marks for the seminar is as follows: i. Presentation : 40% ii. Ability to answer questions : 30% & iii. Report : 30%)

Project preliminary : **50 marks**(Progress evaluation by the supervisor : 40% and progress evaluation by the assessment board excluding external expert : 60%. Two progress evaluations, mid semester and end semester, are mandatory.)

Note: All evaluations are mandatory for course completion and for awarding the final grade.

Course code	Course Name	Credits	Year of Introduction
**492	PROJECT	6	2016

Prerequisite : Nil

Course Objectives

- To apply engineering knowledge in practical problem solving
- To foster innovation in design of products, processes or systems
- To develop creative thinking in finding viable solutions to engineering problems

Course Plan

In depth study of the topic assigned in the light of the preliminary report prepared in the seventh semester
Review and finalization of the approach to the problem relating to the assigned topic
Preparing a detailed action plan for conducting the investigation, including team work
Detailed Analysis/Modelling/Simulation/Design/Problem Solving/Experiment as needed
Final development of product/process, testing, results, conclusions and future directions
Preparing a paper for Conference presentation/Publication in Journals, if possible
Preparing a report in the standard format for being evaluated by the dept. assessment board
Final project presentation and viva voce by the assessment board including external expert

Expected outcome

The students will be able to

iii. Think innovatively on the development of components, products, processes or technologies in the engineering field
iv. Apply knowledge gained in solving real life engineering problems

Evaluation

Maximum Marks : 100

(i) Two progress assessments	20% by the faculty supervisor(s)
(ii) Final project report	30% by the assessment board
(iii) Project presentation and viva voce	50% by the assessment board

Note: All the three evaluations are mandatory for course completion and for awarding the final grade.