DEPARTMENT OF CHEMICAL ENGINNEERING
SRI VENKATESWARA UNIVERSITYCOLLEGE OF ENGINEERING
TIRUPATI – 517 502
(Autonomous Institute)

M.Tech Degree Program (CBCS) Regulations-2018
(With effect from the batch admitted in the academic year 2018 -2019)

CHOICE-BASED CREDIT SYSTEM

1. Preamble

M.Tech Degree Program is of two academic years with each academic year being divided into two consecutive semesters.

Choice-Based Credit System (CBCS) is a flexible system of learning and provides choice for students to select from the prescribed elective courses. A course defines learning objectives/outcomes and comprises of lectures/tutorials/laboratory work/dissertation work/viva/seminars/ assignments/ presentations/ self-study etc. or a combination of some of these.

Under the CBCS, the requirement for awarding a degree is prescribed in terms of number of credits to be completed by the students.

The CBCS permits students to

i. Choose electives from a wide range of elective courses offered by the Departments of the Institute.
ii. undergo additional courses of interest
iii. adopt an inter-disciplinary approach in learning
iv. make the best use of expertise of the available faculty

2. Minimum Qualification

Minimum qualification for seeking admission into a specialization of M.Tech Degree Programme is B.Tech Degree, with at least 50% marks in aggregate or equivalent grade, awarded by Sri Venkateswara University (SVU) in appropriate Branch of Engineering or any other Degree recognized by SVU as equivalent thereto including AMIE, AMIICHE and AMIETE.

3. Specializations of Study

The specializations of study in M.Tech Degree Programme are

1. Department of Chemical Engineering
    a. Chemical Engineering
2. Department of Civil Engineering
    a. Environmental Engineering
    b. Geotechnical Engineering
    c. Hydraulics and Water Resources Engineering
    d. Structural Engineering
3. Department of Electrical and Electronics Engineering
    a. Power Systems
4. Department of Electronics and Communication Engineering
    a. Communication Systems
    b. Signal Processing
5. Department of Mechanical Engineering
    a. Industrial Engineering
    b. Production Engineering
6. Department of Computer Science and Engineering
    a. Computer Science and Engineering

4. Programme Duration

4.1 Minimum duration of the M.Tech Program is two academic years i.e. four semesters and maximum period is four academic years.

4.2 Each semester shall consist of 18 weeks with a typical academic work of 30 hours/week equivalent to 90 instruction days. However, the number of instruction days may be reduced to 72, when necessary, with increased number of instruction hours per course per week.

4.3 A candidate admitted as a full-time student and completed the course work and obtained a job may be permitted to pursue dissertation work (Phase II) on part-time basis with prior permission from the Principal. The duration of dissertation work (Phase II) under part-time mode shall be two semesters.

5. Credit Definition

Credit defines the quantum of contents/syllabus prescribed for a course and determines the number of instruction hours per week. The norms for assigning credits to a course for a duration of one semester shall be as follows:

- i One credit for every one hour of lecture/tutorial per week
- ii One credit for every two hours of practical work/ /seminar per week
- iii 26 credits for dissertation work

6. Classification of Courses

The courses of each specialization of study are classified into Core, Elective and Audit Courses. It is mandatory for a student to complete successfully all the courses pertaining to his/her specialization of study.

6.1 Core Courses

These are compulsorily courses to be studied by a student in a said specialization of study.

6.2 Elective Courses

Elective course is a course which is supportive to the specialization of study. It shall

- ✓ provide an expanded scope
- ✓ enable exposure to some other specialization/domain
- ✓ nurture student's proficiency/skill

Students of a particular specialization of a department can also take Core/Elective courses of other specializations offered in the same department as Elective courses. Students have to choose one open elective in the third semester from the courses offered by the college/department.

6.3 Audit Courses

These are the non-credit courses offered to supplement general knowledge/skills of the students. A student shall audit one course each in the first and second semesters from the courses offered by the college/department.

6.4 MOOCs and e-Learning

Massive Open Online Courses (MOOCs) and e-learning platforms can be utilized for learning the courses with the permission of the Head of the Department concerned. Students can complete open elective in the first to third semesters from the list of courses suggested by the department concerned by registering it as a MOOC of a minimum duration of 8 weeks in Swayam (UGC)/Spoken-Tutorials(IIT-Mumbai)/NPTEL(AICTE). The certificate issued by the above platform(s) shall be submitted at the end of third semester in order to include it with an appropriate grade as decided by the department in the third semester marks statement.

7 Course Registration

Every student has to register for the Courses offered by the Department in the beginning of every semester with the total number of credits being limited by considering the permissible weekly contact hours (30/Week). Audit courses are over and above these courses.

8 Credits Required for the Award of Degree

A student shall become eligible for the award of M.Tech degree, if he/she earns 68 credits prescribed for the program by passing all the core and elective courses along with practicals, mini-project and dissertation work.

8.1 It is mandatory for a student to complete successfully all the core courses pertaining to his/her specialization of study.

8.2 A student shall choose professional electives including open elective from the list of courses offered by the department.

8.3 A student shall register audit courses of his/her interest from the list of audit courses offered by the department.

9. Scheme of Instruction

The Board of Studies (BoS) of the department concerned shall formulate the scheme of instruction and detailed syllabi of all the courses. The course outcomes shall be defined for all the courses. The syllabi of theory courses shall be organized into five units of equal weightage.

10. Course Numbering Scheme

Each course is denoted by an alphanumeric code of six characters as detailed below:

First two	Alphabetic characters	Specialization	CH : Chemical Engineering EE : Environmental Engineering GT: Geotechnical Engineering HW: Hydraulics and Water Resources Engineering SE: Structural Engineering PS: Power Systems CS: Communication Systems SP: Signal Processing IE: Industrial Engineering PE: Production Engineering CO : Computer Science and Engineering PG : Post-Graduate

Next two	Alphabetic characters	Course Type	PC : Program Core PE : Program Elective PA : Program Audit OE : Open Elective CP : Core Practical EP : Elective Practical MP : Mini-Project PD : Program Dissertation MC : Mandatory Course
Next two	Numerals	Serial Number	01, 02, …

11. Attendance Requirements

11.1 A student is required to complete the Program of Study satisfying the attendance requirements in all the semesters within twice the prescribed period of study from the year of admission failing which he/she forfeits his/her admission.

11.2 A student shall be detained in a semester if he/she fails to satisfy the attendance requirements as given below:

i. A student shall attend at least 60 percent of the maximum hours of instruction taken by the teacher for each course.

ii. A student shall attend at least 75 percent of the maximum hours of instruction taken for all the courses put together in that semester.

11.3 A student who fails to satisfy the attendance requirements specified in clause 11.2 shall repeat that semester in the subsequent academic years with the written permission of the Principal.

11.4 A student shall not be permitted to study any semester more than two times during the Program of his/her study.

11.5 A student who satisfies the attendance requirements specified in clause 11.2 in any semester and wants to repeat the courses in that semester may be permitted by canceling the previous attendance and sessional marks of that semester with the written permission of the Principal. However, this facility shall be extended to any student for two times during the entire Program of study provided the stipulation in clause 11.1 is satisfied.

12. Evaluation

12.1 Evaluation shall be done on a continuous basis i.e. through Continuous Internal Evaluation(CIE) and the Semester and Semester End Examination(SEE). For each theory course, there shall be two sessional tests of two hours duration carrying 40 marks each and one Semester End Examination of three hours duration carrying 60 marks. Sessional marks for a maximum of 40 shall be awarded based on the performance of the two sessional tests.

12.2 First Sessional Test shall be conducted in the middle of the semester i.e. after the completion of 50 % of instruction days covering 50% of the syllabus. Second Sessional Test shall be conducted immediately after the completion of instruction days covering rest of the syllabus.

12.3 It is mandatory for a student to attend both the sessional tests in each theory course. The weighted average of the marks secured in two tests is awarded as sessional marks. A weightage of 0.8 shall be assigned for the better performance of the two tests and 0.2 for the other test. If a student is absent for any of the internal tests for whatsoever reason, the marks for that test shall be zero.

12.4 The students shall be permitted to verify the valuation of answer scripts of sessional tests.

12.5 The valuation and verification of answer scripts of Sessional Tests shall be completed within 15 days after the conduct of the Sessional Tests.

12.6 The valuation of Semester End Examination answer scripts shall be arranged by the Controller of Examinations as per the University procedure in vogue.

12.7 **Evaluation of Practicals**

For each practical course, the sessional marks for a maximum of 40 shall be awarded by the teacher concerned based on the continuous assessment of practical work. The Semester End Examination of three hours duration carrying 60 marks shall be conducted by two examiners: i) teacher concerned and ii) teacher nominated by the HoD.

12.8 **Evaluation of Audit Courses**

For each audit course, a maximum of 100 marks shall be awarded by the teacher concerned through continuous evaluation.

. **13. Evaluation of Dissertation Work**

Normally, the dissertation work shall be carried out at Sri Venkateswara University College of Engineering (SVUCE). However, it can also be carried out in any of the recognized Educational

Institutions/National Laboratories/ Research Institutions/ Industrial Organizations/ Service Organizations/ Government Organizations with the prior permission from the supervisor and Head of the Department concerned.

13.1 The dissertation work shall be evaluated for a total of 26 credits as indicated in the Table below.

13.2 An open pre-submission seminar shall be given by the student at least four weeks ahead of the completion of the programme and submit the dissertation work. A committee comprising of the Chairman - BoS(PG), HoD(Convener) and Supervisor shall evaluate the open pre-submission seminar. If the open pre-submission seminar delivered by a student is not satisfactory, another seminar shall be scheduled within two weeks.

13.3 A student shall submit his dissertation work duly certified by the supervisor and HoD, after successfully completing the requisite credits pertaining to theory, practical and mini-project. As soon as a student submits his/her dissertation, Principal shall appoint the External Examiner from among the panel of examiners recommended by the Chairman, BoS (PG) for evaluating the dissertation work.

13.4 Head of the Department in consultation with the Supervisor and External Examiner shall schedule the viva-voce Examination of dissertation work and send the evaluation report to the Controller of Examinations.

The evaluation of the dissertation work and the marks allotted are as under:

Evaluation of	Evaluation Committee	Marks
Dissertation (Phase-I) (Evaluation at the end of III Semester) i)Continuous Evaluation ii) Seminar	 Supervisor A committee with Head of the Department as Chairman, and Supervisor and Chairman - BoS (PG) as members	 50 50

Dissertation (Phase-II) (Evaluation at the end of IV Semester)		
i)Continuous evaluation	Supervisor	20
ii)An open pre-submission seminar	A committee with Head of the Department as Chairman, Supervisor and Chairman - BoS (PG) as members	20
iii)Semester End University Examination(An open seminar followed by a Viva-voce)	A committee comprising of External Examiner, HoD and Supervisor wherein the HOD shall be the Chairman of the committee.	60

14. Question Paper Setting

14.1 Model Question Paper for each theory course shall be prepared by the teacher concerned within 30 days from the commencement of the Semester and the same shall be forwarded to the Controller of Examinations through the Chairman, BOS(PG) concerned. Two questions shall be set from each unit of the syllabus, out of which one question shall be answered by the student. Each question of the unit carries a maximum of 12 marks. However, the Chairman, BoS(PG) shall accord exception in question paper format, if necessary. The question papers shall assess the understanding of the concepts and their applications in solving problems and at least 50% of the questions shall be numerical. Further, the question papers of design-oriented courses shall assess the abilities of analyzing and evaluating design alternatives.

14.2 For each theory course, the question paper shall be set by an external paper setter. The Chairman, BoS(PG) shall recommend a panel comprising at least six external paper setters for each theory course to the University. The University shall arrange for setting the question paper by appointing one external paper setter from the panel.

15. Grading and Grade Points

Grade Point: It is a numerical weight allotted to each letter grade on a 10-point scale.

Letter Grade: It is an index of the performance of students in a said course. Grades are denoted by letters O, A+, A, B+, B, C, P and F.

Semester Grade Point Average (SGPA): It is a measure of student's performance in a semester.

Cumulative Grade Point Average (CGPA): It is a measure of overall performance of a student over all semesters.

Letter Grades and Grade Points:

A 10-point grading system with the letter grades are as given below:

Grades and Grade Points

Letter Grade	Range of Marks	Grade Point
O (Outstanding)	91 - 100	10
A+(Excellent)	81 – 90	9
A(Very Good)	71 – 80	8
B+(Good)	61 – 70	7
B(Above Average)	51 – 60	6
P (Pass)	50	5
F(Fail)	<50	-
Ab (Absent)	-	-

Student obtaining Grade F shall be considered failed and shall be required to reappear in the Semester- end examination.

Computation of SGPA and CGPA

SGPA is the ratio of sum of the products of the number of credits with the grade points scored by a student in all the courses and the sum of the number of credits of all the courses in the semester.

SGPA $(S_i) = \sum_{i=1}^{N} (C_i \times G_i) / \sum_{i=1}^{N} C_i$

where C_i is the number of credits of the i^{th} course, G_i is the grade point scored in the i^{th} course and N is the number of courses in the semester.

The CGPA is also calculated in the same manner taking into account all the courses taken over all the semesters of the program.

CGPA = $\sum_{i=1}^{M} (C_i \times S_i) / \sum_{i=1}^{M} C_i$

where S_i is the SGPA of the i^{th} semester, C_i is the total number of credits in that semester and M is the number of semesters.

SGPA and CGPA shall be rounded off to two decimal points and reported in the transcripts.

15.1 In each semester, every student who satisfies the attendance requirements has to register for the semester-end examination, failing which he/she shall not be promoted to the next semester. Any such student who has not registered for the semester-end examination in a semester shall repeat that semester in the next academic year with the written permission of the Principal.

15.2 To pass a course in the program, a student has to secure a minimum of 50% of maximum marks in the semester-end examination and a minimum Grade of P overall (both sessional and semester-end examination marks put together). A student obtaining Grade F shall be considered failed and shall be required to reappear for the semester-end examination. A student shall not be allowed to reappear for the semester-end examination in a course which he/she has already passed the course to improve the score.

15.3 A student who has failed in a course shall be allowed to reappear for the semester-end examination as and when it is conducted in the normal course. The Sessional Marks obtained by the student shall be carried over for declaring the results.

15.4 The semester-end examination in any course of a particular regulation shall be conducted three times. Thereafter, the students who failed in that course shall take the semester-end examination in the equivalent papers of the subsequent regulations, suggested by the Chairman, BoS concerned.

16. **Award of Degree**

A student who has earned 68 credits and with a minimum CGPA of 5.0 shall become eligible for the award of degree.

17. **Ranking and Award of Prizes / Medals**

17.1 The students who have become eligible for the award of M.Tech degree by passing regularly all the courses in the first attempt shall only be considered for the award of ranks.

17.2 Ranks shall be awarded in each branch of study on the basis of Cumulative Grade Point Average (CGPA) for the top three students.

17.3 Award of prizes, scholarships and other honors shall be according to the rank secured by the student as said above and in conformity with the desire of the Donor.

18. Transitory Regulations

18.1 A student who has been detained in a particular regulation for not satisfying the attendance requirements shall be permitted to rejoin the course, by obtaining due permission from the Principal, with the regulations in force provided the clauses 11.1 and 11.4 hold good.

18.2 Semester End University Examinations under the regulations that precede immediately the revised regulations shall be conducted two times after the conduct of last regular examination under those regulations.

18.3 The students who satisfy the attendance requirements under the regulations that precede immediately the revised regulations, but do not pass the courses shall appear for the Semester End University Examination in equivalent courses under the revised regulations as recommended by the BoS(PG) concerned.

19 Grievance Redressal Committee

The Principal shall constitute a Grievance Redressal Committee by nominating three Professors from among the faculty of the college for a period of two years. The convener of the committee, one among the three, shall receive the complaints from the students and place the same before the committee for its consideration. The committee shall submit its recommendations to the Principal for his consideration.

20. Amendment to Regulations

Sri Venkateswara University reserves the right to amend these regulations at any time in future without any notice. Further, the interpretation of any of the clauses of these regulations entirely rests with the University.

DEPARTMENT OF CHEMICAL ENGINEERING :: S V U C E :: TIRUPATI
SCHEME OF INSTRUCTION –- CHOICE BASED CREDIT SYSTEM
R-18 M.Tech (Chemical Engineering) , Effective 2018-19

I Semester

Course Code	COURSE TITLE	SCHEME OF INSTRUCTION, hr/week L	P/D	TOT.	Credits	SCHEME OF EVALUATION, Marks Int.	End Sem	TOTAL MARKS
	PROGRAM CORE							
CHPC 01	Mathematics & Statistical Methods in Chemical Engineering	3	--	3	**3**	40	60	100
CHPC 02	Advanced Transport Phenomena	3	--	3	**3**	40	60	100
	PROGRAM ELECTIVE – I	3	--	3	**3**	40	60	100
CHPE 11	Process Design & Synthesis							
CHPE 12	Chemical Reactor Analysis							
CHPE 13	Fluidization Engineering							
CHPE 14	Process Plant Simulation							
	PROGRAM ELECTIVE – II	3	--	3	**3**	40	60	100
CHPE 21	Industrial Pollution Control							
CHPE 22	Applications of Nanotechnology in Chemical Engineering							
CHPE 23	Chemo-informatics							
CHPE 24	Advanced Control Systems							
	PROGRAM PRACTICALS							
CHPP 01	Computational Techniques Lab	--	4	4	**2**	40	60	100
CHPS 02	Seminar – I	--	2	2	**1**	100	--	100
	MANDATORY COURSE							
PGMC 41	Research Methodology & IPR	2	--	2	**2**	40	60	100
	AUDIT COURSE – I	2	--	2	**--**	100	--	100
PGPA 11	English For Research Paper Writing							
PGPA 12	Disaster Management							
PGPA 13	Sanskrit for Technical Knowledge							
PGPA 14	Value Education							
	TOTAL	**16**	**6**	**22**	**17**	**440**	**360**	**800**

DEPARTMENT OF CHEMICAL ENGINEERING :: S V U C E :: TIRUPATI
SCHEME OF INSTRUCTION –- CHOICE BASED CREDIT SYSTEM
R-18 M.Tech (Chemical Engineering) , Effective 2018-19
II Semester

Course Code	COURSE TITLE	SCHEME OF INSTRUCTION, hr/week			Credits	SCHEME OF EVALUATION, Marks		TOTAL MARKS
		L	P/D	TOT.		Int.	End Sem	
	PROGRAM CORE							
CHPC 03	Separation Techniques	3	--	3	**3**	40	60	100
CHPC 04	Chemical Reactor Theory	3	--	3	**3**	40	60	100
	PROGRAM ELECTIVE –III	3	--	3	**3**	40	60	100
CHPE 31	Modern Concepts in Catalysis & Surface Phenomenon							
CHPE 32	Advanced Downstream Processing							
CHPE 33	Computational Fluid Dynamics							
CHPE 34	Enzyme Science & Engineering							
CHPE 35	Optimization Theory & Practice							
CHPE 36	Micro and Nano Fluidics							
CHPE 37	Process Intensification							
	PROGRAM ELECTIVE – IV	3	--	3	**3**	40	60	100
CHPE 41	Phase Transitions in Process Equipment							
CHPE42	Process Integration							
CHPE 43	Transport in Porous Media							
CHPE 44	Microflow Chemistry &Process Technology							
CHPE 45	Process Plant Design & Flow sheeting Tools							
CHPE 46	Process Synthesis & Analysis							
CHPE 47	Membrane Separations							
	PRACTICALS							
CHPP 02	Advanced Chem. Engg. Lab	--	4	4	**2**	100	--	100
CHPS 02	Seminar – II	--	2	2	**1**	100	--	100
CHCV 01	Comprehensive Viva	--	--	--	**2**	--	100	100
CHMP 01	Mini Project	--	4	4	**2**	100	--	100
	Audit Course – II	2	--	2	**--**	100	--	100

PGPA 21	Constitution of India							
PGPA 22	Pedagogy Studies							
PGPA 23	Stress Management by Yoga							
PGPA 24	Personality Development through Life Enhancement Skills							
	TOTAL	**14**	**10**	**24**	**19**	**560**	**340**	**900**

III Semester

Course Code	COURSE TITLE	SCHEME OF INSTRUCTION, hr/week			Credits	SCHEME OF EVALUATION, Marks		TOTAL MARKS
		L	P/D	TOT.		Int.	End Sem	
	PROGRAM ELECTIVE – V	3	--	3	**3**	40	60	100
CHPE 51	Design of Experiments & Parameter Estimation							
CHPE 52	Computer Aided Design							
CHPE 53	Cleaner Production							
CHPE 54	Fuel Cell Systems							
CHPE 55	Polymer Science & Engineering							
CHPE 56	Bioprocess Engineering							
	OPEN ELECTIVE	3	--	3	**3**	40	60	100
PGOP 11	Business Analytics							
PGOP 12	Industrial Safety							
PGOP 13	Operations Research							
PGOP 14	Cost Management in Engineering Projects							
PGOP 15	Composite Materials							
PGOP 16	Waste to Energy							
CHPD01	**Dissertation Phase I**	--	20	20	**10**	100	--	100
	TOTAL	**6**	**20**	**26**	**16**	**180**	**120**	**300**

IV Semester

Course Code	COURSE TITLE	SCHEME OF INSTRUCTION, hr/week			Credits	SCHEME OF EVALUATION, Marks		TOTAL MARKS
		L	P/D	TOT.		Int.	End Sem	
CHPD 02	**Dissertation Phase II**	--	32	32	**16**	40	60	100
	TOTAL	--	32	32	**16**	40	60	100

*****

CHPC 01 **MATHEMATICAL AND STATISTICAL METHODS IN CHEMICAL ENGINEERING**

Instruction: hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives:

1. To give students an insight in various Chemical Engineering Processes using advanced Numerical and Statistical Methods.
2. To provide adequate background of Mathematics to deal with Chemical Engineering Problems
3. To understand research papers on relevant topics involving advanced Mathematics.
4. To study correlation and regression of multivariate data.
5. To evaluate Experimental design methods and statistical quality control measures.

Unit-1: Equation Forms in Process Modeling, Introduction and Motivation, Linear and Nonlinear Algebraic Equation, Optimization based Formulations, ODE-IVPs and Differential Algebraic Equations, ODE-BVPs and PDEs, Abstract model forms. Fundamentals of Vector Spaces, Generalized concepts of vector space, sub-space, linear dependence, Concept of basis, dimension, norms defined on general vector spaces, Examples of norms defined on different vector spaces, Cauchy sequence and convergence, introduction to concept of completeness and Banach spaces, Inner product in a general vector space, Inner-product spaces and their examples, Cauchy-Schwartz inequality and orthogonal sets, Gram-Schmidt process and generation of orthogonal basis, well known orthogonal basis Matrix norms.

Unit-2: Problem Discretization Using Approximation Theory, Transformations and unified view of problems through the concept of transformations, classification of problems in numerical analysis, Problem discretization using approximation theory, Weierstrass theorem and polynomial approximations, Taylor series approximation, Finite difference method for solving ODE-BVPs with examples, Finite difference method for solving PDEs with examples, Newton's Method for solving nonlinear algebraic equation as an application of multivariable Taylor series, Introduction to polynomial interpolation, Polynomial and function interpolations, Orthogonal Collocations method for solving ODE-BVPs, Orthogonal Collocations method for solving ODE-BVPs with examples, Orthogonal Collocations method for solving PDEs with examples, Necessary and sufficient conditions for unconstrained multivariate optimization, Least square approximations, Formulation and derivation of weighted linear least square estimation, Geomtraic interpretation of least squares. Projections and least square solution, Function approximations and normal equation in any inner product space, Model Parameter Estimation using linear least squares method, Gauss Newton Method, Method of least squares for solving ODE-BVP, Gelarkin's method and generic equation forms arising in problem discretization, Errors in Discretization, Generic equation forms in transformed problems.

Unit-3: Solving Linear Algebraic Equations, System of linear algebraic equations, conditions for existence of solution - geometric interpretations (row picture and column picture), review of concepts of rank and fundamental theorem of linear algebra, Classification of solution approaches as direct and iterative, review of Gaussian elimination, Introduction to methods for solving sparse linear systems: Thomas algorithm for tri-diagonal and block tri-diagonal matrices, Block-diagonal, triangular and block-triangular systems, solution by matrix decomposition, Iterative methods: Derivation of Jacobi, Gauss-Siedel and successive over-relaxation methods, Convergence of iterative solution schemes: analysis of asymptotic behavior of linear difference equations using Eigen values, Convergence of iterative solution schemes with examples, Convergence of iterative solution schemes, Optimization based solution of linear algebraic equations, Matrix conditioning, examples of well conditioned and ill-conditioned linear systems.

Unit-4: Solving Nonlinear Algebraic Equations, Method of successive substitutions derivative free iterative solution approaches. Secant method, regula falsi method and Wegsteine iterations, Modified Newton's method and qausi-Newton method with Broyden's update, Optimization based formulations and Leverberg-Marquardt method, Contraction mapping principle and introduction to convergence analysis.

Unit-5: Solving Ordinary Differential Equations, Initial Value Problems (ODE-IVPs), Introduction, Existence of Solutions (optional topic),Analytical Solutions of Linear ODE-IVPs, Analytical Solutions of Linear ODE-IVPs (contd.), Basic concepts in numerical solutions of ODE-IVP: step size and marching, concept of implicit and explicit methods, Taylor series based and Runge-Kutta methods: derivation and examples, Runge-Kutta methods, Multi-step (predictor-corrector) approaches: derivations and examples, Multi-step (predictor-corrector) approaches: derivations and examples, Stability of ODE-IVP solvers, choice of step size and stability envelopes, Stability of ODE-IVP solvers (contd.), stiffness and variable step size implementation, Introduction to solution methods for differential algebraic equations (DAEs), Single shooting method for solving ODE-BVPs.

References

1. Gilbert Strang, Linear Algebra and Its Applications (4th Ed.), Wellesley Cambridge Press (2009).
2. Philips, G. M.,Taylor, P. J. ; Theory and Applications of Numerical Analysis (2nd Ed.), Academic
Press, 1996.
3. Gourdin, A. and M Boumhrat; Applied Numerical Methods. Prentice Hall India, New Delhi, (2000).
4. Gupta, S. K.; Numerical Methods for Engineers.Wiley Eastern, New Delhi, 1995.
5. Linz, P.; Theoretical Numerical Analysis, Dover, New York, (1979).
6. Gilbert Strang , Introduction to Applied Mathematics, Wellesley Cambridge Press (2009)

Outcomes:

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

1. Students should be able to solve system of linear algebraic equations
2. Students should be able to do numerical integrations of functions.
3. Students should be able to fit relationship between two data sets using linear, non-linear regression.
4. Students should be able to calculate maxima/minima and functions

CHPC 02 **ADVANCES IN TRANSPORT PHENOMENA**

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives:

1. To familiarize the student with basic concepts of transport phenomena and brief review of mathematics.
2. To enable students to understand the equations of change for isothermal flow and for non-isothermal flow.
3. To introduce them details of equations of change for multi component systems.
4. To give them insight into properties of two-dimensional flows and aspects of dimensional analysis

Unit-1: Equations of Change for Isothermal Systems: Equation of Continuity, Equation of Motion,Equation of Mechanical Energy, Equations of Change in terms of the Substantial Derivative, Use of the Equations to solve Flow Problems, Dimensional Analysis of the Equations of Change.Velocity Distributions with more than one Independent Variable: Time Dependent Flow of Newtonian Fluids. Velocity Distributions in Turbulent Flow -Comparisons of Laminar and Turbulent Flows, Time Smoothed Equations of Change for Incompressible Fluids, Time Smoothed Velocity Profile near a wall, Empirical Expressions for the Turbulent Momentum Flux, Turbulent Flow in Ducts, Turbulent Flow in Jets.

Unit-2: Macroscopic Balances for Isothermal Systems: The Macroscopic Mass Balance, The Macroscopic Momentum Balance, The Macroscopic Mechanical Energy Balance, Estimation of the Viscous loss, Use of the Macroscopic Balances for Steady-State Problems, Derivation of the Macroscopic Mechanical Energy Balance.

Equations of Change for Non-Isothermal Systems: The Energy Equation, Special forms of the Energy Equation, The Boussine sq Equation of Motion for Forced and Free Convection, Use of the Equations of change to Solve Steady-State Problems, Dimensional Analysis of the Equations of Change for Non-Isothermal Systems.

Unit-3: Temperature Distributions in Solids and in Laminar Flow: Heat Conduction with an Electrical Heat Source, Heat Conduction with a Viscous Heat Source. Temperature Distributions with more than One Independent Variable - Unsteady Heat Conduction in Solids, Steady Heat Conduction in Laminar, Incompressible Flow. Temperature Distributions in Turbulent Flow - Time-Smoothed Equations of Change for Incompressible Non-Isothermal Flow, Time-Smoothed Temperature Profile near a Wall, Empirical Expressions for the Turbulent Heat Flux Temperature Distribution for Turbulent Flow in Tubes.

Unit-4: Macroscopic Balances For Non-Isothermal Systems: Macroscopic Energy Balance, Macroscopic Mechanical Energy Balance, Use Of The Macroscopic Balances To Solve Steady State Problems With Flat Velocity Profiles, Concentration Distributions in Solids and in Laminar

Flow: Shell Mass Balances Boundary Conditions, Diffusion through a Stagnant Gas Film, Diffusion with a Heterogeneous Chemical Reaction. Concentration Distributions with more than One Independent Variable: Time-Dependent Diffusion, Steady-State Transport in Binary Boundary Layers, Concentration Distributions in Turbulent Flow - Concentration Fluctuations and the Time-Smoothed Concentration, Time-Smoothing of the Equation of Continuity of A, Semi-Empirical Expressions for the Turbulent Mass Flux, Enhancement of Mass Transfer by a First-Order Reaction in Turbulent Flow.

Unit -5: Interphase Transport in Multi-Component Systems: Definition of Transfer Coefficients in One Phase, Analytical Expressions for Mass Transfer Coefficients, Correlation of Binary Transfer Coefficients in One Phase, Definition of Transfer Coefficients in Two Phases, Mass Transfer and Chemical Reactions. Macroscopic Balances For Multi-Component Systems: Macroscopic Mass Balances, Macroscopic Momentum, Use of the Macroscopic Balances to solve Steady-State Problems.

References

1) Thomson W. J., Transport Phenomena, Pearson education, Asia, 2001.

2) Geankopolis C. J., Transport Processes and Unit Operations, 4th Ed., Prentice Hall (India) Pvt.
Ltd., New Delhi. 2004.

3) Bird R. B., Stewart W. E. and Light Foot E. N., Transport Phenomena, Revised 2nd Edition, John Wiley & Sons, 2007.

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

1. Understand the mechanism of momentum, heat and mass transport for steady and unsteady flow.
2. Perform momentum, energy and mass balances for a given system at macroscopic and microscopic scale.
3. Solve the governing equations to obtain velocity, temperature and concentration profiles.
4. Model the momentum, heat and mass transport under turbulent conditions.
5. Develop analogies among momentum, energy and mass transport.

CHPE 11 **PROCESS DESIGN AND SYNTHESIS**

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives:

1. To understand the systematic approaches for the development of conceptual chemical process designs
2. To learn the advances in problem formulation and software capabilities which offer the promise of a new generation of practical process synthesis techniques based directly on structural optimization.
3. Learning chemical process synthesis, analysis, and optimization principles
4. Product design and development procedure and Process life cycle assessment.

Unit I : Introduction

Introduction to fundamental concepts and principles of process synthesis and design and use of flow sheet simulators to assist process design. Process Flow sheet Models: An Introduction to Design, Chemical process synthesis, analysis and optimization. Introduction to commercial process design software such as HYSYS, Aspen plus etc., Chemical Process (reactor, heat exchanger, distillation etc) analysis using commercial software

Unit II : Product design and developments

Process engineering economics and project evaluation Life Cycle Assessments of process: From design to product development, Engineering Economic Analysis of Chemical Processes, Project costing and performance analysis, Environmental concerns, Green engineering, Engineering ethics, Health and safety.

Unit III : Reactor Networks

Geometry of mixing and basic reactor types, The Attainable Region (AR) approach, AR in higher dimensions & for other processes, Reactive Separation processes, Fundamental behavior and problems, Separation through reactions. Reactive Residue Curve Maps

Unit IV : Synthesis of Separation Trains

Criteria for selection of separation methods, select ion of equipment**:** Absorption, Liquid-liquid extraction Membrane separation, adsorption, leaching, drying, crystallization, Ideal distillation - Column and sequence fundamentals, Sharp splits & sequencing Phase diagrams for 2, 3 and 4 components, Feasibility and vapor ow rates for single columns, Residue curve basics, Non-ideal Distillation **-** Azeotropic systems; detecting binary azeotropes, Residue curve maps for azeotropic systems, Topological analysis, Feasibility for single azeotropic columns ,Binary VLLE and pressure-swing separation, Non-ideal distillation synthesis. Equipment sequencing: VLE + VLLE, Detailed Residue Curve Maps, Residue curve maps: Interior structure

Unit V : Heat Exchanger Network Synthesis

Minimum heating and cooling requirements, Minimum Energy Heat Exchanger Network, Loops and Paths, Reducing Number of Exchangers, HENS basics & graphics, The pinch point approach, Stream Splitting, Performance targets, trade-off & utilities, Heat & power integration, HENS as mathematical programming

References

1. Douglas, J. "Conceptual Design of Chemical Processes",New York, NY: McGraw-Hill Science/Engineering/Math, 1988. ISBN: 0070177627.

2. Seider, W. D., J. D. Seader, and D. R. Lewin. "Product and Process Design Principles: Synthesis, Analysis, and Evaluation",. *2*nd ed. New York, NY: Wiley, 2004. ISBN: 0471216631.

3. Richard Turton, Richard C. Bailie, Wallace B. Whiting, Joseph A. Shaeiwitz., "Analysis, Synthesis, and Design of Chemical Processes", 2nd Edition, 2002, Prentice Hall ISBN-10: 0-13-064792-6

4. Biegler L.T., Grossmann I.E. and Westerberg A.W., "Systematic Methods of Chemical Process Design", Prentice Hall, 1997.

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

1. Analyze alternative processes and equipment
2. Synthesize a chemical process flow sheet that would approximate the real process
3. Design best process flow sheet for a given product
4. Perform economic analysis related to process design and evaluate project profitability

CHPE 12 **CHEMICAL REACTOR ANALYSIS**

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives:

1. To learn the heterogeneous catalyzed reactions and the models involved in reactor design
2. To study mass and heat transfer mechanisms in the different reactors
3. To appreciate the importance of both external and internal transport effects in gas-solid and liquid-solid systems
4. To design isothermal and non-isothermal reactors for heterogeneous catalytic reactions

Unit-I: Chemical factor affecting the choice of the reactor, fundamental mass, energy and momentum balance, Model for a semi-batch reactor, optimum operation policies and control strategies, optimal batch operation time, optimal temperature policies, stability of operation and transient behavior for mixed flow reactor. Transient CSTR analysis, Hot spot equation; Optimization using Lagrange multiplier, Poyntrgins maximum principle.

Unit-II: Fixed bed catalytic reactor: The importance and scale of fixed bed catalytic processes, factors in preliminary design, modeling of fixed bed reactor. Pseudo-homogeneous model, the multi-bed adiabatic reactor, auto-thermal operation, non-steady-state model with axial mixing, two dimensional pseudo-homogeneous models, heterogeneous models, global and intrinsic rates, Mechanism of catalytic reactions, Engineering properties of catalysts - BET surface area, pore volume, pore size, pore size distribution, one dimensional and two dimensional model equation.

Unit-III: Multiphase flow reactor: Types of multiphase flow reactors, packed columns, plate columns, empty columns, stirred vessel reactors.Development of rate equations for solid catalyzed fluid phase reactions; Estimation of kinetic parameters. External mass and heat transfer in catalyst particles. Stability and selectivity, Packed bed reactor, slurry reactor; Trickle bed reactor and fluidized bed reactor. Intra-particle heat and mass transfer - Wheelers parallel pore model, random pore model of Wakao and Smith. deactivation of catalyst, Ideal and non-ideal flow in reactors.

Unit -IV: Design model for multiphase flow reactors, gas and liquid phase in completely mixed and plug flow, gas phase in plug flow and liquid phase in completely mixed flow, effective diffusion model, two zone model, specific design aspects, packed absorber, two-phase fixed bed reactor, plate column, spray tower, bubble reactor, stirred vessel reactor.Computer - aided reactor design.

Unit-V: Temperature effects in reactor: Introduction, well mixed system with steady feed, the stability and start-up of CSTR, limit cycles and oscillatory reactions, the plug flow reactors, tubular reactor, diffusion control, prorogation of reaction zone.

References :

1. Froment G. F. and K.B.Bischoff, " Chemical Reactor Analysis and Design", John Wiley & Sons
2. Denbigh K. G. and J.C. Turner, " Chemical Reactor and Theory – an Introduction", 3rd edition Cambridge University Press.
3. Bruce Nauman, " Chemical Reactor Design", John Wiley & Sons
4. Elements of Chemical Reaction Engineering by H. Scott Fogler
5. Chemical Engineering Kinetics by J. M. Smith.
6. Chemical Reactor Design and Operation by K. R. Westerterp, W. P. M. Van Swaaij and A. A. C. M. BeenackersReference
7. Chemical Reactor Analysis and Design by G. F. Froment and K. B. Bischoff

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

1. Evaluate heterogeneous reactor performance considering mass transfer limitations
2. Perform the energy balance and obtain concentration profiles in multiphase reactors.
3. Estimate the performance of multiphase reactors under non-isothermal conditions

CHPE 13 **FLUIDIZATION ENGINEERING**

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives

1. To study the phenomenon of fluidization with industrial processing objective
2. To study the various regimes of fluidization and their mapping.
3. To study the design of equipments based on fluidization technique

Unit I : Introduction to fluidization and applications

Phenomenon of fluidization, behavior of fluidized bed, contacting modes, advantages and disadvantages of fluidization, fluidization quality, selection of contacting mode, Beds for Industrial applications, coal gasification, synthesis reactions, physical operations, cracking of hydrocarbons

Unit II : Mapping of fluidization regimes

Characterization of particles, mechanics of flow around single particles, minimum fluidization velocity, pressure drop versus velocity diagram, The Geldart classification of solids, fluidization with carryover of particles, terminal velocity of particles, distributor types, gas entry region of bed, pressure drop requirements, design of gas distributor, power consumption

Unit III : Bubbling fluidized beds

Davidson model for bubble in a fluidized bed, and its implications, the wake region and movement of solids at bubbles, coalescence and splitting of bubbles, bubble formation above a distributor, slug flow, Turbulent and fast fluidization - mechanics, flow regimes and design equations, Emulsion movement, estimation of bed properties, bubble rise velocity, scale up aspects, flow models, two phase model, K-L model

Unit IV : Solids movement and Gas dispersion

Vertical and horizontal movement of solids, Dispersion model, large solids in beds of smaller particles, staging of fluidized beds

Gas dispersion in beds, gas interchange between bubble and emulsion, estimation of gas interchange coefficient, Heat and mass transfer in fluidized systems, Mixing in fluidized systems - measurements and models.

Unit V : Fluidized bed reactors

Entrainment and elutriation, Freeboard behavior, gas outlet, entrainment from tall vessel, freeboard entrainment model, high velocity fluidization, pressure drop in turbulent and fast fluidization, Slugging, Spouted beds, Circulating Fluidized Beds.

Mathematical model of a homogeneous fluidized bed, Design of catalytic reactors, pilot plant reactors, information for design, bench scale reactors, design decisions, deactivating catalysts,Design of noncatalytic reactors, kinetic models for conversion of solids, models for shrinking particles, conversion of solids of unchanging size]

References

1. Levenspiel O. and Kunnii D., "Fluidization Engineering", John Wiley, 1972
2. Liang-Shih Fan, "Gas-Liquid-Solid Fluidization Engineering", Butterworths, 1989

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

1. Performing and understanding the behavior fluidization in fluidized bed
2. Evaluate the characterization of particles and power consumption in fluidization regimes
3. Understanding the applicability of the fluidized beds in chemical industries

CHPE14 **PROCESS PLANT SIMULATION**

Instruction : 3 hr/week Credits : 3 Evaluation : 40 + 60

Course Objectives ; Students will have to learn the following

1) Learn the Chemical Systems Modeling and Artificial Neural Networks
2) Understand how to design Steady State Extraction and Heat Conduction through Hollow Cylindrical, Unsteady State Mass Balance for CSTR and Heat Transfer in a Tubular Gas Pre Heater
3) Understand how to design models from Fluid Flow and Reaction Engineering
4) Develop Errors of Measurement, Problems in Data Regression and Solving Equation Solving and Modular Approach
5) Develop Algorithms based on Signal Flow Graph, Tearing Algorithms and Physical and Thermodynamic Properties of Convergence Promotion

UNIT I

Modeling Aspects: Deterministic vs. Stochastic Processes, Physical modeling, Mathematical modeling, Chemical Systems Modeling, Cybernetics, Controlled System, Principles of Similarity

Classification of Mathematical Modeling: Independent and Dependent variables, Classification based on variation of independent variables, Classification based on state of the process, Classification based on type of the process, Boundary Conditions, The black Box Principle, Artificial Neural Networks

UNIT II - Process Modeling - I

Models from mass transfer: steady state single stage solvent extraction, steady state two stage solvent extraction, steady state two stage cross current solvent extraction, , steady state N- stage solvent counter current extraction, unsteady state single stage solvent extraction, unsteady state mass balance in a stirred tank and in a mixing tank.

Models from Heat Transfer : steady state heat conduction through a hollow cylindrical pipe, unsteady state steam heating of a liquid, unsteady state heat loss through a measuring tank, heat transfer through extended surfaces, unsteady state heat transfer in a tubular gas pre heater

UNIT III – Process Modeling -II

Models from fluid flow: flow through a packed bed column, flow of a film on the outside of a circular tube, annular flow with inner cylinder moving axially, flow between coaxial cylinders and concentric spheres

Models from Reaction Engineering : chemical reaction with diffusion in a tubular reactor, chemical reactor with heat transfer in a packed bed reactor, gas absorption accompanied by chemical reaction

UNIT IV

Error Propagation & Data Regression :Propagation of errors through addition, subtraction, multiplication and division, Errors of measurement, Precision errors, errors method

Data Regression : Theoretical properties, data regression methods, Problems in data regression

Process Simulation : Modular Approach, The equation solving approach

UNIT V

Decomposition of Networks : Tearing Algorithms, Algorithms based on signal flow graph and reduced digraph

Convergence Promotion: Newton's method, direct substitution method, Wegstein's method, dominant Eigen value method, quasi Newton method, Criterion for acceleration, Physical and Thermodynamic Properties

TEXTBOOKS:

1. Process Plant Simulation, B.V.Babu, Oxford University press, 2004

2. Process Modeling, Simulation and Control for Chemical Engineers, 2nd ed., W. L. Luyben, McGraw-Hill, New York, 1990

REFERENCE:

1. Introduction to Numerical Methods in Chemical Engineering, P. Ahuja, PHI , New Delhi, 2010

2. Process Modeling and Simulation, Amiya K. Jana, 2012.

Course Objectives : Students will be trained in

1) Modeling Aspects and Classification of Mathematical Modeling
2) How to Prepare Models from Mass Transfer and Models on Heat Transfer
3) How to Prepare Models from Fluid Flow and Models on Reaction Engineering
4) The analysis through Propagation of Errors, Error Methods, Data Regression Methods and Process Simulation
5) Decomposition of Networks and Convergence Promotion

CHPE 21 **INDUSTRIAL POLLUTION CONTROL**

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives

1. To understand the importance of industrial pollution and its abatement
2. To study the underlying principles of industrial pollution control
3. To acquaint the students with case studies
4. Student should be able to design complete treatment system

Unit I : Industries & Environment

Industrial scenario in India - Industrial activity and Environment - Uses of Water by industry - Sources and types of industrial wastewater - Industrial wastewater and environmental impacts - Regulatory requirements for treatment of industrial wastewater - Industrial waste survey - Industrial wastewater generation rates, characterization and variables - Population equivalent - Toxicity of industrial effluents and Bioassay tests.

Unit II : Industrial Noise pollution

Sources of noise pollution, characterization of noise pollution prevention& control of noise pollution, Factories Act 1948 for regulatory aspects of noise pollution.

Unit III : Air Pollutant Abatement

Air pollutants scales of concentration, lapse rate and stability, plume behavior, dispersion of air pollutants, atmospheric dispersion equation and its solutions, Gaussian plume models.Air pollution control methods, Source correction methods, Design concepts for pollution abatement systems for particulates and gases. Such as gravity chambers, cyclone separators, filters, electrostatic precipitators, condensation, adsorption and absorption, thermal oxidation and biological processes.

Unit IV : Waste water treatment processes

Design concepts for primary treatment, grid chambers and primary sedimentation basins, selection of treatment process flow diagram, elements of conceptual process design, design of thickner, biological treatment Bacterial population dynamics, kinetics of biological growth and its applications to biological treatment, process design relationships and analysis, determination of kinetic coefficients, activated sludge process. Design, trickling filter design considerations, advanced treatment processes, Study of environment pollution from process industries and their abatement: Fertilizer, paper and pulp, inorganic acids, petroleum and petrochemicals, recovery of materials from process effluents.

Unit V : Solid waste and Hazardous waste management

xSources and classification, properties, public helth aspects, Sanitary land fill design, Hazardous waste classification and rules, management strategies, Nuclear waste disposal Treatment methods – component separation, chemical and biological treatment, incineration, solidification and stabilization, and disposal methods, Latest Trends in solid waste management.

References

1. Rao C.S., "Environmental Pollution Control Engineering", 2nd edition
2. Mahajan S.P., "Pollution Control in Process Industries".
3. Nemerow N.L., "Liquid waste of industry- theories, Practices and Treatment", Addison Wesley, New York, 1971
4. Weber W.J., "Physico-Chemical Processes for water quality control", Wiley Interscience New York, 1969
5. Strauss W., "Industrial Gas Cleaning", Pergamon, London, 1975
6. Stern A.C., "Air pollution", Volumes I to VI, academic Press, New York, 1968
7. Peterson and Gross .E Jr., "Hand Book of Noise Measurement", 7th Edn, 2003.
8. Antony Milne, "Noise Pollution: Impact and Counter Measures", David & Charles PLC, 2009.

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

1. Recognize the causes and effects of environmental pollution
2. Analyze the mechanism of proliferation of pollution
3. Develop methods for pollution abatement and waste minimization
4. Design treatment methods for gas, liquid and solid wastes

CHPE 22 APPLICATION OF NANOTECHNOLOGY IN CHEMICAL ENGINEERING

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives

1. To understand the fundamentals of the preparation and properties of nanomaterials from a chemical engineering perspective.
2. To gain knowledge of structure, properties, manufacturing, and applications of various nanomaterials and characterization methods in nanotechnology
3. To give a survey of the key processes, principles, and techniques used to build novel nanomaterials and assemblies of nanomaterials

Unit I : Introduction

Introduction to nanotechnology, Feynman's Vision-There's Plenty of Room at the Bottom, Classification of nanostructures, Nanoscale architecture, Chemical interactions at nanoscale, Types of carbon based nanomaterials, Synthesis of fullerenes, Graphene, Carbon nanotubes, Functionalization of carbon nanotubes, One, two and multidimensional structures, Crystallography.

Unit II : Approaches to Synthesis of Nanoscale Materials and characterization

Top down approach, Bottom up approach Bottom-up vs. top-down fabrication; Top-down: Atomization, Sol gel technique, Arc discharge, Laser ablation, RF sputtering; Bottom-up: Chemical Vapor Deposition (CVD), Metal Oxide Chemical Vapor Deposition (MOCVD), Atomic layer deposition (ALD), Molecular beam Molecular self-assembly; Ultrasound assisted, microwave assisted, Mini, micro and nanoemulsion. Wet grinding method, Spray pyrolysis, Ultrasound assisted pyrolysis, atomization techniques. Surfactant based synthesis procedures, Types of molecular modeling methods. Size, shape, crystallinity, topology, chemistry analysis usingX-ray imaging, Transmission Electron Microscopy, HRTEM, Scanning Electron Microscopy, SPM, AFM, STM, PSD, Zeta potential, DSC and TGA.

Unit III : Semiconductors and Quantum dots

Intrinsic semiconductors, Extrinsic semiconductors, Review of classical mechanics, de Broglie's hypothesis, Heisenberg uncertainty principle Pauli exclusion principle Schrödinger's equation Properties of the wave function, Applications: quantum well, wire, dot, Quantum cryptography

Unit IV : Polymer-based and Polymer-filled Nanocomposites

Nanoscale Fillers, Nanofiber or Nanotube Fillers, Plate-like Nanofillers, Equi-axed Nanoparticle Fillers, Inorganic Filler Polymer Interfaces, Processing of Polymer Nanocomposites, Nanotube/Polymer Composites, Layered Filler Polymer Composite Processing, Nanoparticle/Polymer Composite Processing: Direct Mixing, Solution Mixing, In-Situ Polymerization, In-Situ Particle Processing, In-Situ Particle Processing Metal/Polymer Nanocomposites, Properties of nanocomposites.

Unit V : Applications to Safety, Environment and Others

Chemical and Biosensors- Classification and Main Parameters of Chemical and Biosensors, Nanostructured Materials for Sensing, Waste Water Treatment, Nanobiotechnology, Drug Delivery, Nanocoatings, Self cleaning Materials, Hydrophobic Nanoparticles, Photocatalysts, Biological nanomaterials, Nanoelectronics, Nanomachines & nanodevices, Societal, Health and Environmental Impacts.

References

1. Louis Hornyak G., Dutta Joydeep, Tibbals Harry F. and Rao Anil K., "Introduction to Nanoscience", (CRC Press of Taylor and Francis Group LLC), May 2008, 856pp, ISBN-13: 978142004805

2. Ajayan P. M., Schadler L. S., Braun P. V., "Nanocomposite Science and Technology", Edited by WILEY-VCH Verlag GmbH Co. KGaA, Weinheim ISBN: 3-527-30359-6, 2003.

3. Kelsall Robert W., Hamley Ian W., GeogheganMark, "Nanoscale Science and Technology",John Wiley & Sons, Ltd, 2006.

4. Kal Ranganathan Sharma, "Nanostructuring Operations in Nanoscale Science and Engineering", McGraw-Hill Companies, Inc. ISBN: 978-0-07-162609-5, 2010.

5. "Organic and inorganic nanostructures".-(Artech House MEMS series), Nabok, Alexei, ISBN 1-58053-818-5, 2005.

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

1. Understanding the different top down and bottom up approaches for nanoparticles
2. Get to know the different applications of nanoparticles in chemical engineering field.
3. Learning the characterization techniques for nanoparticles

3. Lear

CHPE 23 **CHEMOINFORMATICS**

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives

1. To give students a concept of Chemo-informatics related to chemical structure databases and database search methods

2. To understand the quantum methods and models involved in drug discovery and targeted drug delivery

3. To study the application of Chemical Libraries, Virtual Screening, Prediction of Pharmacological Properties

Unit I : Chemo-informatics

Introduction, scope and application, Basics of Chemo-informatics, Current Chemo-informatics resources for synthetic polymers, pigments. Primary, secondary and tertiary sources of chemical information, Databases: Chemical Structure Databases (PubChem, Binding database, Drugbank), Database search methods:chemical indexing, proximity searching, 2D and 3D structure and substructure searching. Drawing the Chemical Structure: 2D & 3D drawing tools (ACD Chemsketch) Structure optimization.

Unit II : Introduction to quantum methods

Combinatorial chemistry (library design, synthesis and deconvolution), spectroscopic methods and analytical techniques,Representation of Molecules and Chemical Reactions: Different types of Notations, SMILES Coding, Structure of Mol files and Sd files (Molecular converter, SMILES Translator).

Unit III : Analysis and use of chemical reaction information

Chemical property information, spectroscopic information, analytical chemistry information, chemical safety information, Drug Designing: Prediction of Properties of Compounds, QSAR Data Analysis, Structure-Activity Relationships, Electronic properties, Lead Identification, Molecular Descriptor Analysis.

Unit IV : Target Identification

Molecular Modeling and Structure Elucidation: Homology Modelling (Modeller 9v7, PROCHECK), Visualization and validation of the Molecule (Rasmol, Pymol Discovery studio), Applications of Chemoinformatics in Drug Research - Chemical Libraries, Virtual Screening, Prediction of Pharmacological Properties.

Unit V : Drug Discovery

Structure based drug designing, Docking Studies (Target Selection, Active site analysis, Ligand preparation and conformational analysis, Rigid and flexible docking, Structure based design of lead compounds, Library docking), Pharmacophore - Based Drug Design, Pharmacophore Modeling (Identification of pharmacophore features, Building 2D/3D pharmacophore hypothesis), Toxicity Analysis-Pharmacological Properties (Absorption, Distribution and Toxicity), Global Properties (Oral Bioavailability and Drug-Likeness) (ADME, OSIRIS, and MOLINSPIRATION)

References

1. Bajorath J (2004), "Chemoinformatics: Concepts, Methods and Tools for Drug Discovery" Humana Press
2. Leach A, Gillet V, "An Introduction to Chemoinformatics" Revised edition, Springer
3. Gasteiger J. Engel T. "A textbook of Chemoinformatics" Wiley- VCH GmbH & Co. KGaA
4. Bunin B. Siesel B. Guillermo M. "Chemoinformatics: Theory, Practice & Products", Springer
5. Lavine B. (2005), "Chemometrics and Chemoinformatics", American Chemical Society
6. Casteiger J. and Engel T (2003) "Chemoinformatics" Wiley-VCH
7. Bunin Barry A. Siesel Brian, Morales Guillermo,Bajorath Jürgen. Chemoinformatics: Theory, Practice, & Products Publisher:New York, Springer. 2006.
8. Leach Andrew R., Valerie J. Gillet, "An introduction to Chemoinformatics", Publisher: Kluwer academic, 2003. ISBN: 1402013477
9. Gasteiger Johann, Handbook of Chemoinformatics: From Data to Knowledge (4 Volumes),
   2003. Publisher: Wiley-VCH.

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

1. The course will introduce the students preparing for professional work in chemistry must learn how to retrieve specific information from the enormous and rapidly expanding chemical literature.
2. The course will provide a broad overview of the computer technology to chemistry in all of its manifestations.
3. The course will expose the student to current and relevant applications in QSAR and Drug Design.

CHPE 24 **ADVANCED CONTROL SYSTEMS**

Instruction : 3 hr/week Credits : 3 Evaluation : 40 + 60

Course Educational Objectives ; Students will have to learn the following

1) Learn the Concepts of Advanced Control Strategies
2) Understand the Multi Input and Multi Output controlling
3) Understand the Purpose of Digital Data Acquisition and Control
4) Develop Discrete Time Models & Their Dynamic Response
5) Design the Digital Controllers

Unit I :

Feed Forward and Ratio Control – Introduction, Feed forward controller design based on steady state and dynamic models, tuning and configuration of feed forward control

Advanced Control Strategies – Cascade control, time delay compensation and inferential control, selective and override systems, adaptive control, statistical process control

Unit II :

Control of Multi Input, Multi-Output Systems – Process interactions and control loop interactions, pairing of controlled and manipulated variables, strategy for reducing interactions, decoupling, multivariable control techniques

Supervisory Control – Basic requirements, applications, formulation and solution of optimization problems, unconstrained and constrained optimization

Unit III :

Digital Computer Control – Digital control systems in process control, distributed instrumentation and control systems, general purpose digital data acquisition, digital control hardware and software, table driven PID controller, Programmable logic controllers and batch process control

Sampling and Filtering of Continuous Measurements – Sampling and signal reconstruction, selection of sampling period, signal processing and data filtering, comparison of analog and digital filters, effect of filter selection on control system performance

Unit IV : _

Development of Discrete Time Models – Finite difference models, exact discretization for linear systems, higher order systems, fitting discrete time equations to process data

Dynamic Response of Discrete –Time Systems – The z-Transform, inversion, pulse transfer function, relating pulse transfer functions to difference equations, effect of pole and zero locations, conversion between laplace and z- transforms

Unit V :_

Analysis of Sampled – Data Control Systems – Open loop block diagram analysis, development of closed loop transfer functions, stability of sampled data control systems

Design of Digital Controllers – Digital PID controller, selection of controller parameters, direct synthesis methods, digital feed forward control, combined load estimation and time delay compensation

Text Books:

1. Process Dynamics and Control – D.E.Seborg, T.F.Edgar and D.A.Mellichamp, John Wiley & Sons
2. Chemical Process control – An Introduction to Theory and Practice - George Stephanopoulos, Prentice hall 1990.

Course Objectives : Students will be able to understand and analyze

1) Feed Forward, Ratio Controls and Advanced Controllers
2) Control Loop Interactions & Optimization
3) Digital Computer Control, selection of sampling period, comparison of analog and digital filters
4) Finite Difference Models, Z-Transforms, Pulse Transfer Functions
5) Samples and Data Control Systems

CHPP 01 COMPUTATIONAL TECHNIQUES LABORATORY

Instruction , hours/week : 4 Credits : 2 Assessment : 40 + 60

Objectives:

1. To learn Numerical methods for interpolation, extrapolation, graphical differentiation and integration, curve fitting….Process Modeling and Simulation of Chemical operations and processes.

2. To implement the above on MAT Lab

List of experiments:

1.Euler Method

2. Runge Kutta 4^{th} Order Method

3. Jacobi Iteration Method

4. Gauss-Siedel Iteration Method

5. Lagrange's Iteration Method

6. Newton Forward Interpolation Method

7. Newton Backward Interpolation Method

8, Bisection Method

9. Newton Raphson Method

10. Regula Falsi Method

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

1. Use numerical methods for various manipulations and be capable of implementing them on a computing system

PGMC 41 **RESEARCH METHODOLOGY AND IPR**

Instruction , hours/week : 2 Credits : 2 Assessment : 40 + 60

Unit 1: Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

Unit 2: Effective literature studies approaches, analysis **,** Plagiarism, Research ethics,

Unit 3: Effective technical writing, how to write report, Paper , Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

Unit 4: Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

Unit 5: Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

Unit 6: New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

References :

1) Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"
2) Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
3) Ranjit Kumar, 2nd Edition , "Research Methodology: A Step by Step Guide for beginners"
4) Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
5) Mayall , "Industrial Design", McGraw Hill, 1992.
6) Niebel , "Product Design", McGraw Hill, 1974.
7) Asimov , "Introduction to Design", Prentice Hall, 1962
8) Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Property in New Technological Age", 2016.

9) T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008

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

Understand research problem formulation. - Analyze research related information - Follow research ethics - Understand that today’s world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.

Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.

Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

CHPC 03 **SEPARATION PROCESSES**

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives:

1) Understand the classification of separation processes
2) To learn the fundamental concepts of rate governed processes
3) To impart the basic concepts of multistage separation processes
4) Understand the design of distillation column using different methods
5) Understand the energy requirements of different separation processes

UNIT I

Use and Characteristics of Separation Processes – Importance and variety of Separations – Characteristics of separation Processes- Inherent separation factors for equilibrium and rate Governed Processes

Simple equilibrium processes: Equilibrium calculations- Checking phase conditions for a mixture- Analysis of simple equilibrium separation-processes for binary and multi component systems - Computational and Graphical Approaches.

Unit II

Additional Factors Influencing Product Purities – Incomplete Mechanical Separation of Product Phases – Flow Configuration and Mixing Effects – Batch Operations – Methods of Regeneration – Mass and Heat Transfer Limitations – Stage Efficiencies

Multistage Separation Processes: Increasing product purity - Reducing consumption of separating agent - co-current, crosscurrent and countercurrent flow - Other separation processes - Fixed bed processes.

Unit-III:

Binary Multistage Separations - Distillation: Binary Systems - Equilibrium stages and McCabe-Thiele Diagram - design and other problems – Multistage batch distillation - Straight operating lines and curved operating lines.

UNIT IV

Patterns of Change: Binary and Multi component multistage separations

Group Methods - Linear stage-exit relationships and constant flow rates- non linear stage –Exit Relationships and varying flow rates.

Capacity of contacting devices: factors limiting capacity and factors influencing efficiency.

UNIT V

Energy Requirements of separations processes:

Thermodynamic efficiency - single stage and multistage separation processes - reduction of energy consumption**.**

Selection of Separation processes: Factors influencing the choice of separation Process - solvent extraction and Illustrative examples

TEXT BOOKS:

1. Separation Processes - C.Judson King,, McGraw – Hill, 1982

REFERENCE BOOKS

1. Separation Process Principles - J.D.Seader and E.J.Henley, , John Wiley, 1998.
2. Mass Transfer Operation - R.E. Treybal, , 3rd edition - McGraw – Hill 1980
3. Transport Processes and Unit Operations – Geankoplis C.J. 4th ed – PHI Pvt. Ltd

Course Outcomes: Student will be able to

1) Applies the concepts of diffusion mass transfer, mass transfer coefficients, convective mass transfer, inter-phase mass transfer, equipment for gas-liquid operations
2) Suggest and design equipment for various mass transfer operations
3) Study of the stage wise mass transfer operations, principles of various stage wise contact processes like distillation
4) Student will be able to select a separation process for a particular system.
5) Able to understand the energy requirements of separation processes

CHPC 04 **CHEMICAL REACTOR THEORY**

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Course Educational Objectives:

1) The emphasis of this course is on the fundamentals of chemical reaction kinetics and chemical reactor operation.
2) The overall goal of this course is to develop a critical approach toward understanding complex reaction systems and elucidating chemical reactor design.
3) Integrate concepts from science & engineering to constitute a basis for the design of chemical reactor, a key element in the design of chemical process.
4) Provide a foundation on Non-ideal reactors and RTD
5) Impart knowledge about heterogeneous catalytic reactors

UNIT I

Isothermal Reactor design: Design structure for isothermal reactors - Scale-up of liquid phase batch reactor data to the design of a CSTR - Tubular reactors - Pressure drop in Reactors - Reversible reactions - unsteady state operation of reactors -Simultaneous reaction and Separation.

UNIT-II

Analysis of Non ideal Reactors - RTD - Measurement and characteristics of RTD- RTD in ideal reactors - Reactor modeling with the RTD - Zero and One parameter models - Two-Parameter model - Modeling real reactors with combinations of ideal reactors - Testing a model and determining it's parameters - Other models of non ideal reactors using CSTRs and PFRs

UNIT-III

External diffusion Effect on Heterogeneous Reactions - Binary diffusion - External resistance to mass transfer - the shrinking core model.

Diffusion and reaction in Porous Catalyst – Diffusion and reaction in spherical pellets - Internal Effectiveness factor - Falsified Kinetics - Overall effectiveness factor - Estimation of diffusion and reaction limited regimes - Mass transfer and reaction in a packed bed

UNIT-IV

Internal Transport Processes-Reaction and Diffusion in porous catalysts:

Intra pellet mass transfer and intra pellet heat transfer, Mass transfer with reaction, Mass and Heat transfer with reaction, effect of internal transport on selectivity and poisoning.

UNIT-V

Design of heterogeneous Catalytic Reactors: Fixed bed reactors and isothermal and adiabatic fixed-bed reactors, non isothermal, non adiabatic fixed bed reactors, Two phase model, Fluidized-Bed reactors, Operating characteristics of FBRs. Mass Transfer in Fluidized Beds: Gas-Solid Mass Transfer, Mass Transfer between the Fluidized-Bed Phases, Reaction in Fluidized Bed. Trickle bed reactor Models, Slurry reactor models.

Text Books

1. J.M.Smith "Chemical Engineering Kinetics" 3rd ED., Mc Graw Hill, New York 1980
2. Fogler H. S., Elements of Chemical Reaction Eng.", 3rd Ed., Prentice Hall, 1999
3. Levenspiel, O., "Chemical Reaction Eng." John Wiley & Sons 1972.

Course Outcomes : Student will be able to

1) learn the importance of RTD and Non-ideal flow in reacting vessels.
2) Calculate the conversions based on segregated flow model, dispersion model and tanks-in-series models.
3) Understand the diffusion and reaction in a porous catalyst.
4) Learn the factors influencing catalyst decay, the role of pore diffusion on catalyst activity rate.
5) Understand the design of heterogeneous catalytic reactors.

CHPE31 MODERN CONCEPTS IN CATALYSIS AND SURFACE PHENOMENON

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives

1. To give the students insight into advances in catalytic reaction engineering
2. To understand the mechanisms involved in catalytic reactions
3. To study the catalyst characterization techniques
4. To study the advanced industrial applications in catalysis
5. To understand the principles behind catalyst deactivation and study their models

Unit I : Introduction to Catalysis

Definition of Catalytic activity, Magnitude of Turnover Frequencies and Active Site Concentrations, Evolution of Important Concepts and Techniques in Heterogeneous Catalysis, Classification of Catalysts – Homogeneous, Heterogeneous, Biocatalysts, Dual Functional Catalysts, Enzymes, Solid Catalysts, Powder Catalysts, Pellets, Composition, Active Ingredients, Supportive materials, Catalysts Activation, Catalyst Deactivation.

Unit II : Adsorption in Catalysis

Adsorption and its importance in Catalysis, Adsorption and potential energy curves, Surface Reconstruction, Adsorption Isotherms and Isobars, Dynamical Considerations, Types of Adsorption Isotherms and their Derivation from Kinetic Principles, Mobility at Surfaces, Kinetics of surface Reactions, Photochemistry on oxide and metallic surfaces, Characterization of the adsorbed molecules

Unit III : Catalyst Characterization

Catalyst Characterization Methods – Their Working Principle and Applications – XRF, XRD, IR Spectroscopy, XPS, UPS, ESR, NMR; Infrared, Raman, NMR, Mossbauer and X-Ray Absorption spectroscopy, Surface Acidity and Toxicity, Activity, Life time, Bulk density, Thermal stability Crystal Defects, Peroviskites, Spinels, Clays, Pillared Clays, Zeolites

Unit IV : Significance of Pore Structure and Surface Area

Importance of Surface Area and Pore Structure, Experimental Methods for Estimating Surface Area– Volumetric, Gravimetric, Dynamic Methods, Experimental Methods for Estimating Pore

Volume and Diameter – Gas Adsorption and Mercury Porosimeter Method, Models of the Pore Structure – Hysteresis Loops, Geometric Models, Wheeler's Model, Dusty Gas Model, Random Pore Model, Diffusion in Porous Catalysts – Effective Diffusivity, Knudsen Diffusion, Effect of Intraparticle Diffusion, Non-isothermal Reactions in Pores, Diffusion Control.

Unit V : Industrial applications– Case Studies

Industrial processes involving heterogeneous solid catalyst: Synthesis of Methanol, Fiscer-Tropsch Catalysis, Synthesis of Ammonia, Automobile Exhaust Catalysts and Catalyst Monolith, Photocatalytic Breakdown of Water and the Harnessing of Solar Energy.

Contribution of homogeneous catalytic process in chemical industry:Oxidations of Alkenes such as production of acetaldehyde, propylene oxide etc., Polymerization such as production of polyethylene, polypropylene or polyester production

References

1. Emmett, P.H. - "Catalysis Vol. I and II, Reinhold Corp.", New York, 1954
2. Smith, J.M. - "Chemical Engineering Kinetics ", McGraw Hill, 1971
3. Thomas and Thomas - "Introduction to Heterogeneous Catalysts ", Academic Press, London 1967
4. Piet W.N.M. van Leeuwen, Homogeneous catalysis: Understanding the Art, Springer, 2004
5. Piet W.N.M. van Leeuwen, and John C. Chadwick, Homogeneous catalysis: Activity-stability –deactivation, Wiley, VCH, 2011.

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

1. To understand the concepts of homogenous and heterogeneous catalysis, with specific examples.
2. To study reaction mechanisms and kinetics of homogenous and heterogeneous catalytic reactions.
3. To familiarize with the characterization of catalysts
4. To understand the application and mechanisms of several types of catalysts in chemical industry.

CHPE 32 ADVANCED DOWNSTREAM PROCESSING

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives

1. To understand the unit processes involved in downstream processing.
2. To study advanced treatment methods.
3. To study the energy conservation in different separation processes
4. To understand the underlying design principles

Unit I : Introduction]

Introduction to Downstream processes theory, applications in chemical separation for Gas-Liquid system, Gas-Solid system. Super critical fluids extraction in food, pharmaceutical, environmental and petroleum applications, water treatment, desalination, Bio separation, dialysis, industrial dialysis.

Unit II : Downstream Processes in Petrochemical Industry

Cryogenic distillation for refinery, petrochemical off gases, natural gases, gas recovery-Olefin, Helium, Nitrogen, Desulfurization - coal, flue gases

Unit III : Advanced Distillation Processes

Azeotropic & extractive distillation - residue curve maps, homogeneous azeotropic distillation, pressure swing distillation, Column sequences, heterogeneous azeotropic distillation.

Unit IV : Energy conservation in separation processes

Energy balance, molecular sieves - zeolights, adsorption, catalytic properties, manufacturing processes, hydrogel process, application, New trends.

Unit IV : Non-Ideal Mixtures and Ion Exchange

Separations process synthesis for nonazeotropic mixtures, non ideal liquid mixtures, separation synthesis algorithm, Ion exchange - manufacture of resins, physical & chemical properties, capacity, selectivity, application, regeneration, equipment, catalysis use.

References

1. Perry’s “Chemical Engg. Handbook”: McGraw Hill Pub.
2. Douglas J.M., “Conceptual Design of Chemical Processes”, McGraw Hill
3. Liu Y.A., “Recent Developments in Chemical Process & Plant Design”, John Wiley & Sons Inc.
4. Timmerhaus K.D., “Cryogenic Process Engg.”, Plenum Press
5. Othmer Kirk “Encyclopedia of Separation Technology, Vol I & II”, Wiley Interscience

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

1. To learn effective strategies of downstream processing in chemical industry.
2. Understand the role of downstream processing.
3. Analyze reactors, upstream and downstream processes in production

CHPE 33 **COMPUTATIONAL FLUID DYNAMICS**

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives

1. To make students understand the governing equations of fluid dynamics and their derivation from laws of conservation
2. To develop a good understanding in computational skills, including discretisation, accuracy and stability.
3. To acquaint the students with a process of developing a mathematical and geometrical model of flow, applying appropriate boundary conditions and solving system of equations

Unit I : Introduction to Fluid Dynamics

Concepts of Fluid Flow, Pressure distribution in fluids, Reynolds transport theorem, Integral form of conservation equations, Differential form of conservation equations, Different Types of Flows, Euler and Navier Stokes equations, Properties of supersonic and subsonic flows, Flow characteristics over various bodies. Philosophy of CFD, Governing equations of fluid dynamics and there physical meaning, Mathematical behavior of governing equations and the impact on CFD simulations, Simple CFD techniques and CFL condition. Numerical Methods in CFD:Finite Difference, Finite Volume, and Finite Element, Upwind and downwind schemes, Simple and Simpler schemes, Higher order methods, Implicit and explicit methods, Study and transient solutions

Unit II : Grid Generation

Basic theory of structured grid generation, Surface grid generation, Mono block, multi block, hierarchical multi block, Moving and sliding multiblock, Grid clustering and grid enhancement. Basic theory of unstructured grid generation, advancing front, Delaunay triangulation and various point insertion methods, Unstructured quad and hex generation, grid based methods, various elements in unstructured grids, Surface mesh generation, Surface mesh repair, Volume grid generation, Volume mesh improvement, mesh smoothing algorithms, grid clustering and quality checks for volume mesh. Adaptive, Moving and Hybrid Grids, Need for adaptive and, moving grids, Tet, pyramid, prism, and hex grids, using various elements in combination

Unit III : Turbulence and its Modelling

Transition from laminar to turbulent flow, Effect of turbulence on time-averaged Navier-Stokes equations, Characteristics of simple turbulent flows, Free turbulent flows, Flat plate boundary layer and pipe flow, Turbulence models, Mixing length model,The k-e model, Reynolds stress equation models, Algebraic stress equation models

Unit IV : Chemical Fluid Mixing Simulation

Stirred tank modeling using the actual impeller geometry, Rotating frame model, The MRF Model Sliding mesh model, Snapshot model, Evaluating Mixing from Flow Field Results, Industrial Examples

Unit IV : Post-Processing of CFD results

Contour plots, vector plots, and scatter plots, Shaded and transparent surfaces, Particle trajectories and path line trajectories, Animations and movies, Exploration and analysis of data.

References

1. Anderson John D., "Computational Fluid Dynamics: The Basics with Applications", Mc Graw Hill, 1995
2. Ranade V.V., "Computational Flow Modeling for Chemical Reactor Engineering", Process Engineering Science, Volume 5, 2001
3. Knupp Patrick and Steinberg Stanly, "Fundamentals of Grid Generation", CRC Press, 1994
4. Wilcox D.C., "Turbulence Modelling for CFD", 1993
5. Wesseling Pieter, "An Introduction to Multigrid Methods", John Wiley & Sons, 1992
6. Thompson J.F., Warsi Z.U.A. and Mastin C.W., "Numerical Grid Generation: Foundations and Applications", North Holland, 1985
7. Patankar S.V., "Numerical Heat Transfer and Fluid Flow", McGraw-Hill,1981
8. Gatski Thomas B., Hussaini M. Yousuff and Lumley John L., "Simulation and Modelling of Turbulent Flows", Oxford University Press, 1996
9. Laney, C. B., "Computational Gas Dynamics", Cambridge Uni. Press, 1998.

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

1. Understand the basic principles of mathematics and numerical concepts of fluid dynamics.
2. Develop governing equations for a given fluid flow system.
3. Adapt finite difference techniques for fluid flow models.
4. Apply finite difference method for heat transfer problems.
5. Solve computational fluid flow problems using finite volume techniques.

6. Get familiarized to modern CFD software used for the analysis of complex fluid-flow systems

CHPE 34 ENZYME SCIENCE & ENGINEERING

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Course Educational Objectives ; Students will have to learn the following

1) Understand the Development of Enzymatic Assays
2) Solve Kinetics of Single Substrate Reactions
3) Do the Analysis on Immobilized Enzyme Systems
4) Learn the types of Immobilized Reactors
5) Design the Enzyme Electrodes

UNIT I :

Enzymes : Classification – Protein Structure –Extraction, Purification and characterization from natural sources – Development of enzymatic assays, Comparison of chemical and enzyme catalysis

UNIT II :

Mechanisms and Kinetics of Enzyme Action : Mechanisms of enzyme action – concept of active site and energetics of enzyme-substrate complex formation – Specificity of enzyme action – Kinetics of single substrate reactions (irreversible & reversible), estimation of Michaelis-Menten Parameters – Multi substrate mechanisms and kinetics

Types of inhibition – kinetic Models – substrate and product inhibition – temperature and pH effects on enzyme activity – deactivation kinetics

UNIT-III:

Enzyme Immobilization – Physical and Chemical methods – Comparison of different methods –

Immobilized Enzyme Kinetics - Analysis of Film and Pore Diffusion effects on immobilized enzyme systems – Formulation of dimensionless groups and calculation of effectiveness factors

UNIT-IV :

Enzyme Reactors - Immobilized Enzyme Reactors – Packed bed, Fluidized bed, membrane reactors – Bioconversion calculations in free enzyme CSTRs and immobilized enzyme reactors

UNIT V :

Applications : Applications of free and immobilized enzymes

Biosensors : Applications of enzymes in analysis; Design of enzyme electrodes and their applications as biosensors in industry, health care and environment

Text Books

1. Enzymes-Palmer;T,(Affiliated East West Press Pvt.Ltd.), 2004
2. Biochemical Engineering Fundamentals – Bailey, J.E. & Ollis,D.F., McGraw Hill

References

1. Biochemistry- Stryer,Berg, 6thEdition, (W.H.Freeman and Co.), 2007.
2. Enzyme Biotechnology- Tripathi;G, (ABD Publishers), 2003.
3. Enzyme Technology, M.F. Chaplin and C. Bucke. Cambridge University Press
4. Industrial Enzymes & their applications, H. Uhlig, (John Wiley and Sons Inc.)

Course Objectives : Students will be able to

1) Know the mechanisms of Chemical and Enzyme Catalysts
2) Develop, understand and apply Kinetic Models
3) Formulate and Analyze Immobilized Enzyme Kinetics
4) Design and analyze Enzyme Reactors
5) Gain knowledge on Applications of Enzyme and on Biosensors

CHPE 35 **OPTIMIZATION THEORY & PRACTICE**

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Course Educational Objectives :

1) To learn problem formulation and basic concepts of optimization.
2) To study the numerical methods to solve single variable un-constrained problems
3) To understand and apply numerical methods to solve un-constrained multi-variable problems
4) To learn linear& non-linear programming methods
5) To know the applications of optimization through different examples

Unit-I: Introduction

Basic concepts of optimization, applications of optimization, general procedure for solving optimization problem, formulation of the objective function, fitting models to data, classification of functions.

Unit-II: Single Variable unconstrained optimization methods

Direct search methods-Interval halving method, Fibonacci method, Golden section method;
Direct root methods-Newton method and Quasi Newton method;
Polynomial approximation methods - Quadratic interpolation and cubic interpolation.

Unit-III: Optimization of unconstrained multivariable functions

Direct search methods-random search, grid search, uni-variate search and pattern search methods. ; Indirect search methods - steepest descent, conjugate gradient methods, Newton's method and secant method.

Unit-IV: Linear and non-linear programming

Linear programming: Basic concepts in linear programming, Standard LP from, Graphical solution and Simplex method.

Non-linear programming: Lagrange multiplier method, Quadratic programming, Penalty function and augmented Lagrangian methods.

Unit –V: Applications of optimization

Optimizing recovery of waste heat, optimal design and operation of a conventional staged-distillation column, optimal pipe diameter, optimal residence time for maximum yield in chemostat and optimization of a thermal cracker using linear programming.

Text Book:

1.Edgar, T. F., Himmelblau, D. M. and Ladson, L. S., "Optimization of Chemical Processes", 2nd Ed., McGraw Hill, New York.

Reference Books :

1. Diwaker, U. W. "Introduction to Applied Optimization", Kluwer.
2. Joshi, M. C. and Moudgalya, K. M., "Optimization, Theory and Practice", Narosa, New Delhi, 2004.
3. Rao, S. S., Engineering Optimization: Theory and Practice, New Age Publishers.

Course Outcomes: Student will be able to

1) formulate and analyse the optimization of the given physical situation.
2) Apply different methods of optimization and to suggest a technique for specific problem
3) Understand the difference between constrained and unconstrained optimization
4) Understand the importance of linear programming problems
5) Realize the importance of optimization by understanding different examples

CHPE 36 **MICRO AND NANO FLUIDICS**

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives:

1. To introduce to the students, the various opportunities in the emerging field of micro and nano fluids.
2. To the make students familiar with the important concepts applicable to small micro and nano fluidic devices, their fabrication, characterization and application
3. To get familiarize with the new concepts of real-time nano manipulation &

ssembly

Unit-1: Introduction: Fundamentals of kinetic theory-molecular models, micro and macroscopic properties, binary collisions, distribution functions, Boltzmann equation and Maxwellian distribution functions-Wall slip effects and accommodation coefficients, flow and heat transfer analysis of microscale Couette flows, Pressure driven gas micro-flows with wall slip effects, heat transfer in micro-Poiseuille flows, effects of compressibility. Pressure Driven Liquid Microflow: apparent slip effects, physics of near-wall microscale liquid flows, capillary flows, electro-kinetically driven liquid micro - flows and electric double layer (EDL) effects, concepts of electroosmosis, electrophoresis and dielectro-phoresis.

Unit- 2: Laminar flow: Hagen-Poiseullie eqn, basic fluid ideas, Special considerations of flow in small channels, mixing, microvalves & micropumps, Approaches toward combining living cells, microfluidics and 'the body' on a chip, Chemotaxis, cell motility. Case Studies in Microfluidic Devices. Ionic transport: Polymer transport – microtubule transport in nanotuble channels driven by Electric Fields and by Kinesin Biomolecular Motors - Electrophoresis of individual nanotubules in microfluidic channels.

Unit-3: Fabrication techniques for Nanofluidic channels – Biomolecules separation using Nanochannels - Biomolecules Concentration using Nanochannels – Confinement of Biomolecules using Nanochannels. Hydrodynamics: Particle moving in flow fields – Potential Functions in Low Renoylds Number Flow – Arrays of Obstacles and how particles Move in them: Puzzles and Paradoxes in Low Re Flow.

Unit-4: Microfluidics and Lab-on-a-chip: Microfluidic Devices - Microchannels, Microfilters, Microvalves, Micropumps, Microneedles, Microreserviors, Micro-reaction chambers. Concepts and Advantages of Microfluidic Devices - Fluidic Transport - Stacking and Scaling – Materials for The Manufacture (Silicon, Glass, Polymers) - Fluidic Structures - Fabrication Methods - Surface Modifications - Spotting - Detection Mechanisms. Microcontact printing of ProteinsStrategies-printing types- methods and characterization- Cell nanostructure interactions-networks for neuronal cells. Applications in Automatic DNA sequencing, DNA and Protein microarrays.

Unit-5: BioMEMS (Micro-Electro-Mechanical Systems): Introduction and Overview, Biosignal Transduction Mechanisms: Electromagnetic Transducers Mechanical Transducers, Chemical Transducers, Optical Transducers – Sensing and Actuating mechanisms (for all types). Case Studies in Biomagnetic Sensors, Applications of optical and chemical transducers. Ultimate Limits of Fabrication and Measurement, Recent Developments in BioMEMS and BioNEMS - An alternative approach to traditional surgery, Specific targeting of tumors and other organs for drug delivery, Micro-visualization and manipulation, Implantation of microsensors, microactuators and other components of a larger implanted device or external system (synthetic organs).

Text Books

1. Joshua Edel "Nanofluidics" RCS publishing, 2009.

2. Patric Tabeling "Introduction to Microfluids" Oxford U. Press, New York 2005.
3. K. Sarit "Nano Fluids; Science and Technology", RCS Publishing, 2007.

References

1. M. Madou, Fundamentals of Microfabrication, CRC Press, 1997
2. G. Kovacs, Micromachined Transducers, McGraw-Hill, 1998

3. Steven S Saliterman, Fundamentals of BioMEMS and Medical Microdevices, 2006

Outcomes: At the end of this course, students are able to:

1. Introduce students to the physical principles to analyze fluid flow in micro and nano-size devices. It unifies the thermal sciences with electrostatics, electrokinetics, colloid science; electrochemistry; and molecular biology.

CHPE 37 **PROCESS INTENSIFICATION**

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives:

1. Understand the concept of Process Intensification.
2. Know the limitations of intensification of the chemical processes.
3. Apply the techniques of intensification to a range of chemical processes.
4. Develop various process equipment used for intensifying the processes.
5. Infer alternative solutions keeping in view point, the environmental protection, economic viability and social acceptance.

Unit-I: Introduction: Techniques of Process Intensification (PI) Applications, The philosophy and opportunities of Process Intensification, Main benefits from process intensification, ProcessIntensifying Equipment, Process intensification toolbox, Techniques for PI application.

Unit-II: Process Intensification through micro reaction technology: Effect of miniaturization on unit operations and reactions, Implementation of Microreaction Technology, From basic Properties To Technical Design Rules, Inherent Process Restrictions in Miniaturized Devices and Their Potential Solutions, Microfabrication of Reaction and unit operation Devices - Wet and Dry Etching Processes.

Unit-III: Scales of mixing, Flow patterns in reactors, Mixing in stirred tanks: Scale up of mixing, Heat transfer. Mixing in intensified equipment, Chemical Processing in High-Gravity Fields Atomizer Ultrasound Atomization, Nebulizers, High intensity inline MIXERS reactors Static mixers, Ejectors, Tee mixers, Impinging jets, Rotor stator mixers, Design Principles of static Mixers Applications of static mixers, Higee reactors.

Unit-IV: Combined chemical reactor heat exchangers and reactor separators: Principles of operation; Applications, Reactive absorption, Reactive distillation, Applications of RD Processes, Fundamentals of Process Modelling, Reactive Extraction Case Studies: Absorption of NOx Coke Gas Purification. Compact heat exchangers: Classification of compact heat exchangers, Plate heat exchangers, Spiral heat exchangers, Flow pattern, Heat transfer and pressure drop, Flat tube-and-fin heat exchangers, Microchannel heat exchangers, Phase-change heat transfer, Selection of heat exchanger technology, Feed/effluent heat exchangers, Integrated heat exchangers in separation processes, Design of compact heat exchanger - example.

Unit-V: Enhanced fields: Energy based intensifications, Sono-chemistry, Basics of cavitation, Cavitation Reactors, Flow over a rotating surface, Hydrodynamic cavitation applications, Cavitation reactor design, Nusselt-flow model and mass transfer, The Rotating Electrolytic Cell, Microwaves, Electrostatic fields, Sonocrystallization, Reactive separations, Superctrical fluids

References:

1. Stankiewicz, A. and Moulijn, (Eds.), Reengineering the Chemical Process Plants, Process Intensification, Marcel Dekker, 2003.
2. Reay D., Ramshaw C., Harvey A., Process Intensification, Butterworth Heinemann, 2008.
3. Kamelia Boodhoo (Editor), Adam Harvey (Editor),Process Intensification Technologies for Green Chemistry: Engineering Solutions for Sustainable Chemical Processing, Wiley, 2013.
4. Segovia-Hernández, Juan Gabriel, Bonilla-Petriciolet, Adrián (Eds.)Process Intensification in Chemical Engineering Design Optimization and Control, Springer, 2016.
5. Reay, Ramshaw, Harvey, Process Intensification, Engineering for Efficiency, Sustainability and Flexibility, Butterworth-Heinemann, 2013.

Outcomes: At the end of this course, students are able to:

1. Assess the values and limitations of process intensification, cleaner technologies and waste minimization options.
2. Measure and monitor the usage of raw materials and wastes generating from production and frame the strategies for reduction, reuse and recycle.
3. Obtain alternative solutions ensuring a more sustainable future based on environmental protection, economic viability and social acceptance.
4. Analyze data, observe trends and relate this to other variables.
5. Plan for research in new energy systems, materials and process intensification.

CHPE 41 PHASE TRANSITIONS IN PROCESS EQUIPMENT

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives:

1. Basic laws in thermodynamics.
2. Basic statistical concepts and methods: heat, work, energy, temperature and the kinetic theory of matter; entropy, ensemble, partition function, etc
3. Learning phase transition catalysis
4. Have a good grasp of the basic thermodynamic interactions and process: adiabatic, isothermal, etc

Unit-I: Thermodynamic aspects of phase transitions: Concept of phase, First-order phase transition, conditions for phase coexistence lines, free energy barrier of nucleation, and crystal-melt interfacial free energy, Ehrenfest classification of phase transitions, Van der Waals equation of state, Critical point

Unit-II: Single phase and multiphase catalytic reactions, Acid--base catalysis, Transition metal catalysis, Phase transfer catalysis, Micellar catalysis, Microemulsion catalysis, Electron transfer catalysis, Heteropoly acid catalysis, Homogeneous polymer catalysis, Heterogenisation of homogeneous catalysts.

Unit-III: Applications to Multi-phase Systems Stability conditions for a homogeneous system, equilibrium between phases, phase transformations, general relations for a system with several components, general conditions for chemical equilibrium, chemical equilibrium between ideal gases, and the equilibrium constants in terms of partition functions.

Unit -IV: Phase diagrams and transformations Phase rule- single and binary phase diagrams, lever rule, micro structural changes during cooling, Al_2O_3, Cr_2O_3, Pb-Sn, Ag-Pt and Fe-Fe_3C Systems phase diagrams, phase transformations, corrosion- theories of corrosion, control and prevention of corrosion

UNIT-V: Energy balance - heat capacity and calculation of enthalpy changes, Enthalpy changes for phase transitions, evaporation, clausius - clapeyron equation,

References:

1. Hegedus, L.S., Transition Metals in the Synthesis of Complex Organic Molecules, University Science Book (2010) 3rd ed.

2. Raghavan V., Material Science and Engineering Prentice Hall of India, 1996

3. David.M.Himmelblau, "Basic principles and calculations in chemical engineering", Prentice Hall of India Ltd., 6th Edition, 1998.

4. A.Hougen, K.M. Watson and K.A.Ragatz, "Chemical Process Principles", Vol 1, John Wiley, 1960.

Outcomes: At the end of this course, students are able to:

1. The student is expected to obtain considerable insight into various types of phase transitions, and how these can be described theoretically in different ways

2. Predict relationships between physical quantities using the laws and methods of thermodynamics.

3. Find probabilities and thermal quantities (free energy, entropy, etc) given the energy eigen values of a system.
4. The student is expected to obtain considerable insight into various types of phase transitions, and how these can be described theoretically in different ways

5. Predict relationships between physical quantities using the laws and methods of thermodynamics.

6. Find probabilities and thermal quantities (free energy, entropy, etc) given the energy eigen values of a system.

CHPE 42 **PROCESS INTEGRATION**

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives:

1. To introduce to the students, the various opportunities in the process integration in chemical industries.
2. To the make students familiar with the important concepts process integration for heat recovery/minimization.
3. To get familiarize with the case studies.

Unit-I: Introduction to process Intensification and Process Integration (PI). Areas of application and techniques available for PI, onion diagram.

Unit-II: Pinch Technology-an overview: Introduction, Basic concepts, How it is different from energy auditing, Roles of thermodynamic laws, problems addressed by Pinch Technology, Key steps of Pinch Technology: Concept of T_{min} , Data Extraction, Targeting, Designing, Optimization Super targeting, Basic Elements of Pinch Technology: Grid Diagram, Composite curve, Problem Table Algorithm, Grand Composite Curve.

Unit-III: Heat exchanger networks analysis, Maximum Energy Recovery (MER) networks for multiple utilities and multiple, Chemical Engineering Pre-requisites: Knowledge of basic process design of process equipment. Pinches, design of heat exchanger network.

Unit-IV: Heat integrated distillation columns, evaporators, dryers, and reactors.

Unit-V: Waste and waste water minimization, flue gas emission targeting, and heat and power integration. Case studies.

References:

1. Shenoy U.V.;"Heat Exchanger Network Synthesis", Gulf Publishing company.
2. Smith R.;"Chemical Process Design", McGraw-Hill.

3. Linnhoff B., Townsend D. W.,Boland D, Hewitt G. F., Thomas B.E.A., Guy A. R., and Marsland R. H.;"A User Guide on Process Integration for the Efficient Uses of Energy", Inst. of Chemical Engineers.

Outcomes: At the end of this course, students are able to:

1. Maximum heat recovery for a given process (both new processes, and retrofit of existing processes) identify opportunities for integration of high-efficiency energy.
2. Energy-intensive thermal separation operations (distillation, evaporation) at an industrial process site.
3. Evaluate the process integration measures with respect to energy efficiency, greenhouse gas emissions and economic performance.

CHPE 43 **TRANSPORT IN POROUS MEDIA**

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives:

1. Introduce the physics and governing mechanisms controlling flow and transport processes in porous media.
2. Learning Liquid and solute transport in porous media.

Unit-I: Fundamentals: Mass, momentum and energy transport, Darcy and Non-Darcy equations, equilibrium and non-equilibrium conditions, species transport, radioactive decay.

Unit-II: Effective medium approximation: equivalent thermal conductivity, viscosity, dispersion.

Unit-III: Exact solutions: Flow over a flat plate, flow past a cylinder, boundary-layers, reservoir problems.

Unit-IV: Special topics: Field scale and stochastic modeling, Turbulent flow, compressible flow, multiphase flow, numerical techniques, hierarchical porous media, nanoscale porous media, multiscale modeling.

Unit-V: Engineering applications: Groundwater, waste disposal, oil and gas recovery, regenerators,energy storage systems. Experimental techniques: Flow visualization, quantitative methods, inverse parameter estimation.

References:

1. Principles of Heat Transfer in Porous Media, by M. Kaviany, Springer New York (1995).
2. Transport Phenomena in Porous Media, Volumes I-III, edited by D. R. Ingham and I. Pop, Elsevier, New York (1998-2005).

3. Dynamics of Fluids in Porous Media, J. Bear, Dover (1988).
4. Introduction to Modeling of Transport Phenomena in Porous Media, J. Bear and Y. Bachmat, Kluwer Academic Publishers, London (1990).
5. Enhanced Oil Recovery, L.W. Lake, Gulf Publishing Co. Texas (1989).
6. The Mathematics of Reservoir Simulation, R.E. Ewing, SIAM Philadelphia (1983).
7. Stochastic Methods for Flow in Porous Media: Coping with Uncertainties, Zhang, D., Academic Press, California (2002).
8. The Method of Volume Averaging, S. Whitaker, Springer, New York (1999).

Outcomes: At the end of this course, students are able to:

1. Students will understand the mechanisms involved in transport processes in porous media and will be able to work with the equations that govern the fate and transport of gas, water and solutes in porous media.

CHPE 44 MICRO FLOW CHEMISTRY AND PROCESS TECHNOLOGY

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives:

1. Introduce the students to micro flow chemistry and process technology.
2. Learning Micromixers, Mixing Principles.
3. Learning micro reactor based chemicals production

Unit-I: State of the Art of Micro reaction Technology, Structural Hierarchy of Micro reactors, Functional Classification of Micro reactors, Fundamental Advantages of Micro reactors, Advantages of Micro reactors Due to Decrease of Physical Size, Advantages of Micro reactors Due to Increase of Number of Units, Potential Benefits of Micro reactors

Unit-II: Modern Micro fabrication Techniques for Micro reactors, Evaluation of Suitability of a Technique, Anisotropic Wet Etching of Silicon, Dry Etching of Silicon, LIGA Process, Injection Molding, Wet Chemical Etching of Glass, Advanced Mechanical Techniques

Unit-III: Micro mixers, Mixing Principles and Classes of Macroscopic Mixing Equipment, Mixing Principles and Classes of Miniaturized Mixers, Mixing Tee-Type Configuration

Unit-IV: Microsystems for Gas Phase Reactions, Catalyst Supply for Micro reactors , Types of Gas Phase Micro reactors, Micro channel Catalyst Structures, H_2/O_2 Reaction, Selective Partial Hydrogenation of Benzene, Selective Oxidation of 1-Butene to Maleic Anhydride, Selective Oxidation of Ethylene to Ethylene Oxide, Oxidative Dehydrogenation of Alcohols, Synthesis of Methyl Isocyanate and Various Other Hazardous Gases, Synthesis of Ethylene Oxide, Oxidation of Ammonia

Unit-V: Microsystems for Energy Generation, Micro devices for Vaporization of Liquid Fuels, Micro devices for Conversion of Gaseous Fuels to Syngas by Means of Partial Oxidations, Hydrogen Generation by Partial Oxidations, Micro devices for Conversion of Gaseous Fuels to Syngas by Means of Steam Reforming

References:

1. Wolfgang Ehrfeld, Volker Hessel, Holger Löwe MicroreactorsNew Technology for Modern Chemistry © WILEY-VCH Verlag GmbH, D-69469 Weinheim (Federal Republic of Germany), 2000.
2. S.V. Luis and E. Garcia-Verdugo, Chemical Reactions and Processes under Flow Conditions, University Jaume I/CSIC, Castello´n, Spain, The Royal Society of Chemistry 2010
3. Madhvanand N. Kashid, Albert Renken,and Lioubov Kiwi-Minsker, Microstructured Devices for Chemical Processing, Wiley-VCH Verlag GmbH & Co. KGaA, Boschstr ©2015 12, 69469 Weinheim, German.
4. Hessel, V., Renken, A., Schouten, J.C., Yoshida, Micro Process Engineering" A Comprehensive Handbook 2009, ISBN 978-3-527-31550-5.

Outcomes: At the end of this course, students are able to:

1. Students will understand the role of micro flow chemistry and process technology in chemical engineering.
2. The student is expected to obtain considerable insight into various types of micro reactors.

CHPE 45 PROCESS PLANT DESIGN & FLOW SHEETING TOOLS

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives:

1. Understanding of the scope, principles, norms, accountabilities and bounds of contemporary engineering practice in the specific discipline.
2. Application of established engineering methods to complex engineering problem solving.
3. Application of systematic engineering synthesis and design processes.

Unit-I: Introduction: Basic concepts: General design considerations, Process design development, Layout of plant items, Flow sheets and PI diagrams, Economic aspects and Optimum design, Practical considerations in design and engineering ethics, Degrees of freedom analysis in interconnected systems, Network analysis, PERT/CPM, Direct and Indirect costs, Optimum scheduling and crashing of activities.

Unit-II: Hierarchy of chemical process design; Nature of process synthesis and analysis; Developing a conceptual design and flow sheet synthesis. Synthesis of reaction-separation systems; Distillation sequencing; Energy targets. Heat integration of reactors, distillation columns, evaporators and driers; Process change for improved heat integration. Heat and mass exchange networks and network design.

Unit-III: Flow-sheeting: Synthesis of flow sheet: Propositional logic and semantic equations, Deduction theorem, Algorithmic flow sheet generation using P-graph theory, Sequencing of operating units, Feasibility and optimization of flow sheet using various algorithms viz, Solution Structure Generation (SSG), Maximal Structure Generation (MSG), Simplex, Branch-and-bound etc.

Unit-IV: Analysis of Cost estimation: Factors affecting Investment and production costs, Estimation of capital investment and total product costs, Interest, Time value of money, Taxes and Fixed charges, Salvage value, Methods of calculating depreciation, Profitability, Alternative investments and replacements.

Unit- V: Optimum Design and Design Strategy: Break-even analysis, Optimum production rates in plant operation, Optimum batch cycle time applied to evaporator and filter press, Economic pipe diameter, Optimum insulation thickness, Optimum cooling water flow rate and optimum distillation reflux ratio.

References:

1. Peters, M.A. and Timmerhaus, K.D., Plant Design and Economics for Chemical Engineers, McGraw Hill (2003).
2. Anil Kumar, Chemical Process Synthesis and Engineering Design, Tata McGraw Hill (1982).
3. Ulrich, G.D., A Guide to Chemical Engineering Process Design and Economics, John Wiley & Sons (1984).
4. Perry, R.H. and Green, D., Chemical Engineer's Handbook, McGraw-Hill (1997).

Outcomes: At the end of this course, students are able to:

1. Analyze, synthesize and design processes for manufacturing products commercially
2. Integrate and apply techniques and knowledge acquired in other courses such as thermodynamics, heat and mass transfer, fluid mechanics, instrumentation and control to design heat exchangers, plate and packed columns and engineering flow diagrams
3. Use commercial flow sheeting software to simulate processes and design process equipment
4. Recognize economic, construction, safety, operability and other design constraints
5. Estimate fixed and working capitals and operating costs for process plants

CHPE 46 **PROCESS SYNTHESIS & ANALYSIS**

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Course Objectives:

1) To familiarize the students about various economic aspects of chemical processes
2) To Learn basics of Cost estimation and to understand the time value of money
3) To Learn the importance of Cash flow diagrams and Break-even analysis.
4) To Study depreciation methods and methods of estimation of profitability of an industry
5) To Study about heat exchanger networks.

UNIT-I :

Nature of Process Synthesis & Analysis : Creative aspects – A hierarchial approach

Enginering Economics : Cost Information – Estimation of Capital and Operating Costs – Total Capital Investment- Total Product Cost - Time Value of Money – Measures of Process Profitability – Simplifying the Economic Analysis for Conceptual Design

UNIT II :

Economic Decision Making : Solvent Recovery System – Problem Definition & General Considerations – Design of a Gas Absorber – Equipment Design Consideration – Rules of Thumb

Input Information & Batch- Continuous: Input Information – Level 1 Decision – Batch Vs. Continuous

UNIT III :

Input-Output Structure of the Flow Sheet : Decisions for the I/O structure – Design Variables – Over all Material Balances – Stream Costs – Process Alternatives

Recycle Structure of the Flow Sheet : Decisions determining the recycle Structure – Recycle Material balances – reactor Heat Effects – Equilibrium Limitations – Compress Design & Costs – Reactor Design – recycle Economic Evaluation

Unit IV :

Heat Exchanger Networks – Minimum Heating & Cooling Requirements – Minimum Number of Exchangers – Area Estimates – Design of Minimum Energy Heat Exchanger Networks – Loops and Paths – Reducing the Number of Exchanger – Stream Splitting – Heat and Power Integration – Heat Distillation – HAD Process

UNIT V :

Separation System : General Structure – Vapor Recovery System – Liquid Separation System – Azeotropic Systems – Rigorous Material Balances

Cost Diagrams and Quick Screening of Process Alternatives - Cost Diagrams for simple and complex process – Quick Screening of Process Alternatives – HAD Process

Text Book :

1. Conceptual Design of Chemical Processes, Douglas, J.M., McGraw Hill,

Reference Books :

1. Chemical Process Design, Robin Smith, McGraw Hill,
2. Chemical Process Design, Dimian A.C, & Bidea,C.S., Wiley – VCH,2008
3. Chemical Process Synthesis & Engineering Design, Kumar,A, Tata McGraw Hill,1982
4. Systematic Methods of Chemical Process Design, Bieglar, L.T., Grossman, E.I and Westerberg, A.W. Prentice Hall Inc.
5. Product and Process Design Principles, Seider, W.D., Seider,J.D & Lewin, D.R. Wiley,2005

Course Outcomes: Student will be able to

1) understand the concepts of Engineering economics
2) Able to estimate various costs involved in a process industry and evaluate the tax burden of an establishment
3) Able to estimate profitability of a company
4) Understand the heat exchanger networks and their importance in industry
5) Compute break even period for an investment and rate of return

CHPE 47 **MEMBRANE SEPARATIONS**

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Course Educational Objectives ; Students will have to learn the following

1) Learn the Properties of Membrane and Types of Membrane
2) Learn the Types of Filtrations used
3) Design Reverse Osmosis Module
4) Learn Gas Separation and Pervaporation
5) Understand different Membrane Processes

UNIT I :

OverView of Membrane Separations

Membrane Types, Materials, Preparation and Characterization - Types of Synthetic Membranes – Membrane Modules – Typical Flow patterns – Membrane materials – Pore Characteristics – Membrane Manufacture – Measurement of Pore size and Solute rejection Properties – surface Properties measurement and interpretation

UNIT II :

Nano Filtration – principles – nano-filtration membranes – Mass Transfer – Process Limitations – Industrial application

Ultrafiltration - Basic Principles – Membranes – Configuration – Types of Devices – Factors affecting performance – Flux – Models for Solvent Flux – Fouling and Flux decline – Methods to reduce Concentration Polarization – Energy Considerations – Micellar enhanced UF – Affinity UF – Applications

Microfiltration – Basic Principles – Membranes – Transport Mechanism – retention characteristics – Flow Characteristics – Membrane Plugging and Throughput – Fouling – energy Considerations – Applications

UNIT III :

Reverse Osmosis - Concepts – Phenomenon of RO – Models for RO transport – Design and Operating parameters – Concentration Polarization – Membrane plugging – Equivalent work requirement – Design of an RO module – RO of non-aqueous systems – Osmotic pinch effect – Forward osmosis – Applications

Dialysis – Principles – Dialysis systems – Membranes – Mass transfer – Applications – Diffusion dialysis

UNIT IV :

Gas Separation - Basic Principles – Membranes – Membrane Modules – Fundamental Mechanisms of Gas Transport - Factors affecting Gas Permeation – Complete Mixing Model – Cross and Countercurrent models – Applications

Pervaporation - Basic Principles – Advantages – Membrane characteristics – Thermodynamic Considerations – Mass transfer – Thermodynamic Considerations – Design of a Module – Concentration Polarization – factors affecting pervaporation – Temperature drop at the interface – Applications

UNIT V :

Ion Exchange Membrane Process - Basic Principles – Ion exchange Membranes – Energy requirement, Efficiency- Concentration Polarization and limiting current density – Other operating parameters – applications

Liquid Membranes - Types of liquid membranes – Mechanism of Mass transfer – Applications

Other Membrane Processes – Membrane contactor and applications – Membrane distillation – Membrane reactors – PEM Hydrogen Fuel Cell

Text Book

1. Membrane Separation Processes – Kaushik nath – Prentice Hall, 2008

References

1. Reverse Osmosis and Synthetic Membranes Theory, Technology and Engineering, Sourirajan,S National Research Council, Canada.

2. Reverse Osmosis/ Ultrafiltration Process Principles, Sourirajan,S. and Matsuura, T., National Research Council, Canada. Separation Processes, Elsevier Scientific Publication.
3. Industrial Membrane Separation Technology, Scott,K., and Hughes, R. (Eds.), Blackie Academic & Professional London.
4. Separation Processes, King, C.J, Tata McGraw Hill, New Delhi.
5. Membrane Processes, Rautenbatch, R., and Albrecht, R John Wiley & Sons, New York.
6. Membrane Separation Processes, Baum,B., Halley, W. and White, R.A, Elsevier Scientific Publication

Course Objectives : Students gain

1) Knowledge on Preparation and Characterization of Materials and Types of Membrane

2) Knowledge on Nano-Filtration, Ultra-Filtration and Micro-Filtration
3) Knowledge on Designing Reverse Osmosis and Dialysis
4) Concepts of Gas Separation and Pervaporation and Design of Pervaporation Module
5) Knowledge on Ion Exchange Membrane Process, Liquid Membranes and Other Membrane Processes

CHPP02 ADVANCED CHEMICAL ENGINEERING LABORATORY

Instruction , hours/week : 4 Credits : 2 Assessment : 40 + 60

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

1. To design and perform experimentation in chemical engineering core subjects
2.

List of Laboratory Experiments:

Selected experiments in Momentum, Heat and Masstransfer, Reaction Engineering and Process Control.

Outcomes: Students will be able

1. to design and perform Chemical Engineering related experiments

CHPE 51 DESIGN OF EXPERIMENTS AND PARAMETER ESTIMATION

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives:

This subject provides students with the knowledge to

1. Use statistics in experimentation;
2. Understand the important role of experimentation in new product design, manufacturing process development, and process improvement;
3. Analyze the results from such investigations to obtain conclusions; become familiar methodologies that can be used in conjunction with experimental designs for robustness and optimization.

Unit-1: Design of experiments. Basic concepts, Bias and confounding, controlling bias, causation, Examples. Random Variables: Introduction to discrete and continuous random variables, quantify spread and central tendencies of discrete and continuous random variables.

Unit-2: Exploratory Data Analysis Variable types, Displaying the distribution, mean variance and typical spread, quartiles and unusual spread, multivariate data: finding relations. Probability Definition of a random variable, expectation, percentiles, common distributions such as the binomial, Poisson and normal distributions.

Unit-III: Point Estimation Estimators as random variables, sample mean and the central limit theorem, normal approximations, assessing normality. Interval Estimation Confidence intervals for the mean when the variance is known, confidence interval for the mean when the variance is unknown, confidence intervals for a single proportion, sample size, Student distribution. Hypothesis Testing Hypothesis testing for a mean or proportion, testing the equality of two means assuming equal variances, testing the equality of two means with unequal variances, comparison of two proportions.

Unit-IV: Linear Regression analysis: The linear regression model, Parameter estimation, accuracy of the coefficient estimates, checking the model, multiple linear regression, confidence and prediction intervals, potential issues, high leverage points, outliers. Matrix approach to linear regression, Variance-Covariance matrix, ANOVA in regression analysis, quantifying regression fits of experimental data, Extra sum of squares approach, confidence intervals on regression coefficients, lack of fit analysis.

Unit-V: Response Surface Methodology: Method of steepest ascent, first and second order models, identification of optimal process conditions

References:

1. Hanneman, Robert A., Kposowa, Augustine J., Riddle, Mark D. (2012). Research Methods for the Social Sciences: Basic Statistics for Social Research. John Wiley & Sons.

2. Saunders, Mark, Brown, Reva Berman (2007). Dealing with Statistics: What You Need to Know. McGraw-Hill Education.

3. Cowles, Michael (2000). Statistics in Psychology: An Historical Perspective (2nd Edition). Lawrence Erlb

Outcomes: At the end of this course, students are able to:

1. Plan experiments for a critical comparison of outputs
2. Include statistical approach to propose hypothesis from experimental data
3. Implement factorial and randomized sampling from experiments
4. Estimate parameters by multi-dimensional optimization

CHPE 52 **COMPUTER AIDED DESIGN**

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives:

1. To understand importance and applications of CAD in the field of chemical engineering
2. To understand the basic structure and components of CAD software
3. To understand the underlying thermodynamic and physical principles To give insight into the approaches used in the simulation of flow sheets
4. To understand flow charts, computer languages and numerical methods used for writing algorithms

Unit I :;;Introduction

Introduction to CAD, Scope and applications in chemical Engineering, Mathematical methods used in flow sheeting and simulation, Introduction to solution methods for linear and non-linear algebraic equations, solving one equation one unknown, solution methods for linear and nonlinear equations, general approach for solving sets of differential equations, solving sets of sparse non-linear equations.

Unit II: Properties Estimation

Physical properties of compounds, Thermodynamic properties of gases and binary mixtures, Viscosity, Vapour pressure, Latent heat, Bubble point and drew point calculation, phase equilidria, Vapour-liquid equilibria, Liquid phase activity coefficients, K-values, Liquid phase activity coefficients, K-values, Liquid-Liquid equilidria, Gas solutions.

Unit III : Equipment Design

Computer aided Design of Equipment: Design of Shell and Tube Heat exchangers; Design of Evaporators; Design of Distillation columns; Design of Reactors, Design of adsorption columns. Distillation columns (specific attention to multi components systems. Heat exchangers)

Unit IV : Computer Aided Flow Sheet Synthesis

Computerized physical property systems – physical property calculations, degrees of freedom in process design, degrees of freedom for a unit, degrees of freedom in a flow sheet, steady state flow sheeting and process design, approach to flow sheeting systems, introduction to sequential modular approach, simultaneous modular approach and equation solving approach, sequential modular approach to flow sheeting, examples. Tear streams, convergence of tear streams, partitioning and tearing of a flow sheet, partitioning and precedence ordering, tearing a group of units. Flow sheeting by equation solving methods based on tearing.

Unit V : Dynamic Simulation

Numerical recipes in CLinear and nonlinear equations, Ordinary and partial differential equations, Dynamic simulation of stirred tanks system with heating Multi component system, Reactors, Absorption and distillation columns, Application of orthogonal collocation and weighted residuals techniques in heat and mass transfer systems, Introduction to special software for steady and dynamic simulation of Chemical engineering systems. Introduction to various commercial design software and optimizers used in field of chemical engineering.

References

1. Douglas James M., "Conceptual design of Chemical Processes", McGraw -Hill Book Company, New York, 1988

2. Remirez, W.F. - " Computational methods for Process Simulations ", Butterworths, New York, 1989

3. Sinnott R.K. "Chemical Engineering", Volume 6, Pergamon Press, New York, 1989

4. Westerberg A.W., et al, "Process Flow Sheeting", Cambridge University Press
5. Biegler Lorenz T, et al, "Systematic method of Chemical Process Design", Prentice Hall

6. Crowe C.M., et al, "Chemical Plant Simulation-An Introduction to Computer Aided Steady State Analysis", Prentice Hall

7. Anil Kumar, "Chemical Process Synthesis and Engineering Design",TMH,1981

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

1. Students get the knowledge about computer Aided Flow Sheet Synthesis

2. Computer aided equipment design of Evaporators; Distillation columns; Reactors, adsorption columns.

CHPE 53 **CLEANER PRODUCTION**

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives

1. To give student an understanding about the concept of cleaner production.
2. To understand in detail, the methodologies involved
3. Financial evaluation of cleaner production technologies
4. To study the practical applications of cleaner production technologies

Unit I : Introduction

Cleaner production definition: Evaluation of cleaner production, Cleaner production network, Area covered by cleaner production (what is not cleaner production?).Difference between cleaner production and other methods, End of the pipe treatment to curb pollution, prerequisites of cleaner production.

Unit II : Cleaner production technique

Waste reduction at source, (a) Good housekeeping, (b) Process changes: change in raw material,

batter process, control, equipment modification and technology changes, Recycling: on site recovery and reuse creation of useful byproducts, Product modification.

Unit III : Cleaner production methodology

Methods of environmental protection -- preventive strategy, Methods of environmental protection -- preventive strategy, making team for cleaner production, Analyzing process steps, Generating C.P opportunities

Selection of C.P solution, Implementing C.P solution

Unit IV : Concept of cleaner production

Overview of CP Assessment Steps and skills, Preparing for the site visit, Information Gathering, and process flow diagram, material balance, CP Option Generation Technical and Environmental feasibility analysis-Economic valuation of alternatives fuels, Total cost analysis-CP Financing-

Establishing a program-Organizing a program preparing a program plan-Measuring progress-pollution prevention and cleaner production Awareness plan -Waste audit-Environmental Statement. Energy audit related tocleaner production, Energy audit's need and scope, Types of energy audit. Preliminary or walk through energy audit. Detailed energy audit, Methodology of energy audit, Energy balance and identifying the energy conservation opportunities.

Unit V : Financial analysis of cleaner production

Gathering base line information, Determining the capital or investment cost, Establishing lifetime of equipment and annual depreciation, Determine revenue implication of the project. Estimating change in operating cost, Calculating incremental cash flow, Assessing project's viability.

Case studies and Cleaner Production applications

Application (Industrial application of CP,LCA,EMS and Environmental Audits. C.P in chemical process industry, Practical ways & means to save material loss in loading/unloading and unit operations equipment like distillation column, drying and other equipments like heat exchanger, vacuum unit, conveying, etc. Practical ways & means for energy saving in industries. Case Studies of cleaner production.

References

1. "Cleaner Production Worldwide", 1993, United Nations Environment Programme, Industry and Environment, Paris, France, 1993

2. "Cleaner Production: Training Resource Package", UNEP IE, Paris, 1996

3. "Clean Technology for manufacture of Specialty Chemicals", Editor-W. Hoyle and M. Lancaster, Royal Society of Chemistry, U.K

4. Randall Paul M, "Engineers Guide to Cleaner Production Technologies".

5. Ahluvalia V. K., "Green Chemistry: Environmentally Benign Reactions".

6. Sanders R.E., "Chemical Process Safety: Learning from case Histories", Oxford Butter Worth Publication

7. "Training Manual Package" by NCPC

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

1. Explain the concept and principles of cleaner production.
2. Suggest different unit operations in industrial production process to minimize pollutions.
3. Plan good housekeeping practices for Industry/other places with concern of safety, hygiene and waste reduction.
4. Suggest basic methods and techniques of pollution prevention during production.
5. Suggest cleaner production methods for a given situation which will also lead to cost reduction in long run

CHPE 54 **FUEL CELL SYSTEMS**

Instruction : 4 Hr/week Credits : 4 Assessment : 40 + 60

Course Objectives ; Students will have to learn the following

1) Understand the Thermodynamic Aspects of Electrochemical Energy Conversion
2) Learn the Working Principle of Fuel Cell and Mechanisms of Electrode Reactions
3) Understand the Technology of Phosphoric acid and Solid Oxide Fuel Cells
4) Learn the Non Catalytic Aspects and Engineering Aspects of DMFC
5) Develop Modeling for PEMFC

UNIT-I

Introduction – Fuel Cells- Relevance and Importance – Historical Highlights - Difference from Batteries – Fuel Choice – Classification

Electrochemistry – Thermodynamic Aspects of Electrochemical(EC) Energy Conversion – Theoretical Efficiency of Heat of a Reaction to Mechanical Energy – Efficiency of EC Energy Conversion – Factors Affecting Efficiency of EC Energy Conversion Electrode Kinetics of EC Energy Conversion

UNIT-II

Alkaline Fuel Cells – Description – Working Principle – Components - Modules – Fuel Cell Stacks – General Performance Characteristics – Advancements – System Issues – Ammonia as AFC Fuel

Molten Carbonate Fuel Cells – General Principle – Cell Components – Mechanisms of Electrode Reactions- Status

UNIT-III

Phosphorus Acid Fuel Cells- Technology- Electrode Materials and Manufacturing – Stacks and Systems

Solid Oxide Fuel Cells – History – Advantages and Limitations- Cell Components – Electrode Materials – Interconnects – Fuel – Configuration and Performance – Environmental Impact – Applications

UNIT-IV

Direct Methanol Fuel Cells – Technology Evolution – The Noble Metal Issue- The Catalyst – Electro-oxidation of Methanol – The Electrolyte – Non Catalytic Aspects – Methanol Cross over to DMFC – catalyst Optimization and Scale up – Engineering Aspects

UNIT-V

Proton Exchange Membrane Fuel Cells – Basic Scientific aspects- Challenges – Technology Development – Fuel Processing – Modeling Studies of PEMFC Performance – Applications – Challenges to High Temperature Operations – Technological and Economic Challenges

Text Book :

1. Fuel Cell : Principles and Applications – B.Viswanathan and M. Aulice Scibioh – Universities Press - 2006

Course Outcomes : Students will be able to

1) Classify Fuel Cells, and understand factors affecting efficiency of electrochemical energy
2) Construct, operate AFC & MCFC
3) Gain knowledge on manufacturing and materials, environmental impacts and applications of PAFC & SOFC
4) Gain knowledge on electrode- oxidation of methanol and crossover to DMF and Engineering Aspects
5) Gain knowledge on Technological and Economical Challenges on PEMFC

CHPE 55 POLYMER SCIENCE AND ENGINEERING

Instruction: 3 hr/week Credits: 3 Assessment : 40 + 60

UNIT - I:

Classification of Polymers, Functionality, Mechanisms of Polymerization, Chair Polymerisation - Free radical, Ionic and cationic Polymerisation - Step polymerization methods. Stereoisomerism in Polymers, Chemicals and Geometrical structures in Polymers. Block and Graft Polymers. Molecular weight of Polymers - weight average, number average and viscosity average molecular weight. Principles and calculations for determination of the molecular weights - Osmometry, Ebulliometry, Light scattering, ultracentrifugation, End group Analysis and viscosity methods.

UNIT II:

Thermodynamics of Solubility of polymers. Transition in polymers. Crystallinity in Polymers. Polymer Degradation method.

Kinetics of Polymerization Reactions – Free radical, Ionic Polymerization and step polymerization reactions. Derivation of rate equations and related numerical problems.

UNIT-III:

Polymerization Methods - Bulk, solution, suspension and emulsion polymerization. Comparison of Polymerization methods. Fabrication methods - Compounding Injection molding, Extrusion blow, blow extrusion, calendaring, Rotational molding, Thermoforming and vacuum forming.

Polymer processing and Rheology: Non-Newtonian flow, Viscosity of Polymer solutions and suspensions, Constitutive, equations; Capillary Rheometer, Couette Rheometer, Cone and Plate Rheometer, Rheometric characterization of polymer solution and melts.

UNIT-IV**:**

Brief description of individual polymers. Reaction equations, brief process description with a schematic flow sheet, physical properties and uses of the following polymers.

Individual Polymers**:** Thermosets: Phenol Formaldehyde, Urea formaldehyde, Polyester and epoxy resins, Polyrethane. Thermo plastics: Polyethylene, Polypropylene, PVC, Polystyrene, and Co-polymers, PMMA, Polycarbonates.

UNIT-V:

Applications of Polymers: Membrane Separations: Membrane Applications for Polymeric materials, mechanisms of transport and membrane preparation: Biomedical Applications: Artificial organs, Controlled drug delivery, hemodialysis and hemo filtration; Electronics: Electrically conductive polymers, electronic shielding, encapsulation, photonic polymers.

Reference Books:

1. Polymer Science, V.R.Gowariker, M.V.Viswanthan, Jaidev Sridhar, Wiley eastern Ltd, 1988.
2. Plastics engineering – R.J.Crawford, Butterworth Heinemann
3. Rubber and Plastic Technology – R.Chandra and S.Mishra, CBS Publishers
4. Outlines of Polymer Technology: Manufacture of Polymers by R.N.Sinha, Prentice Hall India.
5. J R Fried – Polymer Science and Technology, Prentice Hall of India Pvt., New Delhi, Eastern Economy Edition, 2000.

CHPE 56 BIOPROCESS ENGINEERING

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives

1. To learn the principles of bioprocessing for traditional chemical engineering in the design and development of processes involving biocatalyst.

2. To study engineering principles in the development of products based on living cells or subcomponents of such cells.

3. To learn and develop quantitative models and approaches related to bioprocesses
4. To learn mechanisitic models for enzyme catalyzed reactions for large scale production of
bioproducts

Unit I : Introduction:

Biotechnology and bioprocessing. An overview of biological basics. Basics of enzyme and microbial kinetics. Operating considerations for bioreactors: cultivation method, modifying batch and continuous reactors, immobilized cell systems, solid state fermentations.

Unit II : Advance Enzyme Kinetics

Models for complex enzyme kinetics, modeling of effect of pH and temperature, models for insoluble substrate, models for immobilized enzyme systems, diffusion limitations in immobilized enzyme system, electrostatic and steric effects.

Unit III : Bioreactors

Selection, scale-up, operation and control of bioreactors: Scale-up and its difficulties, bioreactor instrumentation and control, sterilization of process fluids.Modifications of batch and continuous reactors, chemostat with recycle, multistage chemostat, fed-batch operation, perfusion system, active and passive immobilization of cells, diffusional limitations in the immobilized system, solid state fomenters.

Unit IV : Homogeneous and heterogeneous reactions in bioprocesses

Reaction thermodynamics, growth kinetics with Plasmid instability, The Thiele Modulus and effectiveness factor, diffusion and reaction in waste treatment lagoon. Reactors and choice of reactors.

Unit V : Recovery and purification of products:

Strategies to recover and purify products, separation of insoluble products, cell disruption, separation of soluble products.

References

1. Bailey J.E. and Ollis D.F., "Biochemical Engineering Fundamentals", McGraw-Hill
2. Doran P.M., "Bioprocess Engineering Principles", Academic Press
3. Shuler M.L., Kargi F., "Bioprocess Engineering", Prentice -Hall

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

1. Understand the different cells and their use in biochemical processes.
2. Understand the role of enzymes in kinetic analysis of biochemical reaction.
3. Analyze bioreactors, upstream and downstream processes in production of bio-products
4. Demonstrate the fermentation process and its products for the latest industrial revolution

CHMP 01 MINI PROJECT

Laboratory Work 4 hr/week Credits : 2

CHPD 01 & CHPD 02 DISSERTATION Phase – I and Phase – II

Phase I Lab work: 20 hr / week Credits : 10 and

Phases II 32 hr/week Credits : 16

Objectives:

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

- Ability to synthesize knowledge and skills previously gained and applied to an in-depth study and execution of new technical problem.
- Capable to select from different methodologies, methods and forms of analysis to produce a suitable research design, and justify their design.
- Ability to present the findings of their technical solution in a written report.
- Presenting the work in International/ National conference or reputed journals.

Syllabus Contents:

The dissertation / project topic should be selected / chosen to ensure the satisfaction of the urgent need to establish a direct link between education, national development and productivity and thus reduce the gap between the world of work and the world of study. The dissertation should have the following

- Relevance to social needs of society
- Relevance to value addition to existing facilities in the institute
- Relevance to industry need
- Problems of national importance

- Research and development in various domain

The student should complete the following:

- Literature survey Problem Definition
- Motivation for study and Objectives
- Preliminary design / feasibility / modular approaches
- Implementation and Verification
- Report and presentation

The dissertation stage II is based on a report prepared by the students on dissertation allotted to them.

It may be based on:

- Experimental verification / Proof of concept.
- Design, fabrication, testing of Communication System.
- The viva-voce examination will be based on the above report and work. Guidelines for Dissertation Phase – I and II
- As per the AICTE directives, the dissertation is a yearlong activity, to be carried out and evaluated in two phases i.e. Phase – I: July to December and Phase – II: January to June.
- The dissertation may be carried out preferably in-house i.e. department's laboratories and centers OR in industry allotted through department's T & P coordinator.
- After multiple interactions with guide and based on comprehensive literature survey, the student shall identify the domain and define dissertation objectives. The referred literature should preferably include Springer/Science Direct. In case of Industry sponsored projects, the relevant application notes, while papers, product catalogues should be referred and reported.
- Student is expected to detail out specifications, methodology, resources required, critical issues involved in design and implementation and phase wise work distribution, and submit the proposal within a month from the date of registration.
- Phase – I deliverables: A document report comprising of summary of literature survey, detailed objectives, project specifications, paper and/or computer aided design, proof of concept/functionality, part results, A record of continuous progress.
- Phase – I evaluation: A committee comprising of guides of respective specialization shall assess the progress/performance of the student based on report, presentation and Q & A. In case of unsatisfactory performance, committee may recommend repeating the phase-I work.
- During phase – II, student is expected to exert on design, development and testing of the proposed work as per the schedule. Accomplished results/contributions/innovations should be published in terms of research papers in reputed journals and reviewed focused conferences OR IP/Patents.

- Phase – II deliverables: A dissertation report as per the specified format, developed system in the form of hardware and/or software, A record of continuous progress.
- Phase – II evaluation: Guide along with appointed external examiner shall assess the progress/performance of the student based on report, presentation and Q & A. In case of unsatisfactory performance, committee may recommend for extension or repeating the work

OPEN ELECTIVES

PGOP 11 BUSINESS ANALYTICS

Teaching scheme

Objectives :

1. Understand the role of business analytics within an organization.
2. Analyze data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization.
3. To gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making.
4. To become familiar with processes needed to develop, report, and analyze business data.
5. Use decision-making tools/Operations research techniques.
6. Mange business process using analytical and management tools.
7. Analyze and solve problems from different industries such as manufacturing, service, retail, software, banking and finance, sports, pharmaceutical, aerospace etc.

Unit I :

Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics.

Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.

Unit II :

Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression.

Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.

Unit III :

Organization Structures of Business Analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring. Data Quality, Measuring Contribution of Business Analytics, Managing Changes

Descriptive Analytics, Predictive Analysis, Predictive Modeling, Predictive Analytics Analysis, Data Mining , Data Mining Methodologies, Prescriptive Analysis and its step in the business analytics process, Prescriptive Modeling, Nonlinear Optimization

Unit IV :

Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model.

Unit V : Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making

Unit V : Recent Trends in : Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism

References :

1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.
2. Business Analytics by James Evans, persons Education.

Outcomes :

1. Students will demonstrate knowledge of data analytics.
2. Students will demonstrate the ability of think critically in making decisions based on data and deep analytics.
3. Students will demonstrate the ability to use technical skills in predicative and prescriptive modeling to support business decision-making.

4. Students will demonstrate the ability to translate data into clear, actionable insights.

PGOP 12 INDUSTRIAL SAFETY

Unit-I: Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

Unit-II: Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

Unit-III: Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

Unit-IV: Fault tracing: Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

Unit-V: Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

Reference:

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

PGOP 13 OPERATIONS RESEARCH

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

1. Students should able to apply the dynamic programming to solve problems of discreet and continuous variables.
2. Students should able to apply the concept of non-linear programming
3. Students should able to carry out sensitivity analysis
4. Student should able to model the real world problem and simulate it.

Unit 1:

Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models

Unit 2

Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming

Unit 3:

Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT

Unit 4

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

Unit 5

Competitive Models, Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation

References:

1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009
5. Pannerselvam, Operations Research: Prentice Hall of India 2010
6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010

PGOP 14 COST MANAGEMENT IN ENGINEERING PROJECTS

Introduction and Overview of the Strategic Cost Management Process

Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution : conception to commissioning. Project execution as conglomeration of technical and non technical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team : Role of each member. Importance Project site : Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process

Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

References:

1. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
2. Charles T. Horngren and George Foster, Advanced Management Accounting
3. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
4. Ashish K. Bhattacharya, Principles & Practices of CostAccounting A. H. Wheeler publisher
5. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

PGOP15 COMPOSITE MATERIALS

UNIT–I: INTRODUCTION: Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

UNIT – II: REINFORCEMENTS: Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

UNIT – III: Manufacturing of Metal Matrix Composites: Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.

UNIT–IV: Manufacturing of Polymer Matrix Composites: Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.

UNIT – V: Strength: Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

TEXT BOOKS:

1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.

References:

1. Hand Book of Composite Materials-ed-Lubin.
2. Composite Materials – K.K.Chawla.
3. Composite Materials Science and Applications – Deborah D.L. Chung.
4. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi.

PGOP16 WASTE TO ENERGY

Unit-I: Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors **Unit-II:** Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

Unit-III: Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

Unit-IV: Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

Unit-V: Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

References:

1. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.

2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.

PGPA 11 ENGLISH FOR RESEARCH PAPER WRITING

Course objectives:
Students will be able to:

1. Understand that how to improve your writing skills and level of readability
2. Learn about what to write in each section
3. Understand the skills needed when writing a Title
4. Ensure the good quality of paper at very first-time submission

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising,

Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction

Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check key

Skills needed when writing a Title, key skills needed when writing an Abstract, key skills needed when writing an Introduction, skills needed when writing a Review of the Literature,

5 Skills needed when writing the Methods, skills needed when writing the Results, skills needed when writing the Discussion, skills needed when writing the Conclusions useful phrases, how to ensure paper is as good as it could possibly be the first- time

Suggested Studies:

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book .
4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

PGPA 12 DISASTER MANAGEMENT

Course Objectives:-Students will be able to:

1. learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.
2. critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
3. develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
4. critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in

Introduction

Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude.

Repercussions Of Disasters And Hazards: Economic Damage, Loss Of Human And Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts Tsunami; Post-Disaster Diseases And Epidemics

Disaster Preparedness And Management Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness.

Risk Assessment Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global And National Disaster Risk Situation. Techniques Of Risk Assessment, Global Co-Operation In Risk Assessment And Warning, People's Participation In Risk Assessment. Strategies for Survival.

Disaster Mitigation Meaning, Concept And Strategies Of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs Of Disaster Mitigation In India.

SUGGESTED READINGS:

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal book Company.

2. Sahni, Pardeep Et.Al. (Eds.)," Disaster Mitigation Experiences And Reflections", Prentice Hall Of India, New Delhi.

3. Goel S. L. , Disaster Administration And Management Text And Case Studies" ,Deep &Deep Publication Pvt. Ltd., New Delhi.

PGPA 13 SANSKRIT FOR TECHNICAL KNOWLEDGE

Course Objectives

1. To get a working knowledge in illustrious Sanskrit, the scientific language in the world
2. Learning of Sanskrit to improve brain functioning
3. Learning of Sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power
4. The engineering scholars equipped with Sanskrit will be able to explore the huge knowledge from ancient literature

Syllabus

Alphabets in Sanskrit, Past/Present/Future Tense, Simple Sentences

Order, Introduction of roots, Technical information about Sanskrit Literature

Technical concepts of Engineering-Electrical, Mechanical Architecture, Mathematics

Suggested reading

1. "Abhyaspustakam" – Dr.Vishwas, Samskrita-Bharti Publication, New Delhi

2. "Teach Yourself Sanskrit" Prathama Deeksha-Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication

3. "India's Glorious Scientific Tradition" Suresh Soni, Ocean books (P) Ltd., New Delhi.

Course Output

Students will be able to

1. Understanding basic Sanskrit language
2. Ancient Sanskrit literature about science & technology can be understood
3. Being a logical language will help to develop logic in students

PGPA 14 VALUE EDUCATION

Course Objectives

Students will be able to

1**.**Understand value of education and self- development

2. Imbibe good values in students

3. Let the should know about the importance of character

Syllabus

Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of Moral and non- moral valuation., Standards and principles humanism. Value judgments.

Importance of cultivation of values, Sense of Duty, Devotion, Reliance, .Confidence, Concentration,

Truthfulness, Cleanliness, Honesty ,Humanity, Power of faith, National Unity, Patriotism, Love for nature , Discipline

Personality and Behaviour Development - Soul and Scientific attitude, .Positive Thinking. Integrity and discipline Punctuality, Love and Kindness

Avoid fault Thinking Free from anger, Dignity of labour Universal brotherhood and religious tolerance True friendship Happiness Vs suffering, love for truth Aware of self-destructive habits, Doing best for saving nature

Character and Competence –Holy books vs Blind faith Self-management and Good health

Science of reincarnation. Equality ,Non violence ,Humility, Role of Women. All religions and same message Mind your Mind ,Self-control Honesty, Studying effectively

Suggested reading

1 Chakroborty , S.K. "Values and Ethics for organizations Theory and practice", Oxford University Press ,New Delhi

Course outcomes ; Students will be able to

1.Knowledge of self-development 2.Learn the importance of Human values

3.Developing the overall personality

PGPA 21 CONSTITUTION OF INDIA

Course Objectives: Students will be able to:

1. Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
2. To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism
3. To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution

History of Making of the Indian Constitution - : History - Drafting Committee, (Composition & Working

Philosophy of the Indian Constitution - Preamble - Salient Features

Contours of Constitutional Rights & Duties - Fundamental Rights - Right to Equality - Right to Freedom - Right against Exploitation- ight to Freedom of Religion -Cultural and Educational Rights Right to Constitutiona Remedies Directive Principles of State Policy Fundamental Duties

Organs of Governance Parliament Composition Qualifications and Disqualifications Powers and Functions Executive President Governor Council of Ministers Judiciary, Appointment and Transfer of Judges, Qualifications Powers & Functions

Local Administration – Districts, Administration Head Role & Importance,

Municipalities – Introduction , Mayor and Role of Elected Representatives, CEO of Municipal Corporation,

Panchayat Raj, Introduction, PRI, Zilla Parishad,

Elected Officials and their roles, CEO Zillaparishad, Position and Role

Block Level – Organizational Heirarchy (Different Departments)

Village Level – Role of Elected and appointed Officials

Importance of Grass Root Democracy

Election Commission Election Commission: Role and Functioning Chief Election Commissioner and Election Commissioners

Suggested reading

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

Course Outcomes:

Students will be able to:

1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.

2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.

3. Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.

4. Discuss the passage of the Hindu Code Bill of 1956.

PGPA 22 PEDAGOGY STUDIES

Course Objectives: Students will be able to:

1. Review existing evidence on the review topic to inform programme design and policy making undertaken by the DfID, other agencies and researchers.
2. Identify critical evidence gaps to guide the development

Introduction and Methodology: Aims and rationale, Policy background, Conceptual framework and terminology Theories of learning, Curriculum, Teacher education. Conceptual framework, Research questions**.** Overview of methodology and Searching

Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries Curriculum, Teacher education.

Evidence on the effectiveness of pedagogical practices Methodology for the in depth stage: quality assessment of included studies How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? Theory of change. Strength and nature of the body of evidence for effective pedagogical practices Pedagogic theory and pedagogical approaches Teachers' attitudes and beliefs and Pedagogic strategies.

Professional development: alignment with classroom practices and follow- up support Peer support Support from the head teacher and the community Curriculum and assessment Barriers to learning: limited resources and large class sizes

Research gaps and future directions Research design Contexts Pedagogy Teacher education Curriculum and assessment Dissemination and research impact

Suggested reading

1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2): 245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361-379.
3. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272–282.
5. Alexander RJ (2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.
6. Chavan M (2003) Read India: A mass scale, rapid, 'learning to read' campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf.

Course Outcomes:

Students will be able to understand:

1.What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?

2. What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?

3. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

PGPA 23 STRESS MANAGEMENT BY YOGA

Course Objectives

1. To achieve overall health of body and mind
2. To overcome stress

Syllabus

Definitions of Eight parts of yog. (Ashtanga)

Yam and Niyam Do`s and Don't's in life. i) Ahinsa, satya, astheya, bramhacharya and aparigraha ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan

Asan and Pranayam i) Various yog poses and their benefits for mind & body ii)Regularization of breathing techniques and its effects-Types of pranayam

Suggested reading

1. 'Yogic Asanas for Group Tarining-Part-I" : Janardan Swami Yogabhyasi Mandal, Nagpur

2. "Rajayoga or conquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata

Course Outcomes: Students will be able to:

1. Develop healthy mind in a healthy body thus improving social health also
2. Improve efficiency

PGPA 24 PERSONALITY DEVELOPMENT THROUGH LIFE ENHANCEMENT SKILLS

Course Objectives

1. To learn to achieve the highest goal happily
2. To become a person with stable mind, pleasing personality and determination
3. To awaken wisdom in students

Syllabus

Neetisatakam-Holistic development of personality Verses- 19,20,21,22 (wisdom) Verses- 29,31,32 (pride & heroism) Verses- 26,28,63,65 (virtue) Verses- 52,53,59 (dont's)m Verses- 71,73,75,78 (do's)

Approach to day to day work and duties.- Shrimad Bhagwad Geeta: Chapter 2-Verses 41,47,48 Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,1723, 35, Chapter 18-Verses 45, 46, 48.

Statements of basic knowledge Shrimad Bhagwad Geeta : Chapter2-Verses 56, 62, 68 Chapter 12 -Verses 13, 14, 15, 16,17, 18 Personality of Role model. Shrimad Bhagwad Geeta Chapter2-Verses 17,Chapter 3-Verses 36,37,42 Chapter 4-Verses 18, 38,39 Chapter18 – Verses 37,38,63

Suggested reading

1. "Srimad Bhagavad Gita" by Swami Swarupananda Advaita Ashram
(Publication Department), Kolkata

2. Bhartrihari's Three Satakam (Niti-sringar-vairagya) by P.Gopinath, Rashtriya Samskrit Sansthanam, New Delhi.

Course Outcomes

Students will be able to

1. Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life

2. The person who has studied Geeta will lead the nation and mankind to peace and prosperity
3. Study of Neetishatakam will help in developing versatile personality of students.

****

CHPC 01 **MATHEMATICAL AND STATISTICAL METHODS IN CHEMICAL ENGINEERING**

Instruction: hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives:

1. To give students an insight in various Chemical Engineering Processes using advanced Numerical and Statistical Methods.
2. To provide adequate background of Mathematics to deal with Chemical Engineering Problems
3. To understand research papers on relevant topics involving advanced Mathematics.
4. To study correlation and regression of multivariate data.
5. To evaluate Experimental design methods and statistical quality control measures.

Unit-1: Equation Forms in Process Modeling, Introduction and Motivation, Linear and Nonlinear Algebraic Equation, Optimization based Formulations, ODE-IVPs and Differential Algebraic Equations, ODE-BVPs and PDEs, Abstract model forms. Fundamentals of Vector Spaces, Generalized concepts of vector space, sub-space, linear dependence, Concept of basis, dimension, norms defined on general vector spaces, Examples of norms defined on different vector spaces, Cauchy sequence and convergence, introduction to concept of completeness and Banach spaces, Inner product in a general vector space, Inner-product spaces and their examples, Cauchy-Schwartz inequality and orthogonal sets, Gram-Schmidt process and generation of orthogonal basis, well known orthogonal basis Matrix norms.

Unit-2: Problem Discretization Using Approximation Theory, Transformations and unified view of problems through the concept of transformations, classification of problems in numerical analysis, Problem discretization using approximation theory, Weierstrass theorem and polynomial approximations, Taylor series approximation, Finite difference method for solving ODE-BVPs with examples, Finite difference method for solving PDEs with examples, Newton's Method for solving nonlinear algebraic equation as an application of multivariable Taylor series, Introduction to polynomial interpolation, Polynomial and function interpolations, Orthogonal Collocations method for solving ODE-BVPs, Orthogonal Collocations method for solving ODE-BVPs with examples, Orthogonal Collocations method for solving PDEs with examples, Necessary and sufficient conditions for unconstrained multivariate optimization, Least square approximations, Formulation and derivation of weighted linear least square estimation, Geomtraic interpretation of least squares. Projections and least square solution, Function approximations and normal equation in any inner product space, Model Parameter Estimation using linear least squares method, Gauss Newton Method, Method of least squares for solving ODE-BVP, Gelarkin's method and generic equation forms arising in problem discretization, Errors in Discretization, Generic equation forms in transformed problems.

Unit-3: Solving Linear Algebraic Equations, System of linear algebraic equations, conditions for existence of solution - geometric interpretations (row picture and column picture), review of concepts of rank and fundamental theorem of linear algebra, Classification of solution approaches as direct and iterative, review of Gaussian elimination, Introduction to methods for solving sparse linear systems: Thomas algorithm for tri-diagonal and block tri-diagonal matrices, Block-diagonal, triangular and block-triangular systems, solution by matrix decomposition, Iterative methods: Derivation of Jacobi, Gauss-Siedel and successive over-relaxation methods, Convergence of iterative solution schemes: analysis of asymptotic behavior of linear difference equations using Eigen values, Convergence of iterative solution schemes with examples, Convergence of iterative solution schemes, Optimization based solution of linear algebraic equations, Matrix conditioning, examples of well conditioned and ill-conditioned linear systems.

Unit-4: Solving Nonlinear Algebraic Equations, Method of successive substitutions derivative free iterative solution approaches. Secant method, regula falsi method and Wegsteine iterations, Modified Newton's method and qausi-Newton method with Broyden's update, Optimization based formulations and Leverberg-Marquardt method, Contraction mapping principle and introduction to convergence analysis.

Unit-5: Solving Ordinary Differential Equations, Initial Value Problems (ODE-IVPs), Introduction, Existence of Solutions (optional topic),Analytical Solutions of Linear ODE-IVPs, Analytical Solutions of Linear ODE-IVPs (contd.), Basic concepts in numerical solutions of ODE-IVP: step size and marching, concept of implicit and explicit methods, Taylor series based and Runge-Kutta methods: derivation and examples, Runge-Kutta methods, Multi-step (predictor-corrector) approaches: derivations and examples, Multi-step (predictor-corrector) approaches: derivations and examples, Stability of ODE-IVP solvers, choice of step size and stability envelopes, Stability of ODE-IVP solvers (contd.), stiffness and variable step size implementation, Introduction to solution methods for differential algebraic equations (DAEs), Single shooting method for solving ODE-BVPs.

References

1. Gilbert Strang, Linear Algebra and Its Applications (4th Ed.), Wellesley Cambridge Press (2009).
2. Philips, G. M.,Taylor, P. J. ; Theory and Applications of Numerical Analysis (2nd Ed.), Academic
Press, 1996.
3. Gourdin, A. and M Boumhrat; Applied Numerical Methods. Prentice Hall India, New Delhi, (2000).
4. Gupta, S. K.; Numerical Methods for Engineers.Wiley Eastern, New Delhi, 1995.
5. Linz, P.; Theoretical Numerical Analysis, Dover, New York, (1979).
6. Gilbert Strang , Introduction to Applied Mathematics, Wellesley Cambridge Press (2009)

Outcomes:

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

1. Students should be able to solve system of linear algebraic equations
2. Students should be able to do numerical integrations of functions.
3. Students should be able to fit relationship between two data sets using linear, non-linear regression.
4. Students should be able to calculate maxima/minima and functions
5. Solving Ordinary Differential Equations, solution methods for differential algebraic equations (DAEs).

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**1**											
CO2		**2**			**2**							
CO3			**3**	**1**								
CO4			**1**									
CO5					**3**	**2**						

6.

CHPC 02 ADVANCES IN TRANSPORT PHENOMENA

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Course Educational Objectives

1. Study the fluid dynamics, heat transfer and mass transfer together at the introductory level.
2. Carry out macroscopic mass, momentum and energy balance to solve engineering problems related to fluid and heat flow laminar flow.
3. Give an idea about simple flow problems involving Non-Newtonian models and turbulent flows.
4. Perform dimensional analysis of equation of motion and energy, time smoothed operations.
5. Analyze flow past solid surface, through packed bed and in fluidized beds and they can able to Focus on diffusivity and mechanism of mass transport, diffusion through a stagnant gas film and falling film

Unit-1: Equations of Change for Isothermal Systems: Equation of Continuity, Equation of Motion,Equation of Mechanical Energy, Equations of Change in terms of the Substantial Derivative, Use of the Equations to solve Flow Problems, Dimensional Analysis of the Equations of Change.Velocity Distributions with more than one Independent Variable: Time Dependent Flow of Newtonian Fluids. Velocity Distributions in Turbulent Flow -Comparisons of Laminar and Turbulent Flows, Time Smoothed Equations of Change for Incompressible Fluids, Time Smoothed Velocity Profile near a wall, Empirical Expressions for the Turbulent Momentum Flux, Turbulent Flow in Ducts, Turbulent Flow in Jets.

Unit-2: Macroscopic Balances for Isothermal Systems: The Macroscopic Mass Balance, The Macroscopic Momentum Balance, The Macroscopic Mechanical Energy Balance, Estimation of the Viscous loss, Use of the Macroscopic Balances for Steady-State Problems, Derivation of the Macroscopic Mechanical Energy Balance.

Equations of Change for Non-Isothermal Systems: The Energy Equation, Special forms of the Energy Equation, The Boussine sq Equation of Motion for Forced and Free Convection, Use of the Equations of change to Solve Steady-State Problems, Dimensional Analysis of the Equations of Change for Non-Isothermal Systems.

Unit-3: Temperature Distributions in Solids and in Laminar Flow: Heat Conduction with an Electrical Heat Source, Heat Conduction with a Viscous Heat Source. Temperature Distributions with more than One Independent Variable - Unsteady Heat Conduction in Solids, Steady Heat Conduction in Laminar, Incompressible Flow. Temperature Distributions in Turbulent Flow - Time-Smoothed Equations of Change for Incompressible Non-Isothermal Flow, Time-Smoothed Temperature Profile near a Wall, Empirical Expressions for the Turbulent Heat Flux Temperature Distribution for Turbulent Flow in Tubes.

Unit-4: Macroscopic Balances For Non-Isothermal Systems: Macroscopic Energy Balance, Macroscopic Mechanical Energy Balance, Use Of The Macroscopic Balances To Solve Steady State Problems With Flat Velocity Profiles, Concentration Distributions in Solids and in Laminar Flow: Shell Mass Balances Boundary Conditions, Diffusion through a Stagnant Gas Film, Diffusion with a Heterogeneous Chemical Reaction. Concentration Distributions with more than One Independent Variable: Time-Dependent Diffusion, Steady-State Transport in Binary Boundary Layers, Concentration Distributions in Turbulent Flow - Concentration Fluctuations and the Time-Smoothed Concentration, Time-Smoothing of the Equation of Continuity of A, Semi-Empirical Expressions for the Turbulent Mass Flux, Enhancement of Mass Transfer by a First-Order Reaction in Turbulent Flow.

Unit -5: Interphase Transport in Multi-Component Systems: Definition of Transfer Coefficients in One Phase, Analytical Expressions for Mass Transfer Coefficients, Correlation of Binary Transfer Coefficients in One Phase, Definition of Transfer Coefficients in Two Phases, Mass Transfer and Chemical Reactions. Macroscopic Balances For Multi-Component Systems: Macroscopic Mass Balances, Macroscopic Momentum, Use of the Macroscopic Balances to solve Steady-State Problems.

References

1) Thomson W. J., Transport Phenomena, Pearson education, Asia, 2001.

2) Geankopolis C. J., Transport Processes and Unit Operations, 4th Ed., Prentice Hall (India) Pvt.
Ltd., New Delhi. 2004.

3) Bird R. B., Stewart W. E. and Light Foot E. N., Transport Phenomena, Revised 2nd Edition, John Wiley & Sons, 2007.

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

1. Understand the mechanism of momentum, heat and mass transport for steady and unsteady flow.

2. Perform momentum, energy and mass balances for a given system at macroscopic and microscopic scale.
3. Solve the governing equations to obtain velocity, temperature and concentration profiles.
4. Model the momentum, heat and mass transport under turbulent conditions.
5. Develop analogies among momentum, energy and mass transport.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1		1	2								
CO2	1	2			2							
CO3		1	2			1						
CO4		1		2								
CO5			2	1	1							

CHPE14 PROCESS PLANT SIMULATION

Instruction : 3 hr/week Credits : 3 Evaluation : 40 + 60

Course Objectives ; Students will have to learn the following

1) Learn the Chemical Systems Modeling and Artificial Neural Networks
2) Understand how to design Steady State Extraction and Heat Conduction through Hollow Cylindrical, Unsteady State Mass Balance for CSTR and Heat Transfer in a Tubular Gas Pre Heater
3) Understand how to design models from Fluid Flow and Reaction Engineering
4) Develop Errors of Measurement, Problems in Data Regression and Solving Equation Solving and Modular Approach
5) Develop Algorithms based on Signal Flow Graph, Tearing Algorithms and Physical and Thermodynamic Properties of Convergence Promotion

UNIT I

Modeling Aspects: Deterministic vs. Stochastic Processes, Physical modeling, Mathematical modeling, Chemical Systems Modeling, Cybernetics, Controlled System, Principles of Similarity

Classification of Mathematical Modeling: Independent and Dependent variables, Classification based on variation of independent variables, Classification based on state of the process, Classification based on type of the process, Boundary Conditions, The black Box Principle, Artificial Neural Networks

UNIT II - Process Modeling - I

Models from mass transfer: steady state single stage solvent extraction, steady state two stage solvent extraction, steady state two stage cross current solvent extraction, , steady state N- stage solvent counter current extraction, unsteady state single stage solvent extraction, unsteady state mass balance in a stirred tank and in a mixing tank.

Models from Heat Transfer : steady state heat conduction through a hollow cylindrical pipe, unsteady state steam heating of a liquid, unsteady state heat loss through a measuring tank, heat transfer through extended surfaces, unsteady state heat transfer in a tubular gas pre heater

UNIT III – Process Modeling -II

Models from fluid flow: flow through a packed bed column, flow of a film on the outside of a circular tube, annular flow with inner cylinder moving axially, flow between coaxial cylinders and concentric spheres

Models from Reaction Engineering : chemical reaction with diffusion in a tubular reactor, chemical reactor with heat transfer in a packed bed reactor, gas absorption accompanied by chemical reaction

UNIT IV

Error Propagation & Data Regression :Propagation of errors through addition, subtraction, multiplication and division, Errors of measurement, Precision errors, errors method

Data Regression : Theoretical properties, data regression methods, Problems in data regression

Process Simulation : Modular Approach, The equation solving approach

UNIT V

Decomposition of Networks : Tearing Algorithms, Algorithms based on signal flow graph and reduced digraph

Convergence Promotion: Newton's method, direct substitution method, Wegstein's method, dominant Eigen value method, quasi Newton method, Criterion for acceleration, Physical and Thermodynamic Properties

TEXTBOOKS:

1. Process Plant Simulation, B.V.Babu, Oxford University press, 2004

2. Process Modeling, Simulation and Control for Chemical Engineers, 2nd ed., W. L. Luyben, McGraw-Hill, New York, 1990

REFERENCE:

1. Introduction to Numerical Methods in Chemical Engineering, P. Ahuja, PHI , New Delhi, 2010

2. Process Modeling and Simulation, Amiya K. Jana, 2012.

Course Objectives : Students will be trained in

1) Modeling Aspects and Classification of Mathematical Modeling
2) How to Prepare Models from Mass Transfer and Models on Heat Transfer
3) How to Prepare Models from Fluid Flow and Models on Reaction Engineering
4) The analysis through Propagation of Errors, Error Methods, Data Regression Methods and Process Simulation
5) Decomposition of Networks and Convergence Promotion

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1		1	2								
CO2	1		2		1							
CO3		1	2	1								
CO4		1		2								
CO5			2		1							

CHPE 21 INDUSTRIAL POLLUTION CONTROL

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives

1. To understand the importance of industrial pollution and its abatement
2. To study the underlying principles of industrial pollution control
3. To acquaint the students with case studies
4. Student should be able to design complete treatment system

Unit I : Industries & Environment

Industrial scenario in India - Industrial activity and Environment - Uses of Water by industry - Sources and types of industrial wastewater - Industrial wastewater and environmental impacts - Regulatory requirements for treatment of industrial wastewater - Industrial waste survey - Industrial wastewater generation rates, characterization and variables - Population equivalent - Toxicity of industrial effluents and Bioassay tests.

Unit II : Industrial Noise pollution

Sources of noise pollution, characterization of noise pollution prevention& control of noise pollution, Factories Act 1948 for regulatory aspects of noise pollution.

Unit III : Air Pollutant Abatement

Air pollutants scales of concentration, lapse rate and stability, plume behavior, dispersion of air pollutants, atmospheric dispersion equation and its solutions, Gaussian plume models.Air pollution control methods, Source correction methods, Design concepts for pollution abatement systems for particulates and gases. Such as gravity chambers, cyclone separators, filters, electrostatic precipitators, condensation, adsorption and absorption, thermal oxidation and biological processes.

Unit IV : Waste water treatment processes

Design concepts for primary treatment, grid chambers and primary sedimentation basins, selection of treatment process flow diagram, elements of conceptual process design, design of thickner, biological treatment Bacterial population dynamics, kinetics of biological growth and its applications to biological treatment, process design relationships and analysis, determination of kinetic coefficients, activated sludge process. Design, trickling filter design considerations, advanced treatment processes, Study of environment pollution from process industries and their abatement: Fertilizer, paper and pulp, inorganic acids, petroleum and petrochemicals, recovery of materials from process effluents.

Unit V : Solid waste and Hazardous waste management

xSources and classification, properties, public helth aspects, Sanitary land fill design, Hazardous waste classification and rules, management strategies, Nuclear waste disposal Treatment methods – component separation, chemical and biological treatment, incineration, solidification and stabilization, and disposal methods, Latest Trends in solid waste management.

References

1. Rao C.S., “Environmental Pollution Control Engineering”, 2nd edition
2. Mahajan S.P., “Pollution Control in Process Industries”.
3. Nemerow N.L., “Liquid waste of industry- theories, Practices and Treatment”, Addison Wesley, New York, 1971
4. Weber W.J., “Physico-Chemical Processes for water quality control”, Wiley Interscience New York, 1969
5. Strauss W., “Industrial Gas Cleaning”, Pergamon, London, 1975
6. Stern A.C., “Air pollution”, Volumes I to VI, academic Press, New York, 1968
7. Peterson and Gross .E Jr., “Hand Book of Noise Measurement”, 7th Edn, 2003.

8. Antony Milne, “Noise Pollution: Impact and Counter Measures”, David & Charles PLC, 2009.

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

1. Recognize the causes and effects of environmental pollution
2. Analyze the mechanism of proliferation of pollution
3. Develop methods for pollution abatement and waste minimization
4. Design treatment methods for gas, liquid and solid wastes
5. component separation, chemical and biological treatment, incineration, solidification and stabilization.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1		1	2								
CO2	1	2			1							
CO3		1				1						
CO4	1	1	2									
CO5			2		1							

PGMC 41 **RESEARCH METHODOLOGY AND IPR**

Instruction , hours/week : 2 Credits : 2 Assessment : 40 + 60

Unit 1: Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

Unit 2: Effective literature studies approaches, analysis **,** Plagiarism, Research ethics,

Unit 3: Effective technical writing, how to write report, Paper , Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

Unit 4: Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

Unit 5: Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

Unit 6: New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

References :

1) Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"

2) Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"

3) Ranjit Kumar, 2nd Edition , "Research Methodology: A Step by Step Guide for beginners"

4) Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.

5) Mayall , "Industrial Design", McGraw Hill, 1992.

6) Niebel , "Product Design", McGraw Hill, 1974.

7) Asimov , "Introduction to Design", Prentice Hall, 1962

8) Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Property in New Technological Age", 2016.

9) T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008

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

Understand research problem formulation. - Analyze research related information - Follow research ethics - Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.

Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.

Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

PGPA 11 ENGLISH FOR RESEARCH PAPER WRITING

Course objectives:

Students will be able to:

1. Understand that how to improve your writing skills and level of readability
2. Learn about what to write in each section
3. Understand the skills needed when writing a Title
4. Ensure the good quality of paper at very first-time submission

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising,

Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction

Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check key

Skills needed when writing a Title, key skills needed when writing an Abstract, key skills needed when writing an Introduction, skills needed when writing a Review of the Literature,

5 Skills needed when writing the Methods, skills needed when writing the Results, skills needed when writing the Discussion, skills needed when writing the Conclusions
useful phrases, how to ensure paper is as good as it could possibly be the first- time

Suggested Studies:

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book .
4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

PGPA 12 DISASTER MANAGEMENT

Course Objectives:-Students will be able to:

1. learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.
2. critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
3. develop an understanding of standards of humanitarian response and practical relevance in

specific types of disasters and conflict situations.

4. critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in

Introduction

Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude.

Repercussions Of Disasters And Hazards: Economic Damage, Loss Of Human And Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts Tsunami; Post-Disaster Diseases And Epidemics

Disaster Preparedness And Management Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness.

Risk Assessment Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global And National Disaster Risk Situation. Techniques Of Risk Assessment, Global Co-Operation In Risk Assessment And Warning, People's Participation In Risk Assessment. Strategies for Survival.

Disaster Mitigation Meaning, Concept And Strategies Of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs Of Disaster Mitigation In India.

SUGGESTED READINGS:

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal book Company.

2. Sahni, Pardeep Et.Al. (Eds.)," Disaster Mitigation Experiences And Reflections", Prentice Hall Of India, New Delhi.

3. Goel S. L. , Disaster Administration And Management Text And Case Studies" ,Deep &Deep Publication Pvt. Ltd., New Delhi.

CHPP 01 COMPUTATIONAL TECHNIQUES LABORATORY

Instruction , hours/week : 4 Credits : 2 Assessment : 40 + 60

Objectives:

1. To learn Numerical methods for interpolation, extrapolation, graphical differentiation and integration, curve fitting….Process Modeling and Simulation of Chemical operations and processes.
2. To implement the above on MAT Lab

List of experiments:

1.Euler Method

2. Runge Kutta 4th Order Method

3. Jacobi Iteration Method

4. Gauss-Siedel Iteration Method

5. Lagrange's Iteration Method

6. Newton Forward Interpolation Method

7. Newton Backward Interpolation Method

8, Bisection Method

9. Newton Raphson Method

10. Regula Falsi Method

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

1. Use numerical methods for various manipulations and be capable of implementing them on a computing system

SEMESTER- II

CHPC 03 SEPARATION TECHNIQUES

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives:

1) Understand the classification of separation processes
2) To learn the fundamental concepts of rate governed processes
3) To impart the basic concepts of multistage separation processes
4) Understand the design of distillation column using different methods
5) Understand the energy requirements of different separation processes

UNIT I

Use and Characteristics of Separation Processes – Importance and variety of Separations – Characteristics of separation Processes- Inherent separation factors for equilibrium and rate Governed Processes

Simple equilibrium processes: Equilibrium calculations- Checking phase conditions for a mixture- Analysis of simple equilibrium separation-processes for binary and multi component systems - Computational and Graphical Approaches.

Unit II

Additional Factors Influencing Product Purities – Incomplete Mechanical Separation of Product Phases – Flow Configuration and Mixing Effects – Batch Operations – Methods of Regeneration – Mass and Heat Transfer Limitations – Stage Efficiencies

Multistage Separation Processes: Increasing product purity - Reducing consumption of separating agent - co-current, crosscurrent and countercurrent flow - Other separation processes - Fixed bed processes.

Unit-III:

Binary Multistage Separations - Distillation: Binary Systems - Equilibrium stages and McCabe-Thiele Diagram - design and other problems – Multistage batch distillation - Straight operating lines and curved operating lines.

UNIT IV

Patterns of Change: Binary and Multi component multistage separations

Group Methods - Linear stage-exit relationships and constant flow rates- non linear stage –Exit Relationships and varying flow rates.

Capacity of contacting devices: factors limiting capacity and factors influencing efficiency.

UNIT V

Energy Requirements of separations processes:

Thermodynamic efficiency - single stage and multistage separation processes - reduction of energy consumption**.**

Selection of Separation processes: Factors influencing the choice of separation Process - solvent extraction and Illustrative examples

TEXT BOOKS:

1. Separation Processes - C.Judson King,, McGraw – Hill, 1982

REFERENCE BOOKS

1. Separation Process Principles - J.D.Seader and E.J.Henley, , John Wiley, 1998.
2. Mass Transfer Operation - R.E. Treybal, , 3rd edition - McGraw – Hill 1980
3. Transport Processes and Unit Operations – Geankoplis C.J. 4th ed – PHI Pvt. Ltd

Course Outcomes: Student will be able to

1) Applies the concepts of diffusion mass transfer, mass transfer coefficients, convective mass transfer, inter-phase mass transfer, equipment for gas-liquid operations
2) Suggest and design equipment for various mass transfer operations
3) Study of the stage wise mass transfer operations, principles of various stage wise contact processes like distillation
4) Student will be able to select a separation process for a particular system.
5) Able to understand the energy requirements of separation processes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	1	1	1		1	1	1			
CO2	1				2							
CO3			2			1						
CO4		1										
CO5				1	1				2			

CHPC 04 **CHEMICAL REACTOR THEORY**

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Course Educational Objectives:

1) The emphasis of this course is on the fundamentals of chemical reaction kinetics and chemical reactor operation.
2) The overall goal of this course is to develop a critical approach toward understanding complex reaction systems and elucidating chemical reactor design.
3) Integrate concepts from science & engineering to constitute a basis for the design of chemical reactor, a key element in the design of chemical process.
4) Provide a foundation on Non-ideal reactors and RTD
5) Impart knowledge about heterogeneous catalytic reactors

UNIT I

Isothermal Reactor design: Design structure for isothermal reactors - Scale-up of liquid phase batch reactor data to the design of a CSTR - Tubular reactors - Pressure drop in Reactors - Reversible reactions - unsteady state operation of reactors -Simultaneous reaction and Separation.

UNIT-II

Analysis of Non ideal Reactors - RTD - Measurement and characteristics of RTD- RTD in ideal reactors - Reactor modeling with the RTD - Zero and One parameter models - Two-Parameter model - Modeling real reactors with combinations of ideal reactors - Testing a model and determining it's parameters - Other models of non ideal reactors using CSTRs and PFRs

UNIT-III

External diffusion Effect on Heterogeneous Reactions - Binary diffusion - External resistance to mass transfer - the shrinking core model.

Diffusion and reaction in Porous Catalyst – Diffusion and reaction in spherical pellets - Internal Effectiveness factor - Falsified Kinetics - Overall effectiveness factor - Estimation of diffusion and reaction limited regimes - Mass transfer and reaction in a packed bed

UNIT-IV

Internal Transport Processes-Reaction and Diffusion in porous catalysts:

Intra pellet mass transfer and intra pellet heat transfer, Mass transfer with reaction, Mass and Heat transfer with reaction, effect of internal transport on selectivity and poisoning.

UNIT-V

Design of heterogeneous Catalytic Reactors: Fixed bed reactors and isothermal and adiabatic fixed-bed reactors, non isothermal, non adiabatic fixed bed reactors, Two phase model, Fluidized-Bed reactors, Operating characteristics of FBRs. Mass Transfer in Fluidized Beds: Gas-Solid Mass Transfer, Mass Transfer between the Fluidized-Bed Phases, Reaction in Fluidized Bed. Trickle bed reactor Models, Slurry reactor models.

Text Books

1. J.M.Smith "Chemical Engineering Kinetics" 3rd ED., Mc Graw Hill, New York 1980
2. Fogler H. S., Elements of Chemical Reaction Eng.", 3rd Ed., Prentice Hall, 1999
3. Levenspiel, O., "Chemical Reaction Eng." John Wiley & Sons 1972.

Course Outcomes : Student will be able to

1) learn the importance of RTD and Non-ideal flow in reacting vessels.
2) Calculate the conversions based on segregated flow model, dispersion model and tanks-in-series models.
3) Understand the diffusion and reaction in a porous catalyst.
4) Learn the factors influencing catalyst decay, the role of pore diffusion on catalyst activity rate.
5) Understand the design of heterogeneous catalytic reactors.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	1	1	1		1	1	1			
CO2	1				2							
CO3			2			1						
CO4		1										
CO5				1	1				2			

CHPE 35 **OPTIMIZATION THEORY & PRACTICE**

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Course Educational Objectives :

1) To learn problem formulation and basic concepts of optimization.
2) To study the numerical methods to solve single variable un-constrained problems
3) To understand and apply numerical methods to solve un-constrained multi-variable problems
4) To learn linear& non-linear programming methods
5) To know the applications of optimization through different examples

Unit-I: Introduction

Basic concepts of optimization, applications of optimization, general procedure for solving optimization problem, formulation of the objective function, fitting models to data, classification of functions.

Unit-II: Single Variable unconstrained optimization methods

Direct search methods-Interval halving method, Fibonacci method, Golden section method;
Direct root methods-Newton method and Quasi Newton method;
Polynomial approximation methods - Quadratic interpolation and cubic interpolation.

Unit-III: Optimization of unconstrained multivariable functions

Direct search methods-random search, grid search, uni-variate search and pattern search methods. ; Indirect search methods - steepest descent, conjugate gradient methods, Newton's method and secant method.

Unit-IV: Linear and non-linear programming

Linear programming: Basic concepts in linear programming, Standard LP from, Graphical solution and Simplex method.

Non-linear programming: Lagrange multiplier method, Quadratic programming, Penalty function and augmented Lagrangian methods.

Unit –V: Applications of optimization

Optimizing recovery of waste heat, optimal design and operation of a conventional staged-distillation column, optimal pipe diameter, optimal residence time for maximum yield in chemostat and optimization of a thermal cracker using linear programming.

Text Book:

1.Edgar, T. F., Himmelblau, D. M. and Ladson, L. S., "Optimization of Chemical Processes", 2nd Ed., McGraw Hill, New York.

Reference Books :

1. Diwaker, U. W. "Introduction to Applied Optimization", Kluwer.
2. Joshi, M. C. and Moudgalya, K. M., "Optimization, Theory and Practice", Narosa, New Delhi, 2004.
3. Rao, S. S., Engineering Optimization: Theory and Practice, New Age Publishers.

Course Outcomes: Student will be able to

1) formulate and analyse the optimization of the given physical situation.
2) Apply different methods of optimization and to suggest a technique for specific problem
3) Understand the difference between constrained and unconstrained optimization
4) Understand the importance of linear programming problems
5) Realize the importance of optimization by understanding different examples

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1		1	1				1	1			
CO2		2		1					1			
CO3		1		1		2	1	1				
CO4	1		1	1								
CO5				1				1	1			

CHPE 46 **PROCESS SYNTHESIS & ANALYSIS**

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Course Objectives:

1) To familiarize the students about various economic aspects of chemical processes
2) To Learn basics of Cost estimation and to understand the time value of money
3) To Learn the importance of Cash flow diagrams and Break-even analysis.
4) To Study depreciation methods and methods of estimation of profitability of an industry
5) To Study about heat exchanger networks.

UNIT-I :

Nature of Process Synthesis & Analysis : Creative aspects – A hierarchial approach

Enginering Economics : Cost Information – Estimation of Capital and Operating Costs – Total Capital Investment- Total Product Cost - Time Value of Money – Measures of Process Profitability – Simplifying the Economic Analysis for Conceptual Design

UNIT II :

Economic Decision Making : Solvent Recovery System – Problem Definition & General Considerations – Design of a Gas Absorber – Equipment Design Consideration – Rules of Thumb

Input Information & Batch- Continuous: Input Information – Level 1 Decision – Batch Vs. Continuous

UNIT III :

Input-Output Structure of the Flow Sheet : Decisions for the I/O structure – Design Variables – Over all Material Balances – Stream Costs – Process Alternatives

Recycle Structure of the Flow Sheet : Decisions determining the recycle Structure – Recycle Material balances – reactor Heat Effects – Equilibrium Limitations – Compress Design & Costs – Reactor Design – recycle Economic Evaluation

Unit IV :

Heat Exchanger Networks – Minimum Heating & Cooling Requirements – Minimum Number of Exchangers – Area Estimates – Design of Minimum Energy Heat Exchanger Networks – Loops and Paths – Reducing the Number of Exchanger – Stream Splitting – Heat and Power Integration – Heat Distillation – HAD Process

UNIT V :

Separation System : General Structure – Vapor Recovery System – Liquid Separation System – Azeotropic Systems – Rigorous Material Balances

Cost Diagrams and Quick Screening of Process Alternatives - Cost Diagrams for simple and complex process – Quick Screening of Process Alternatives – HAD Process

Text Book :

1. Conceptual Design of Chemical Processes, Douglas, J.M., McGraw Hill,

Reference Books :

1. Chemical Process Design, Robin Smith, McGraw Hill,
2. Chemical Process Design, Dimian A.C, & Bidea,C.S., Wiley – VCH,2008
3. Chemical Process Synthesis & Engineering Design, Kumar,A, Tata McGraw Hill,1982
4. Systematic Methods of Chemical Process Design, Bieglar, L.T., Grossman, E.I and Westerberg, A.W. Prentice Hall Inc.
5. Product and Process Design Principles, Seider, W.D., Seider,J.D & Lewin, D.R. Wiley,2005

Course Outcomes

1. Acquired knowledge on creative aspects of process design and a hierarchical approach to conceptual design.Able to estimate capital,operatingcost,total capital investiment and total product cost.
2. Have the knowledge in developing a conceptual design of batch and continuous processes.
3. Cost diagrams and the quick screening of process alternatives.
4. Able to design minimum energy requirement for cooling and heating in heat exchanger networks.
5. Cost Diagrams and Quick Screening of Process Alternatives

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	2								
CO2	1	2			2							
CO3			2			1						
CO4		1		2								
CO5			2		1							

PGPA 23 STRESS MANAGEMENT BY YOGA

Course Objectives

1. To achieve overall health of body and mind
2. To overcome stress

Syllabus

Definitions of Eight parts of yog. (Ashtanga)

Yam and Niyam Do`s and Don't's in life. i) Ahinsa, satya, astheya, bramhacharya and aparigraha ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan

Asan and Pranayam i) Various yog poses and their benefits for mind & body ii)Regularization of breathing techniques and its effects-Types of pranayam

Suggested reading

1. 'Yogic Asanas for Group Tarining-Part-I" : Janardan Swami Yogabhyasi Mandal, Nagpur

2. "Rajayoga or conquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata

Course Outcomes: Students will be able to:

1. Develop healthy mind in a healthy body thus improving social health also
2. Improve efficiency

CHPP02 ADVANCED CHEMICAL ENGINEERING LABORATORY

Instruction , hours/week : 4 Credits : 2 Assessment : 40 + 60

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

1. To design and perform experimentation in chemical engineering core subjects
2.

List of Laboratory Experiments:

Selected experiments in Momentum, Heat and Masstransfer, Reaction Engineering and Process Control.

Outcomes: Students will be able

1. to design and perform Chemical Engineering related experiments

CHMP 01 MINI PROJECT

Laboratory Work 4 hr/week Credits : 2

SEMESTER – III

CHPE 55 POLYMER SCIENCE AND ENGINEERING

Instruction: 3 hr/week Credits: 3 Assessment : 40 + 60

OBJECTIVES

1. To learn aspects of Classification of Polymers.
2. To educate about Special Topics in Polymer Synthesis
3. To know the conceptual concepts on methods Polymer Confirmation and Chain Dimensions
4. To understand the membrane separations..
5. To give knowledge on applications of polymers.

UNIT - I:

Classification of Polymers, Functionality, Mechanisms of Polymerization, Chair Polymerisation - Free radical, Ionic and cationic Polymerisation - Step polymerization methods. Stereoisomerism in Polymers, Chemicals and Geometrical structures in Polymers. Block and Graft Polymers. Molecular weight of Polymers - weight average, number average and viscosity average molecular weight. Principles and calculations for determination of the molecular weights - Osmometry, Ebulliometry, Light scattering, ultracentrifugation, End group Analysis and viscosity methods.

UNIT II:

Thermodynamics of Solubility of polymers. Transition in polymers. Crystallinity in Polymers. Polymer Degradation method.

Kinetics of Polymerization Reactions – Free radical, Ionic Polymerization and step polymerization reactions. Derivation of rate equations and related numerical problems.

UNIT-III:

Polymerization Methods - Bulk, solution, suspension and emulsion polymerization. Comparison of Polymerization methods. Fabrication methods - Compounding Injection molding, Extrusion blow, blow extrusion, calendaring, Rotational molding, Thermoforming and vacuum forming.

Polymer processing and Rheology: Non-Newtonian flow, Viscosity of Polymer solutions and suspensions, Constitutive, equations; Capillary Rheometer, Couette Rheometer, Cone and Plate Rheometer, Rheometric characterization of polymer solution and melts.

UNIT-IV**:**

Brief description of individual polymers. Reaction equations, brief process description with a schematic flow sheet, physical properties and uses of the following polymers.

Individual Polymers**:** Thermosets: Phenol Formaldehyde, Urea formaldehyde, Polyester and epoxy resins, Polyrethane. Thermo plastics: Polyethylene, Polypropylene, PVC, Polystyrene, and Co-polymers, PMMA, Polycarbonates.

UNIT-V:

Applications of Polymers: Membrane Separations: Membrane Applications for Polymeric materials, mechanisms of transport and membrane preparation: Biomedical Applications: Artificial organs, Controlled drug delivery, hemodialysis and hemo filtration; Electronics: Electrically conductive polymers, electronic shielding, encapsulation, photonic polymers.

Reference Books:

1. Polymer Science, V.R.Gowariker, M.V.Viswanthan, Jaidev Sridhar, Wiley eastern Ltd, 1988.
2. Plastics engineering – R.J.Crawford, Butterworth Heinemann
3. Rubber and Plastic Technology – R.Chandra and S.Mishra, CBS Publishers
4. Outlines of Polymer Technology: Manufacture of Polymers by R.N.Sinha, Prentice Hall India.
5. J R Fried – Polymer Science and Technology, Prentice Hall of India Pvt., New Delhi, Eastern Economy Edition, 2000.

Course Out comes

1. Acquired knowledge on Classification of Polymers and its Structure, its degradation.
2. Have the knowledge on Thermodynamics of Solubility of polymers and Kinetics of Polymerization Reactions.
3. Have the knowledge on Comparison of Polymerization methods and Polymer processing and Rheology.
4. Knowledge on description of individual polymers.
5. Mechanisms of transport and membrane preparation.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1									
CO2	1				2							
CO3			2			1						
CO4		1		2								
CO5			2		1							

PGOP 12 INDUSTRIAL SAFETY

OBJECTIVES

1. To learn aspects of industrial safety.
2. To educate Fundamentals of maintenance engineering.
3. To know the conceptual concepts of prevention mmethods .
4. To understand the tracing techniques..
5. To give knowledge on industrial maintainence.

Unit-I: Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

Unit-II: Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

Unit-III: Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

Unit-IV: Fault tracing: Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

Unit-V: Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

Reference:

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

Course Out comes

1. Acquired knowledge on industrial accidents, types, fire prevention ,equipment and methods .
2. Have the knowledge on Fundamentals of maintenance engineering
3. Have the knowledge on Wear and Corrosion and their prevention
4. Knowledge on description of Fault tracing-concept and importance, decision tree concept, need and applications,.
5. Knowledge on Periodic and preventive maintenance .

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9		PO10	PO11	PO12
CO1	1	1	1										
CO2	1				2								
CO3			2			1							
CO4		1		2									
CO5			2		1								

IV SEMESTER

CHPD 01 & CHPD 02 DISSERTATION Phase – I and Phase – II

Phase I Lab work: 20 hr / week Credits : 10 and

Phases II 32 hr/week Credits : 16

Objectives:

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

- Ability to synthesize knowledge and skills previously gained and applied to an in-depth study and execution of new technical problem.
- Capable to select from different methodologies, methods and forms of analysis to produce a suitable research design, and justify their design.
- Ability to present the findings of their technical solution in a written report.
- Presenting the work in International/ National conference or reputed journals.

Syllabus Contents:

The dissertation / project topic should be selected / chosen to ensure the satisfaction of the urgent need to establish a direct link between education, national development and productivity and thus reduce the gap between the world of work and the world of study. The dissertation should have the following

- Relevance to social needs of society
- Relevance to value addition to existing facilities in the institute
- Relevance to industry need

- Problems of national importance
- Research and development in various domain

The student should complete the following:

- Literature survey Problem Definition
- Motivation for study and Objectives

- Preliminary design / feasibility / modular approaches
- Implementation and Verification

- Report and presentation

The dissertation stage II is based on a report prepared by the students on dissertation allotted to them.

It may be based on:

- Experimental verification / Proof of concept.

- Design, fabrication, testing of Communication System.

- The viva-voce examination will be based on the above report and

work. Guidelines for Dissertation Phase – I and II

- As per the AICTE directives, the dissertation is a yearlong activity, to be carried out and evaluated in two phases i.e. Phase – I: July to December and Phase – II: January to June.

- The dissertation may be carried out preferably in-house i.e. department's laboratories and centers OR in industry allotted through department's T & P coordinator.

- After multiple interactions with guide and based on comprehensive literature survey, the student shall identify the domain and define dissertation objectives. The referred literature should preferably include Springer/Science Direct. In case of Industry sponsored projects, the relevant application notes, while papers, product catalogues should be referred and reported.

- Student is expected to detail out specifications, methodology, resources required, critical issues involved in design and implementation and phase wise work distribution, and submit the proposal within a month from the date of registration.

- Phase – I deliverables: A document report comprising of summary of literature survey, detailed objectives, project specifications, paper and/or computer aided design, proof of concept/functionality, part results, A record of continuous progress.

- Phase – I evaluation: A committee comprising of guides of respective specialization shall assess the progress/performance of the student based on report, presentation and Q & A. In case of unsatisfactory performance, committee may recommend repeating the phase-I work.

- During phase – II, student is expected to exert on design, development and testing of the proposed work as per the schedule. Accomplished results/contributions/innovations should be published in terms of research papers in reputed journals and reviewed focused conferences OR IP/Patents.

- Phase – II deliverables: A dissertation report as per the specified format, developed system in the form of hardware and/or software, A record of continuous progress.

- Phase – II evaluation: Guide along with appointed external examiner shall assess the progress/performance of the student based on report, presentation and Q & A. In case of unsatisfactory performance, committee may recommend for extension or repeating the work

CHPE 11 **PROCESS DESIGN AND SYNTHESIS**

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives:

1. To understand the systematic approaches for the development of conceptual chemical process designs
2. To learn the advances in problem formulation and software capabilities which offer the promise of a new generation of practical process synthesis techniques based directly on structural optimization.
3. Learning chemical process synthesis, analysis, and optimization principles
4. Product design and development procedure and Process life cycle assessment.

Unit I : Introduction

Introduction to fundamental concepts and principles of process synthesis and design and use of flow sheet simulators to assist process design. Process Flow sheet Models: An Introduction to Design, Chemical process synthesis, analysis and optimization. Introduction to commercial process design software such as HYSYS, Aspen plus etc., Chemical Process (reactor, heat exchanger, distillation etc) analysis using commercial software

Unit II : Product design and developments

Process engineering economics and project evaluation Life Cycle Assessments of process: From design to product development, Engineering Economic Analysis of Chemical Processes, Project costing and performance analysis, Environmental concerns, Green engineering, Engineering ethics, Health and safety.

Unit III : Reactor Networks

Geometry of mixing and basic reactor types, The Attainable Region (AR) approach, AR in higher dimensions & for other processes, Reactive Separation processes, Fundamental behavior and problems, Separation through reactions. Reactive Residue Curve Maps

Unit IV : Synthesis of Separation Trains

Criteria for selection of separation methods, select ion of equipment**:** Absorption, Liquid-liquid extraction Membrane separation, adsorption, leaching, drying, crystallization, Ideal distillation - Column and sequence fundamentals, Sharp splits & sequencing Phase diagrams for 2, 3 and 4 components, Feasibility and vapor ow rates for single columns, Residue curve basics, Non-ideal Distillation **-** Azeotropic systems; detecting binary azeotropes, Residue curve maps for azeotropic systems, Topological analysis, Feasibility for single azeotropic columns ,Binary VLLE and pressure-swing separation, Non-ideal distillation synthesis. Equipment sequencing: VLE + VLLE, Detailed Residue Curve Maps, Residue curve maps: Interior structure

Unit V : Heat Exchanger Network Synthesis

Minimum heating and cooling requirements, Minimum Energy Heat Exchanger Network, Loops and Paths, Reducing Number of Exchangers, HENS basics & graphics, The pinch point approach, Stream Splitting, Performance targets, trade-off & utilities, Heat & power integration, HENS as mathematical programming

References

1. Douglas, J. "Conceptual Design of Chemical Processes",New York, NY: McGraw-Hill Science/Engineering/Math, 1988. ISBN: 0070177627.

2. Seider, W. D., J. D. Seader, and D. R. Lewin. "Product and Process Design Principles: Synthesis, Analysis, and Evaluation",. *2*nd ed. New York, NY: Wiley, 2004. ISBN: 0471216631.

3. Richard Turton, Richard C. Bailie, Wallace B. Whiting, Joseph A. Shaeiwitz., "Analysis, Synthesis, and Design of Chemical Processes", 2nd Edition, 2002, Prentice Hall ISBN-10: 0-13-064792-6

4. Biegler L.T., Grossmann I.E. and Westerberg A.W., "Systematic Methods of Chemical Process Design", Prentice Hall, 1997.

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

1. Analyze alternative processes and equipment
2. Synthesize a chemical process flow sheet that would approximate the real process
3. Design best process flow sheet for a given product
4. Perform economic analysis related to process design and evaluate project profitability.
5. Heat Exchanger Network Synthesis.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1		1	2								
CO2	1	2			2							
CO3		1	2			1						
CO4		1		2								
CO5			2	1	1							

CHPE 12 **CHEMICAL REACTOR ANALYSIS**

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives:

1. To learn the heterogeneous catalyzed reactions and the models involved in reactor design
2. To study mass and heat transfer mechanisms in the different reactors
3. To appreciate the importance of both external and internal transport effects in gas-solid and liquid-solid systems
4. To design isothermal and non-isothermal reactors for heterogeneous catalytic reactions

Unit-I: Chemical factor affecting the choice of the reactor, fundamental mass, energy and momentum balance, Model for a semi-batch reactor, optimum operation policies and control strategies, optimal batch operation time, optimal temperature policies, stability of operation and transient behavior for mixed flow reactor. Transient CSTR analysis, Hot spot equation; Optimization using Lagrange multiplier, Poyntrgins maximum principle.

Unit-II: Fixed bed catalytic reactor: The importance and scale of fixed bed catalytic processes, factors in preliminary design, modeling of fixed bed reactor. Pseudo-homogeneous model, the multi-bed adiabatic reactor, auto-thermal operation, non-steady-state model with axial mixing, two dimensional pseudo-homogeneous models, heterogeneous models, global and intrinsic rates, Mechanism of catalytic reactions, Engineering properties of catalysts - BET surface area, pore volume, pore size, pore size distribution, one dimensional and two dimensional model equation.

Unit-III: Multiphase flow reactor: Types of multiphase flow reactors, packed columns, plate columns, empty columns, stirred vessel reactors.Development of rate equations for solid catalyzed fluid phase reactions; Estimation of kinetic parameters. External mass and heat transfer in catalyst particles. Stability and selectivity, Packed bed reactor, slurry reactor; Trickle bed reactor and fluidized bed reactor. Intra-particle heat and mass transfer - Wheelers parallel pore model, random pore model of Wakao and Smith. deactivation of catalyst, Ideal and non-ideal flow in reactors.

Unit -IV: Design model for multiphase flow reactors, gas and liquid phase in completely mixed and plug flow, gas phase in plug flow and liquid phase in completely mixed flow, effective diffusion model, two zone model, specific design aspects, packed absorber, two-phase fixed bed reactor, plate column, spray tower, bubble reactor, stirred vessel reactor.Computer - aided reactor design.

Unit-V: Temperature effects in reactor: Introduction, well mixed system with steady feed, the stability and start-up of CSTR, limit cycles and oscillatory reactions, the plug flow reactors, tubular reactor, diffusion control, prorogation of reaction zone.

References :

1. Froment G. F. and K.B.Bischoff, " Chemical Reactor Analysis and Design", John Wiley & Sons
2. Denbigh K. G. and J.C. Turner, " Chemical Reactor and Theory – an Introduction", 3rd edition Cambridge University Press.
3. Bruce Nauman, " Chemical Reactor Design", John Wiley & Sons
4. Elements of Chemical Reaction Engineering by H. Scott Fogler
5. Chemical Engineering Kinetics by J. M. Smith.
6. Chemical Reactor Design and Operation by K. R. Westerterp, W. P. M. Van Swaaij and A. A. C. M. BeenackersReference
7. Chemical Reactor Analysis and Design by G. F. Froment and K. B. Bischoff

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

1. Evaluate heterogeneous reactor performance considering mass transfer limitations
2. Perform the energy balance and obtain concentration profiles in multiphase reactors.
3. Estimate the performance of multiphase reactors under non-isothermal conditions
4. Design model for multiphase flow reactors, gas and liquid phase in completely mixed and plug flow.
5. Temperature effects in reactor.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1		1	2								
CO2	1	2			2							
CO3		1				1						
CO4		1		2								
CO5			2		1							

CHPE 13 **FLUIDIZATION ENGINEERING**

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives

1. To study the phenomenon of fluidization with industrial processing objective
2. To study the various regimes of fluidization and their mapping.
3. To study the design of equipments based on fluidization technique

Unit I : Introduction to fluidization and applications

Phenomenon of fluidization, behavior of fluidized bed, contacting modes, advantages and disadvantages of fluidization, fluidization quality, selection of contacting mode, Beds for Industrial applications, coal gasification, synthesis reactions, physical operations, cracking of hydrocarbons

Unit II : Mapping of fluidization regimes

Characterization of particles, mechanics of flow around single particles, minimum fluidization velocity, pressure drop versus velocity diagram, The Geldart classification of solids, fluidization with carryover of particles, terminal velocity of particles, distributor types, gas entry region of bed, pressure drop requirements, design of gas distributor, power consumption

Unit III : Bubbling fluidized beds

Davidson model for bubble in a fluidized bed, and its implications, the wake region and movement of solids at bubbles, coalescence and splitting of bubbles, bubble formation above a distributor, slug flow, Turbulent and fast fluidization - mechanics, flow regimes and design equations, Emulsion movement, estimation of bed properties, bubble rise velocity, scale up aspects, flow models, two phase model, K-L model

Unit IV : Solids movement and Gas dispersion

Vertical and horizontal movement of solids, Dispersion model, large solids in beds of smaller particles, staging of fluidized beds

Gas dispersion in beds, gas interchange between bubble and emulsion, estimation of gas interchange coefficient, Heat and mass transfer in fluidized systems, Mixing in fluidized systems - measurements and models.

Unit V : Fluidized bed reactors

Entrainment and elutriation, Freeboard behavior, gas outlet, entrainment from tall vessel, freeboard entrainment model, high velocity fluidization, pressure drop in turbulent and fast fluidization, Slugging, Spouted beds, Circulating Fluidized Beds.

Mathematical model of a homogeneous fluidized bed, Design of catalytic reactors, pilot plant reactors, information for design, bench scale reactors, design decisions, deactivating catalysts,Design of noncatalytic reactors, kinetic models for conversion of solids, models for shrinking particles, conversion of solids of unchanging size]

References

1. Levenspiel O. and Kunnii D., "Fluidization Engineering", John Wiley, 1972
2. Liang-Shih Fan, "Gas-Liquid-Solid Fluidization Engineering", Butterworths, 1989

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

1. Performing and understanding the behavior fluidization in fluidized bed
2. Evaluate the characterization of particles and power consumption in fluidization regimes
3. Understanding the applicability of the fluidized beds in chemical industries
4. Dispersion model, Heat and mass transfer in fluidized systems.
5. Entrainment and elutriation, Mathematical model of a homogeneous fluidized bed.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1		1	2								
CO2	1		2		1							
CO3		1				1						
CO4		1		2								
CO5			2		1							

CHPE 22 APPLICATION OF NANOTECHNOLOGY IN CHEMICAL ENGINEERING

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives

1. To understand the fundamentals of the preparation and properties of nanomaterials from a chemical engineering perspective.
2. To gain knowledge of structure, properties, manufacturing, and applications of various nanomaterials and characterization methods in nanotechnology
3. To give a survey of the key processes, principles, and techniques used to build novel nanomaterials and assemblies of nanomaterials

Unit I : Introduction

Introduction to nanotechnology, Feynman's Vision-There's Plenty of Room at the Bottom, Classification of nanostructures, Nanoscale architecture, Chemical interactions at nanoscale, Types of carbon based nanomaterials, Synthesis of fullerenes, Graphene, Carbon nanotubes, Functionalization of carbon nanotubes, One, two and multidimensional structures, Crystallography.

Unit II : Approaches to Synthesis of Nanoscale Materials and characterization

Top down approach, Bottom up approach Bottom-up vs. top-down fabrication; Top-down: Atomization, Sol gel technique, Arc discharge, Laser ablation, RF sputtering; Bottom-up: Chemical Vapor Deposition (CVD), Metal Oxide Chemical Vapor Deposition (MOCVD), Atomic layer deposition (ALD), Molecular beam Molecular self-assembly; Ultrasound assisted, microwave assisted, Mini, micro and nanoemulsion. Wet grinding method, Spray pyrolysis, Ultrasound assisted pyrolysis, atomization techniques. Surfactant based synthesis procedures, Types of molecular modeling methods. Size, shape, crystallinity, topology, chemistry analysis usingX-ray imaging, Transmission Electron Microscopy, HRTEM, Scanning Electron Microscopy, SPM, AFM, STM, PSD, Zeta potential, DSC and TGA.

Unit III : Semiconductors and Quantum dots

Intrinsic semiconductors, Extrinsic semiconductors, Review of classical mechanics, de Broglie's hypothesis, Heisenberg uncertainty principle Pauli exclusion principle Schrödinger's equation Properties of the wave function, Applications: quantum well, wire, dot, Quantum cryptography

Unit IV : Polymer-based and Polymer-filled Nanocomposites

Nanoscale Fillers, Nanofiber or Nanotube Fillers, Plate-like Nanofillers, Equi-axed Nanoparticle Fillers, Inorganic Filler Polymer Interfaces, Processing of Polymer Nanocomposites, Nanotube/Polymer Composites, Layered Filler Polymer Composite Processing, Nanoparticle/Polymer Composite Processing: Direct Mixing, Solution Mixing, In-Situ Polymerization, In-Situ Particle Processing, In-Situ Particle Processing Metal/Polymer Nanocomposites, Properties of nanocomposites.

Unit V : Applications to Safety, Environment and Others

Chemical and Biosensors- Classification and Main Parameters of Chemical and Biosensors, Nanostructured Materials for Sensing, Waste Water Treatment, Nanobiotechnology, Drug Delivery, Nanocoatings, Self cleaning Materials, Hydrophobic Nanoparticles, Photocatalysts, Biological nanomaterials, Nanoelectronics, Nanomachines & nanodevices, Societal, Health and Environmental Impacts.

References

1. Louis Hornyak G., Dutta Joydeep, Tibbals Harry F. and Rao Anil K., "Introduction to Nanoscience", (CRC Press of Taylor and Francis Group LLC), May 2008, 856pp, ISBN-13: 978142004805

2. Ajayan P. M., Schadler L. S., Braun P. V., "Nanocomposite Science and Technology", Edited by WILEY-VCH Verlag GmbH Co. KGaA, Weinheim ISBN: 3-527-30359-6, 2003.

3. Kelsall Robert W., Hamley Ian W., GeogheganMark, "Nanoscale Science and Technology",John Wiley & Sons, Ltd, 2006.

4. Kal Ranganathan Sharma, "Nanostructuring Operations in Nanoscale Science and Engineering", McGraw-Hill Companies, Inc. ISBN: 978-0-07-162609-5, 2010.

5. "Organic and inorganic nanostructures".-(Artech House MEMS series), Nabok, Alexei, ISBN 1-58053-818-5, 2005.

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

1. Understanding the different top down and bottom up approaches for nanoparticles
2. Get to know the different applications of nanoparticles in chemical engineering field.

3. Lear

3. Learning the characterization techniques for nanoparticles

CHPE 23 **CHEMOINFORMATICS**

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives

1. To give students a concept of Chemo-informatics related to chemical structure databases and database search methods
2. To understand the quantum methods and models involved in drug discovery and targeted drug delivery
3. To study the application of Chemical Libraries, Virtual Screening, Prediction of Pharmacological Properties

Unit I : Chemo-informatics

Introduction, scope and application, Basics of Chemo-informatics, Current Chemo-informatics resources for synthetic polymers, pigments. Primary, secondary and tertiary sources of chemical information, Databases: Chemical Structure Databases (PubChem, Binding database, Drugbank), Database search methods:chemical indexing, proximity searching, 2D and 3D structure and substructure searching. Drawing the Chemical Structure: 2D & 3D drawing tools (ACD Chemsketch) Structure optimization.

Unit II : Introduction to quantum methods

Combinatorial chemistry (library design, synthesis and deconvolution), spectroscopic methods and analytical techniques,Representation of Molecules and Chemical Reactions: Different types of Notations, SMILES Coding, Structure of Mol files and Sd files (Molecular converter, SMILES Translator).

Unit III : Analysis and use of chemical reaction information

Chemical property information, spectroscopic information, analytical chemistry information, chemical safety information, Drug Designing: Prediction of Properties of Compounds, QSAR Data Analysis, Structure-Activity Relationships, Electronic properties, Lead Identification, Molecular Descriptor Analysis.

Unit IV : Target Identification

Molecular Modeling and Structure Elucidation: Homology Modelling (Modeller 9v7, PROCHECK), Visualization and validation of the Molecule (Rasmol, Pymol Discovery studio), Applications of Chemoinformatics in Drug Research - Chemical Libraries, Virtual Screening, Prediction of Pharmacological Properties.

Unit V : Drug Discovery

Structure based drug designing, Docking Studies (Target Selection, Active site analysis, Ligand preparation and conformational analysis, Rigid and flexible docking, Structure based design of lead compounds, Library docking), Pharmacophore - Based Drug Design, Pharmacophore Modeling (Identification of pharmacophore features, Building 2D/3D pharmacophore hypothesis), Toxicity Analysis-Pharmacological Properties (Absorption, Distribution and Toxicity), Global Properties (Oral Bioavailability and Drug-Likeness) (ADME, OSIRIS, and MOLINSPIRATION)

References

1. Bajorath J (2004), "Chemoinformatics: Concepts, Methods and Tools for Drug Discovery" Humana Press
2. Leach A, Gillet V, "An Introduction to Chemoinformatics" Revised edition, Springer
3. Gasteiger J. Engel T. "A textbook of Chemoinformatics" Wiley- VCH GmbH & Co. KGaA
4. Bunin B. Siesel B. Guillermo M. "Chemoinformatics: Theory, Practice & Products", Springer
5. Lavine B. (2005), "Chemometrics and Chemoinformatics", American Chemical Society
6. Casteiger J. and Engel T (2003) "Chemoinformatics" Wiley-VCH
7. Bunin Barry A. Siesel Brian, Morales Guillermo,Bajorath Jürgen. Chemoinformatics: Theory, Practice, & Products Publisher:New York, Springer. 2006.
8. Leach Andrew R., Valerie J. Gillet, "An introduction to Chemoinformatics", Publisher: Kluwer academic, 2003. ISBN: 1402013477
9. Gasteiger Johann, Handbook of Chemoinformatics: From Data to Knowledge (4 Volumes),
   2003. Publisher: Wiley-VCH.

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

1. The course will introduce the students preparing for professional work in chemistry must learn how to retrieve specific information from the enormous and rapidly expanding chemical literature.
2. The course will provide a broad overview of the computer technology to chemistry in all of its manifestations.
3. The course will expose the student to current and relevant applications in QSAR and Drug Design.

CHPE 24 **ADVANCED CONTROL SYSTEMS**

Instruction : 3 hr/week Credits : 3 Evaluation : 40 + 60

Course Educational Objectives ; Students will have to learn the following

1) To learn aspects of advanced Control Strategies.
2) To educate about the Process interactions and control loop interactions,
3) To know the Sampling and signal reconstruction,
4) To understand the the z-Transform, inversion
5) To give knowledge about Data Control Systems.

Unit I :

Feed Forward and Ratio Control – Introduction, Feed forward controller design based on steady state and dynamic models, tuning and configuration of feed forward control

Advanced Control Strategies – Cascade control, time delay compensation and inferential control, selective and override systems, adaptive control, statistical process control

Unit II :

Control of Multi Input, Multi-Output Systems – Process interactions and control loop interactions, pairing of controlled and manipulated variables, strategy for reducing interactions, decoupling, multivariable control techniques

Supervisory Control – Basic requirements, applications, formulation and solution of optimization problems, unconstrained and constrained optimization

Unit III :

Digital Computer Control – Digital control systems in process control, distributed instrumentation and control systems, general purpose digital data acquisition, digital control hardware and software, table driven PID controller, Programmable logic controllers and batch process control

Sampling and Filtering of Continuous Measurements – Sampling and signal reconstruction, selection of sampling period, signal processing and data filtering, comparison of analog and digital filters, effect of filter selection on control system performance

Unit IV :

Development of Discrete Time Models – Finite difference models, exact discretization for linear systems, higher order systems, fitting discrete time equations to process data

Dynamic Response of Discrete –Time Systems – The z-Transform, inversion, pulse transfer function, relating pulse transfer functions to difference equations, effect of pole and zero locations, conversion between laplace and z- transforms

Unit V :

Analysis of Sampled – Data Control Systems – Open loop block diagram analysis, development of closed loop transfer functions, stability of sampled data control systems

Design of Digital Controllers – Digital PID controller, selection of controller parameters, direct synthesis methods, digital feed forward control, combined load estimation and time delay compensation

Text Books:

1. Process Dynamics and Control – D.E.Seborg, T.F.Edgar and D.A.Mellichamp, John Wiley & Sons
2. Chemical Process control – An Introduction to Theory and Practice - George Stephanopoulos, Prentice hall 1990.

Course Out comes

1. Acquired knowledge on creative aspects of Feed forward controller design based on steady state and dynamic models, tuning and configuration.
2. Have the knowledge in developing a conceptual Control of Multi Input, Multi-Output Systems.
3. Knowledge on Digital control systems in process control, Sampling and signal reconstruction
4. Able to have knowledge on Development of Discrete Time Models, Dynamic Response of Discrete –Time Systems.
5. Analysis of Sampled – Data Control Systems.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	2								
CO2	1	2			2							
CO3			2			1						
CO4		1		2								
CO5			2		1							

CHPE31 MODERN CONCEPTS IN CATALYSIS AND SURFACE PHENOMENON

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives

1. To give the students insight into advances in catalytic reaction engineering
2. To understand the mechanisms involved in catalytic reactions
3. To study the catalyst characterization techniques
4. To study the advanced industrial applications in catalysis
5. To understand the principles behind catalyst deactivation and study their models

Unit I : Introduction to Catalysis

Definition of Catalytic activity, Magnitude of Turnover Frequencies and Active Site Concentrations, Evolution of Important Concepts and Techniques in Heterogeneous Catalysis, Classification of Catalysts – Homogeneous, Heterogeneous, Biocatalysts, Dual Functional Catalysts, Enzymes, Solid Catalysts, Powder Catalysts, Pellets, Composition, Active Ingredients, Supportive materials, Catalysts Activation, Catalyst Deactivation.

Unit II : Adsorption in Catalysis

Adsorption and its importance in Catalysis, Adsorption and potential energy curves, Surface Reconstruction, Adsorption Isotherms and Isobars, Dynamical Considerations, Types of Adsorption Isotherms and their Derivation from Kinetic Principles, Mobility at Surfaces, Kinetics of surface Reactions, Photochemistry on oxide and metallic surfaces, Characterization of the adsorbed molecules

Unit III : Catalyst Characterization

Catalyst Characterization Methods – Their Working Principle and Applications – XRF, XRD, IR Spectroscopy, XPS, UPS, ESR, NMR; Infrared, Raman, NMR, Mossbauer and X-Ray Absorption spectroscopy, Surface Acidity and Toxicity, Activity, Life time, Bulk density, Thermal stability Crystal Defects, Peroviskites, Spinels, Clays, Pillared Clays, Zeolites

Unit IV : Significance of Pore Structure and Surface Area

Importance of Surface Area and Pore Structure, Experimental Methods for Estimating Surface Area– Volumetric, Gravimetric, Dynamic Methods, Experimental Methods for Estimating Pore Volume and Diameter – Gas Adsorption and Mercury Porosimeter Method, Models of the Pore Structure – Hysteresis Loops, Geometric Models, Wheeler’s Model, Dusty Gas Model, Random Pore Model, Diffusion in Porous Catalysts – Effective Diffusivity, Knudsen Diffusion, Effect of Intraparticle Diffusion, Non-isothermal Reactions in Pores, Diffusion Control.

Unit V : Industrial applications– Case Studies

Industrial processes involving heterogeneous solid catalyst: Synthesis of Methanol, Fiscer-Tropsch Catalysis, Synthesis of Ammonia, Automobile Exhaust Catalysts and Catalyst Monolith, Photocatalytic Breakdown of Water and the Harnessing of Solar Energy.

Contribution of homogeneous catalytic process in chemical industry:Oxidations of Alkenes such as production of acetaldehyde, propylene oxide etc., Polymerization such as production of polyethylene, polypropylene or polyester production

References

1. Emmett, P.H. - "Catalysis Vol. I and II, Reinhold Corp.", New York, 1954
2. Smith, J.M. - "Chemical Engineering Kinetics ", McGraw Hill, 1971
3. Thomas and Thomas - "Introduction to Heterogeneous Catalysts ", Academic Press, London 1967
4. Piet W.N.M. van Leeuwen, Homogeneous catalysis: Understanding the Art, Springer, 2004
5. Piet W.N.M. van Leeuwen, and John C. Chadwick, Homogeneous catalysis: Activity-stability –deactivation, Wiley, VCH, 2011.

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

1. To understand the concepts of homogenous and heterogeneous catalysis, with specific examples.
2. To study reaction mechanisms and kinetics of homogenous and heterogeneous catalytic reactions.
3. To familiarize with the characterization of catalysts
4. To understand the application and mechanisms of several types of catalysts in chemical industry.

CHPE 32 ADVANCED DOWNSTREAM PROCESSING

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives

1. To understand the unit processes involved in downstream processing.
2. To study advanced treatment methods.
3. To study the energy conservation in different separation processes
4. To understand the underlying design principles

Unit I : Introduction]

Introduction to Downstream processes theory, applications in chemical separation for Gas-Liquid system, Gas-Solid system. Super critical fluids extraction in food, pharmaceutical, environmental and petroleum applications, water treatment, desalination, Bio separation, dialysis, industrial dialysis.

Unit II : Downstream Processes in Petrochemical Industry

Cryogenic distillation for refinery, petrochemical off gases, natural gases, gas recovery-Olefin, Helium, Nitrogen, Desulfurization - coal, flue gases

Unit III : Advanced Distillation Processes

Azeotropic & extractive distillation - residue curve maps, homogeneous azeotropic distillation, pressure swing distillation, Column sequences, heterogeneous azeotropic distillation.

Unit IV : Energy conservation in separation processes

Energy balance, molecular sieves - zeolights, adsorption, catalytic properties, manufacturing processes, hydrogel process, application, New trends.

Unit IV : Non-Ideal Mixtures and Ion Exchange

Separations process synthesis for nonazeotropic mixtures, non ideal liquid mixtures, separation synthesis algorithm, Ion exchange - manufacture of resins, physical & chemical properties, capacity, selectivity, application, regeneration, equipment, catalysis use.

References

1. Perry's "Chemical Engg. Handbook": McGraw Hill Pub.
2. Douglas J.M., "Conceptual Design of Chemical Processes", McGraw Hill
3. Liu Y.A., "Recent Developments in Chemical Process & Plant Design", John Wiley & Sons Inc.
4. Timmerhaus K.D., "Cryogenic Process Engg.", Plenum Press
5. Othmer Kirk "Encyclopedia of Separation Technology, Vol I & II", Wiley Interscience

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

1. To learn effective strategies of downstream processing in chemical industry.
2. Understand the role of downstream processing.
3. Analyze reactors, upstream and downstream processes in production

CHPE 33 **COMPUTATIONAL FLUID DYNAMICS**

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives

1. To make students understand the governing equations of fluid dynamics and their derivation from laws of conservation
2. To develop a good understanding in computational skills, including discretisation, accuracy and stability.
3. To acquaint the students with a process of developing a mathematical and geometrical model of flow, applying appropriate boundary conditions and solving system of equations

Unit I : Introduction to Fluid Dynamics

Concepts of Fluid Flow, Pressure distribution in fluids, Reynolds transport theorem, Integral form of conservation equations, Differential form of conservation equations, Different Types of Flows, Euler and Navier Stokes equations, Properties of supersonic and subsonic flows, Flow characteristics over various bodies. Philosophy of CFD, Governing equations of fluid dynamics and there physical meaning, Mathematical behavior of governing equations and the impact on CFD simulations, Simple CFD techniques and CFL condition. Numerical Methods in CFD:Finite Difference, Finite Volume, and Finite Element, Upwind and downwind schemes, Simple and Simpler schemes, Higher order methods, Implicit and explicit methods, Study and transient solutions

Unit II : Grid Generation

Basic theory of structured grid generation, Surface grid generation, Mono block, multi block, hierarchical multi block, Moving and sliding multiblock, Grid clustering and grid enhancement. Basic theory of unstructured grid generation, advancing front, Delaunay triangulation and various point insertion methods, Unstructured quad and hex generation, grid based methods, various elements in unstructured grids, Surface mesh generation, Surface mesh repair, Volume grid generation, Volume mesh improvement, mesh smoothing algorithms, grid clustering and quality checks for volume mesh. Adaptive, Moving and Hybrid Grids, Need for adaptive and, moving grids, Tet, pyramid, prism, and hex grids, using various elements in combination

Unit III : Turbulence and its Modelling

Transition from laminar to turbulent flow, Effect of turbulence on time-averaged Navier-Stokes equations, Characteristics of simple turbulent flows, Free turbulent flows, Flat plate boundary layer and pipe flow, Turbulence models, Mixing length model,The k-e model, Reynolds stress equation models, Algebraic stress equation models

Unit IV : Chemical Fluid Mixing Simulation

Stirred tank modeling using the actual impeller geometry, Rotating frame model, The MRF Model Sliding mesh model, Snapshot model, Evaluating Mixing from Flow Field Results, Industrial Examples

Unit IV : Post-Processing of CFD results

Contour plots, vector plots, and scatter plots, Shaded and transparent surfaces, Particle trajectories and path line trajectories, Animations and movies, Exploration and analysis of data.

References

1. Anderson John D., "Computational Fluid Dynamics: The Basics with Applications", Mc Graw Hill, 1995
2. Ranade V.V., "Computational Flow Modeling for Chemical Reactor Engineering", Process Engineering Science, Volume 5, 2001
3. Knupp Patrick and Steinberg Stanly, "Fundamentals of Grid Generation", CRC Press, 1994
4. Wilcox D.C., "Turbulence Modelling for CFD", 1993
5. Wesseling Pieter, "An Introduction to Multigrid Methods", John Wiley & Sons, 1992
6. Thompson J.F., Warsi Z.U.A. and Mastin C.W., "Numerical Grid Generation: Foundations and Applications", North Holland, 1985
7. Patankar S.V., "Numerical Heat Transfer and Fluid Flow", McGraw-Hill,1981
8. Gatski Thomas B., Hussaini M. Yousuff and Lumley John L., "Simulation and Modelling of Turbulent Flows", Oxford University Press, 1996
9. Laney, C. B., "Computational Gas Dynamics", Cambridge Uni. Press, 1998.

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

1. Understand the basic principles of mathematics and numerical concepts of fluid dynamics.
2. Develop governing equations for a given fluid flow system.
3. Adapt finite difference techniques for fluid flow models.
4. Apply finite difference method for heat transfer problems.
5. Solve computational fluid flow problems using finite volume techniques.
6. Get familiarized to modern CFD software used for the analysis of complex fluid-flow systems

CHPE 34 **ENZYME SCIENCE & ENGINEERING**

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Course Educational Objectives ; Students will have to learn the following

1) Understand the Development of Enzymatic Assays
2) Solve Kinetics of Single Substrate Reactions
3) Do the Analysis on Immobilized Enzyme Systems
4) Learn the types of Immobilized Reactors
5) Design the Enzyme Electrodes

UNIT I :

Enzymes : Classification – Protein Structure –Extraction, Purification and characterization from natural sources – Development of enzymatic assays, Comparison of chemical and enzyme catalysis

UNIT II :

Mechanisms and Kinetics of Enzyme Action : Mechanisms of enzyme action – concept of active site and energetics of enzyme-substrate complex formation – Specificity of enzyme action – Kinetics of single substrate reactions (irreversible & reversible), estimation of Michaelis-Menten Parameters – Multi substrate mechanisms and kinetics

Types of inhibition – kinetic Models – substrate and product inhibition – temperature and pH effects on enzyme activity – deactivation kinetics

UNIT-III:

Enzyme Immobilization – Physical and Chemical methods – Comparison of different methods –

Immobilized Enzyme Kinetics - Analysis of Film and Pore Diffusion effects on immobilized enzyme systems – Formulation of dimensionless groups and calculation of effectiveness factors

UNIT-IV :

Enzyme Reactors - Immobilized Enzyme Reactors – Packed bed, Fluidized bed, membrane reactors – Bioconversion calculations in free enzyme CSTRs and immobilized enzyme reactors

UNIT V :

Applications : Applications of free and immobilized enzymes

Biosensors : Applications of enzymes in analysis; Design of enzyme electrodes and their applications as biosensors in industry, health care and environment

Text Books

1. Enzymes-Palmer;T,(Affiliated East West Press Pvt.Ltd.), 2004
2. Biochemical Engineering Fundamentals – Bailey, J.E. & Ollis,D.F., McGraw Hill

References

1. Biochemistry- Stryer,Berg, 6thEdition, (W.H.Freeman and Co.), 2007.
2. Enzyme Biotechnology- Tripathi;G, (ABD Publishers), 2003.
3. Enzyme Technology, M.F. Chaplin and C. Bucke. Cambridge University Press
4. Industrial Enzymes & their applications, H. Uhlig, (John Wiley and Sons Inc.)

Course Objectives : Students will be able to

1) Know the mechanisms of Chemical and Enzyme Catalysts
2) Develop, understand and apply Kinetic Models
3) Formulate and Analyze Immobilized Enzyme Kinetics
4) Design and analyze Enzyme Reactors
5) Gain knowledge on Applications of Enzyme and on Biosensors

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1									
CO2	1				2							
CO3			2			1						
CO4		1		2								
CO5			2		1							

CHPE 36 **MICRO AND NANO FLUIDICS**

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives:

1. To introduce to the students, the various opportunities in the emerging field of micro and nano fluids.
2. To the make students familiar with the important concepts applicable to small micro and nano fluidic devices, their fabrication, characterization and application
3. To get familiarize with the new concepts of real-time nano manipulation &

ssembly

Unit-1: Introduction: Fundamentals of kinetic theory-molecular models, micro and macroscopic properties, binary collisions, distribution functions, Boltzmann equation and Maxwellian distribution functions-Wall slip effects and accommodation coefficients, flow and heat transfer analysis of microscale Couette flows, Pressure driven gas micro-flows with wall slip effects, heat transfer in micro-Poiseuille flows, effects of compressibility. Pressure Driven Liquid Microflow: apparent slip effects, physics of near-wall microscale liquid flows, capillary flows, electro-kinetically driven liquid micro - flows and electric double layer (EDL) effects, concepts of electroosmosis, electrophoresis and dielectro-phoresis.

Unit- 2: Laminar flow: Hagen-Poiseullie eqn, basic fluid ideas, Special considerations of flow in small channels, mixing, microvalves & micropumps, Approaches toward combining living cells, microfluidics and 'the body' on a chip, Chemotaxis, cell motility. Case Studies in Microfluidic Devices. Ionic transport: Polymer transport – microtubule transport in nanotuble channels driven by Electric Fields and by Kinesin Biomolecular Motors - Electrophoresis of individual nanotubules in microfluidic channels.

Unit-3: Fabrication techniques for Nanofluidic channels – Biomolecules separation using Nanochannels - Biomolecules Concentration using Nanochannels – Confinement of Biomolecules using Nanochannels. Hydrodynamics: Particle moving in flow fields – Potential Functions in Low Renoylds Number Flow – Arrays of Obstacles and how particles Move in them: Puzzles and Paradoxes in Low Re Flow.

Unit-4: Microfluidics and Lab-on-a-chip: Microfluidic Devices - Microchannels, Microfilters, Microvalves, Micropumps, Microneedles, Microreserviors, Micro-reaction chambers. Concepts and Advantages of Microfluidic Devices - Fluidic Transport - Stacking and Scaling – Materials for The Manufacture (Silicon, Glass, Polymers) - Fluidic Structures - Fabrication Methods - Surface Modifications - Spotting - Detection Mechanisms. Microcontact printing of ProteinsStrategies-printing types- methods and characterization- Cell nanostructure interactions-networks for neuronal cells. Applications in Automatic DNA sequencing, DNA and Protein microarrays.

Unit-5: BioMEMS (Micro-Electro-Mechanical Systems): Introduction and Overview, Biosignal Transduction Mechanisms: Electromagnetic Transducers Mechanical Transducers, Chemical

Transducers, Optical Transducers – Sensing and Actuating mechanisms (for all types). Case Studies in Biomagnetic Sensors, Applications of optical and chemical transducers. Ultimate Limits of Fabrication and Measurement, Recent Developments in BioMEMS and BioNEMS - An alternative approach to traditional surgery, Specific targeting of tumors and other organs for drug delivery, Micro-visualization and manipulation, Implantation of microsensors, microactuators and other components of a larger implanted device or external system (synthetic organs).

Text Books

1. Joshua Edel "Nanofluidics" RCS publishing, 2009.

2. Patric Tabeling "Introduction to Microfluids" Oxford U. Press, New York 2005.
3. K. Sarit "Nano Fluids; Science and Technology", RCS Publishing, 2007.

References

1. M. Madou, Fundamentals of Microfabrication, CRC Press, 1997
2. G. Kovacs, Micromachined Transducers, McGraw-Hill, 1998

3. Steven S Saliterman, Fundamentals of BioMEMS and Medical Microdevices, 2006

Outcomes: At the end of this course, students are able to:

1. Introduce students to the physical principles to analyze fluid flow in micro and nano-size devices. It unifies the thermal sciences with electrostatics, electrokinetics, colloid science; electrochemistry; and molecular biology.

CHPE 37 **PROCESS INTENSIFICATION**

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives:

1. Understand the concept of Process Intensification.
2. Know the limitations of intensification of the chemical processes.
3. Apply the techniques of intensification to a range of chemical processes.
4. Develop various process equipment used for intensifying the processes.
5. Infer alternative solutions keeping in view point, the environmental protection, economic viability and social acceptance.

Unit-I: Introduction: Techniques of Process Intensification (PI) Applications, The philosophy and opportunities of Process Intensification, Main benefits from process intensification, ProcessIntensifying Equipment, Process intensification toolbox, Techniques for PI application.

Unit-II: Process Intensification through micro reaction technology: Effect of miniaturization on unit operations and reactions, Implementation of Microreaction Technology, From basic Properties To Technical Design Rules, Inherent Process Restrictions in Miniaturized Devices and Their Potential Solutions, Microfabrication of Reaction and unit operation Devices - Wet and Dry Etching Processes.

Unit-III: Scales of mixing, Flow patterns in reactors, Mixing in stirred tanks: Scale up of mixing, Heat transfer. Mixing in intensified equipment, Chemical Processing in High-Gravity Fields Atomizer Ultrasound Atomization, Nebulizers, High intensity inline MIXERS reactors Static mixers, Ejectors, Tee mixers, Impinging jets, Rotor stator mixers, Design Principles of static Mixers Applications of static mixers, Higee reactors.

Unit-IV: Combined chemical reactor heat exchangers and reactor separators: Principles of operation; Applications, Reactive absorption, Reactive distillation, Applications of RD Processes, Fundamentals of Process Modelling, Reactive Extraction Case Studies: Absorption of NOx Coke Gas Purification. Compact heat exchangers: Classification of compact heat exchangers, Plate heat exchangers, Spiral heat exchangers, Flow pattern, Heat transfer and pressure drop, Flat tube-and-fin heat exchangers, Microchannel heat exchangers, Phase-change heat transfer, Selection of heat exchanger technology, Feed/effluent heat exchangers, Integrated heat exchangers in separation processes, Design of compact heat exchanger - example.

Unit-V: Enhanced fields: Energy based intensifications, Sono-chemistry, Basics of cavitation, Cavitation Reactors, Flow over a rotating surface, Hydrodynamic cavitation applications, Cavitation reactor design, Nusselt-flow model and mass transfer, The Rotating Electrolytic Cell, Microwaves, Electrostatic fields, Sonocrystallization, Reactive separations, Superctrical fluids

References:

1. Stankiewicz, A. and Moulijn, (Eds.), Reengineering the Chemical Process Plants, Process Intensification, Marcel Dekker, 2003.

2. Reay D., Ramshaw C., Harvey A., Process Intensification, Butterworth Heinemann, 2008.
3. Kamelia Boodhoo (Editor), Adam Harvey (Editor),Process Intensification Technologies for Green Chemistry: Engineering Solutions for Sustainable Chemical Processing, Wiley, 2013.
4. Segovia-Hernández, Juan Gabriel, Bonilla-Petriciolet, Adrián (Eds.)Process Intensification in Chemical Engineering Design Optimization and Control, Springer, 2016.
5. Reay, Ramshaw, Harvey, Process Intensification, Engineering for Efficiency, Sustainability and Flexibility, Butterworth-Heinemann, 2013.

Outcomes: At the end of this course, students are able to:

1. Assess the values and limitations of process intensification, cleaner technologies and waste minimization options.
2. Measure and monitor the usage of raw materials and wastes generating from production and frame the strategies for reduction, reuse and recycle.
3. Obtain alternative solutions ensuring a more sustainable future based on environmental protection, economic viability and social acceptance.
4. Analyze data, observe trends and relate this to other variables.
5. Plan for research in new energy systems, materials and process intensification.

CHPE 41 PHASE TRANSITIONS IN PROCESS EQUIPMENT

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives:

1. Basic laws in thermodynamics.
2. Basic statistical concepts and methods: heat, work, energy, temperature and the kinetic theory of matter; entropy, ensemble, partition function, etc
3. Learning phase transition catalysis
4. Have a good grasp of the basic thermodynamic interactions and process: adiabatic, isothermal, etc

Unit-I: Thermodynamic aspects of phase transitions: Concept of phase, First-order phase transition, conditions for phase coexistence lines, free energy barrier of nucleation, and crystal-melt interfacial free energy, Ehrenfest classification of phase transitions, Van der Waals equation of state, Critical point

Unit-II: Single phase and multiphase catalytic reactions, Acid--base catalysis, Transition metal catalysis, Phase transfer catalysis, Micellar catalysis, Microemulsion catalysis, Electron transfer catalysis, Heteropoly acid catalysis, Homogeneous polymer catalysis, Heterogenisation of homogeneous catalysts.

Unit-III: Applications to Multi-phase Systems Stability conditions for a homogeneous system, equilibrium between phases, phase transformations, general relations for a system with several components, general conditions for chemical equilibrium, chemical equilibrium between ideal gases, and the equilibrium constants in terms of partition functions.

Unit -IV: Phase diagrams and transformations Phase rule- single and binary phase diagrams, lever rule, micro structural changes during cooling, Al_2O_3, Cr_2O_3, Pb-Sn, Ag-Pt and Fe-Fe_3C Systems phase diagrams, phase transformations, corrosion- theories of corrosion, control and prevention of corrosion

UNIT-V: Energy balance - heat capacity and calculation of enthalpy changes, Enthalpy changes for phase transitions, evaporation, clausius - clapeyron equation,

References:

1. Hegedus, L.S., Transition Metals in the Synthesis of Complex Organic Molecules, University Science Book (2010) 3rd ed.
2. Raghavan V., Material Science and Engineering Prentice Hall of India, 1996
3. David.M.Himmelblau, “Basic principles and calculations in chemical engineering”, Prentice Hall of India Ltd., 6th Edition, 1998.

4. A.Hougen, K.M. Watson and K.A.Ragatz, “Chemical Process Principles”, Vol 1, John Wiley, 1960.

Outcomes: At the end of this course, students are able to:

1. The student is expected to obtain considerable insight into various types of phase transitions, and how these can be described theoretically in different ways
2. Predict relationships between physical quantities using the laws and methods of thermodynamics.
3. Find probabilities and thermal quantities (free energy, entropy, etc) given the energy eigen values of a system.
4. The student is expected to obtain considerable insight into various types of phase transitions, and how these can be described theoretically in different ways
5. Predict relationships between physical quantities using the laws and methods of thermodynamics.
6. Find probabilities and thermal quantities (free energy, entropy, etc) given the energy eigen values of a system.

CHPE 42 **PROCESS INTEGRATION**

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives:

1. To introduce to the students, the various opportunities in the process integration in chemical industries.

2. To the make students familiar with the important concepts process integration for heat recovery/minimization.

3. To get familiarize with the case studies.

Unit-I: Introduction to process Intensification and Process Integration (PI). Areas of application and techniques available for PI, onion diagram.

Unit-II: Pinch Technology-an overview: Introduction, Basic concepts, How it is different from energy auditing, Roles of thermodynamic laws, problems addressed by Pinch Technology, Key steps of Pinch Technology: Concept of T_{min} , Data Extraction, Targeting, Designing, Optimization Super targeting, Basic Elements of Pinch Technology: Grid Diagram, Composite curve, Problem Table Algorithm, Grand Composite Curve.

Unit-III: Heat exchanger networks analysis, Maximum Energy Recovery (MER) networks for multiple utilities and multiple, Chemical Engineering Pre-requisites: Knowledge of basic process design of process equipment. Pinches, design of heat exchanger network.

Unit-IV: Heat integrated distillation columns, evaporators, dryers, and reactors.

Unit-V: Waste and waste water minimization, flue gas emission targeting, and heat and power integration. Case studies.

References:

1. Shenoy U.V.;"Heat Exchanger Network Synthesis", Gulf Publishing company.
2. Smith R.;"Chemical Process Design", McGraw-Hill.
3. Linnhoff B., Townsend D. W.,Boland D, Hewitt G. F., Thomas B.E.A., Guy A. R., and Marsland R. H.;"A User Guide on Process Integration for the Efficient Uses of Energy", Inst. of Chemical Engineers.

Outcomes: At the end of this course, students are able to:

1. Maximum heat recovery for a given process (both new processes, and retrofit of existing processes) identify opportunities for integration of high-efficiency energy.
2. Energy-intensive thermal separation operations (distillation, evaporation) at an industrial process site.

3. Evaluate the process integration measures with respect to energy efficiency, greenhouse gas emissions and economic performance.

CHPE 43 **TRANSPORT IN POROUS MEDIA**

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives:

1. Introduce the physics and governing mechanisms controlling flow and transport processes in porous media.
2. Learning Liquid and solute transport in porous media.

Unit-I: Fundamentals: Mass, momentum and energy transport, Darcy and Non-Darcy equations, equilibrium and non-equilibrium conditions, species transport, radioactive decay.

Unit-II: Effective medium approximation: equivalent thermal conductivity, viscosity, dispersion.

Unit-III: Exact solutions: Flow over a flat plate, flow past a cylinder, boundary-layers, reservoir problems.

Unit-IV: Special topics: Field scale and stochastic modeling, Turbulent flow, compressible flow, multiphase flow, numerical techniques, hierarchical porous media, nanoscale porous media, multiscale modeling.

Unit-V: Engineering applications: Groundwater, waste disposal, oil and gas recovery, regenerators,energy storage systems. Experimental techniques: Flow visualization, quantitative methods, inverse parameter estimation.

References:

1. Principles of Heat Transfer in Porous Media, by M. Kaviany, Springer New York (1995).
2. Transport Phenomena in Porous Media, Volumes I-III, edited by D. R. Ingham and I. Pop, Elsevier, New York (1998-2005).
3. Dynamics of Fluids in Porous Media, J. Bear, Dover (1988).
4. Introduction to Modeling of Transport Phenomena in Porous Media, J. Bear and Y. Bachmat, Kluwer Academic Publishers, London (1990).
5. Enhanced Oil Recovery, L.W. Lake, Gulf Publishing Co. Texas (1989).
6. The Mathematics of Reservoir Simulation, R.E. Ewing, SIAM Philadelphia (1983).
7. Stochastic Methods for Flow in Porous Media: Coping with Uncertainties, Zhang, D., Academic Press, California (2002).
8. The Method of Volume Averaging, S. Whitaker, Springer, New York (1999).

Outcomes: At the end of this course, students are able to:

1. Students will understand the mechanisms involved in transport processes in porous media and will be able to work with the equations that govern the fate and transport of gas, water and solutes in porous media.

CHPE 44 MICRO FLOW CHEMISTRY AND PROCESS TECHNOLOGY

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives:

1. Introduce the students to micro flow chemistry and process technology.
2. Learning Micromixers, Mixing Principles.
3. Learning micro reactor based chemicals production

Unit-I: State of the Art of Micro reaction Technology, Structural Hierarchy of Micro reactors, Functional Classification of Micro reactors, Fundamental Advantages of Micro reactors, Advantages of Micro reactors Due to Decrease of Physical Size, Advantages of Micro reactors Due to Increase of Number of Units, Potential Benefits of Micro reactors

Unit-II: Modern Micro fabrication Techniques for Micro reactors, Evaluation of Suitability of a Technique, Anisotropic Wet Etching of Silicon, Dry Etching of Silicon, LIGA Process, Injection Molding, Wet Chemical Etching of Glass, Advanced Mechanical Techniques

Unit-III: Micro mixers, Mixing Principles and Classes of Macroscopic Mixing Equipment, Mixing Principles and Classes of Miniaturized Mixers, Mixing Tee-Type Configuration

Unit-IV: Microsystems for Gas Phase Reactions, Catalyst Supply for Micro reactors , Types of Gas Phase Micro reactors, Micro channel Catalyst Structures, H_2/O_2 Reaction, Selective Partial Hydrogenation of Benzene, Selective Oxidation of 1-Butene to Maleic Anhydride, Selective Oxidation of Ethylene to Ethylene Oxide, Oxidative Dehydrogenation of Alcohols, Synthesis of Methyl Isocyanate and Various Other Hazardous Gases, Synthesis of Ethylene Oxide, Oxidation of Ammonia

Unit-V: Microsystems for Energy Generation, Micro devices for Vaporization of Liquid Fuels, Micro devices for Conversion of Gaseous Fuels to Syngas by Means of Partial Oxidations, Hydrogen Generation by Partial Oxidations, Micro devices for Conversion of Gaseous Fuels to Syngas by Means of Steam Reforming

References:

1. Wolfgang Ehrfeld, Volker Hessel, Holger Löwe MicroreactorsNew Technology for Modern Chemistry © WILEY-VCH Verlag GmbH, D-69469 Weinheim (Federal Republic of Germany), 2000.
2. S.V. Luis and E. Garcia-Verdugo, Chemical Reactions and Processes under Flow Conditions, University Jaume I/CSIC, Castello´n, Spain, The Royal Society of Chemistry 2010
3. Madhvanand N. Kashid, Albert Renken,and Lioubov Kiwi-Minsker, Microstructured Devices for Chemical Processing, Wiley-VCH Verlag GmbH & Co. KGaA, Boschstr ©2015 12, 69469 Weinheim, German.
4. Hessel, V., Renken, A., Schouten, J.C., Yoshida, Micro Process Engineering" A Comprehensive Handbook 2009, ISBN 978-3-527-31550-5.

Outcomes: At the end of this course, students are able to:

1. Students will understand the role of micro flow chemistry and process technology in chemical engineering.
2. The student is expected to obtain considerable insight into various types of micro reactors.

CHPE 45 PROCESS PLANT DESIGN & FLOW SHEETING TOOLS

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives:

1. Understanding of the scope, principles, norms, accountabilities and bounds of contemporary engineering practice in the specific discipline.
2. Application of established engineering methods to complex engineering problem solving.
3. Application of systematic engineering synthesis and design processes.

Unit-I: Introduction: Basic concepts: General design considerations, Process design development, Layout of plant items, Flow sheets and PI diagrams, Economic aspects and Optimum design, Practical considerations in design and engineering ethics, Degrees of freedom analysis in interconnected systems, Network analysis, PERT/CPM, Direct and Indirect costs, Optimum scheduling and crashing of activities.

Unit-II: Hierarchy of chemical process design; Nature of process synthesis and analysis; Developing a conceptual design and flow sheet synthesis. Synthesis of reaction-separation systems; Distillation sequencing; Energy targets. Heat integration of reactors, distillation columns, evaporators and driers; Process change for improved heat integration. Heat and mass exchange networks and network design.

Unit-III: Flow-sheeting: Synthesis of flow sheet: Propositional logic and semantic equations, Deduction theorem, Algorithmic flow sheet generation using P-graph theory, Sequencing of operating units, Feasibility and optimization of flow sheet using various algorithms viz, Solution Structure Generation (SSG), Maximal Structure Generation (MSG), Simplex, Branch-and-bound etc.

Unit-IV: Analysis of Cost estimation: Factors affecting Investment and production costs, Estimation of capital investment and total product costs, Interest, Time value of money, Taxes and Fixed charges, Salvage value, Methods of calculating depreciation, Profitability, Alternative investments and replacements.

Unit- V: Optimum Design and Design Strategy: Break-even analysis, Optimum production rates in plant operation, Optimum batch cycle time applied to evaporator and filter press, Economic pipe diameter, Optimum insulation thickness, Optimum cooling water flow rate and optimum distillation reflux ratio.

References:

1. Peters, M.A. and Timmerhaus, K.D., Plant Design and Economics for Chemical Engineers, McGraw Hill (2003).
2. Anil Kumar, Chemical Process Synthesis and Engineering Design, Tata McGraw Hill (1982).

3. Ulrich, G.D., A Guide to Chemical Engineering Process Design and Economics, John Wiley & Sons (1984).
4. Perry, R.H. and Green, D., Chemical Engineer's Handbook, McGraw-Hill (1997).

Outcomes: At the end of this course, students are able to:

1. Analyze, synthesize and design processes for manufacturing products commercially
2. Integrate and apply techniques and knowledge acquired in other courses such as thermodynamics, heat and mass transfer, fluid mechanics, instrumentation and control to design heat exchangers, plate and packed columns and engineering flow diagrams
3. Use commercial flow sheeting software to simulate processes and design process equipment
4. Recognize economic, construction, safety, operability and other design constraints
5. Estimate fixed and working capitals and operating costs for process plants

CHPE 47 **MEMBRANE SEPARATIONS**

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Course Educational Objectives ; Students will have to learn the following

1) Learn the Properties of Membrane and Types of Membrane
2) Learn the Types of Filtrations used
3) Design Reverse Osmosis Module
4) Learn Gas Separation and Pervaporation
5) Understand different Membrane Processes

UNIT I :

OverView of Membrane Separations

Membrane Types, Materials, Preparation and Characterization - Types of Synthetic Membranes – Membrane Modules – Typical Flow patterns – Membrane materials – Pore Characteristics – Membrane Manufacture – Measurement of Pore size and Solute rejection Properties – surface Properties measurement and interpretation

UNIT II :

Nano Filtration – principles – nano-filtration membranes – Mass Transfer – Process Limitations – Industrial application

Ultrafiltration - Basic Principles – Membranes – Configuration – Types of Devices – Factors affecting performance – Flux – Models for Solvent Flux – Fouling and Flux decline – Methods to reduce Concentration Polarization – Energy Considerations – Micellar enhanced UF – Affinity UF – Applications

Microfiltration – Basic Principles – Membranes – Transport Mechanism – retention characteristics – Flow Characteristics – Membrane Plugging and Throughput – Fouling – energy Considerations – Applications

UNIT III :

Reverse Osmosis - Concepts – Phenomenon of RO – Models for RO transport – Design and Operating parameters – Concentration Polarization – Membrane plugging – Equivalent work requirement – Design of an RO module – RO of non-aqueous systems – Osmotic pinch effect – Forward osmosis – Applications

Dialysis – Principles – Dialysis systems – Membranes – Mass transfer – Applications – Diffusion dialysis

UNIT IV :

Gas Separation - Basic Principles – Membranes – Membrane Modules – Fundamental Mechanisms of Gas Transport - Factors affecting Gas Permeation – Complete Mixing Model – Cross and Countercurrent models – Applications

Pervaporation - Basic Principles – Advantages – Membrane characteristics – Thermodynamic Considerations – Mass transfer – Thermodynamic Considerations – Design of a Module – Concentration Polarization – factors affecting pervaporation – Temperature drop at the interface – Applications

UNIT V :

Ion Exchange Membrane Process - Basic Principles – Ion exchange Membranes – Energy requirement, Efficiency- Concentration Polarization and limiting current density – Other operating parameters – applications

Liquid Membranes - Types of liquid membranes – Mechanism of Mass transfer – Applications

Other Membrane Processes – Membrane contactor and applications – Membrane distillation – Membrane reactors – PEM Hydrogen Fuel Cell

Text Book

1. Membrane Separation Processes – Kaushik nath – Prentice Hall, 2008

References

1. Reverse Osmosis and Synthetic Membranes Theory, Technology and Engineering, Sourirajan,S National Research Council, Canada.

2. Reverse Osmosis/ Ultrafiltration Process Principles, Sourirajan,S. and Matsuura, T., National Research Council, Canada. Separation Processes, Elsevier Scientific Publication.
3. Industrial Membrane Separation Technology, Scott,K., and Hughes, R. (Eds.), Blackie Academic & Professional London.
4. Separation Processes, King, C.J, Tata McGraw Hill, New Delhi.
5. Membrane Processes, Rautenbatch, R., and Albrecht, R John Wiley & Sons, New York.
6. Membrane Separation Processes, Baum,B., Halley, W. and White, R.A, Elsevier Scientific Publication

Course Objectives : Students gain

1) Knowledge on Preparation and Characterization of Materials and Types of Membrane
2) Knowledge on Nano-Filtration, Ultra-Filtration and Micro-Filtration
3) Knowledge on Designing Reverse Osmosis and Dialysis
4) Concepts of Gas Separation and Pervaporation and Design of Pervaporation Module
5) Knowledge on Ion Exchange Membrane Process, Liquid Membranes and Other Membrane Processes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1	1	1	2								
CO2	1	2	1									
CO3			2	1		1						
CO4		1		2								
CO5			2		1							

CHPE 51 DESIGN OF EXPERIMENTS AND PARAMETER ESTIMATION

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives:

This subject provides students with the knowledge to

1. Use statistics in experimentation;
2. Understand the important role of experimentation in new product design, manufacturing process development, and process improvement;
3. Analyze the results from such investigations to obtain conclusions; become familiar methodologies that can be used in conjunction with experimental designs for robustness and optimization.

Unit-1: Design of experiments. Basic concepts, Bias and confounding, controlling bias, causation, Examples. Random Variables: Introduction to discrete and continuous random variables, quantify spread and central tendencies of discrete and continuous random variables.

Unit-2: Exploratory Data Analysis Variable types, Displaying the distribution, mean variance and typical spread, quartiles and unusual spread, multivariate data: finding relations. Probability Definition of a random variable, expectation, percentiles, common distributions such as the binomial, Poisson and normal distributions.

Unit-III: Point Estimation Estimators as random variables, sample mean and the central limit theorem, normal approximations, assessing normality. Interval Estimation Confidence intervals for the mean when the variance is known, confidence interval for the mean when the variance is unknown, confidence intervals for a single proportion, sample size, Student distribution. Hypothesis Testing Hypothesis testing for a mean or proportion, testing the equality of two means assuming equal variances, testing the equality of two means with unequal variances, comparison of two proportions.

Unit-IV: Linear Regression analysis: The linear regression model, Parameter estimation, accuracy of the coefficient estimates, checking the model, multiple linear regression, confidence and prediction intervals, potential issues, high leverage points, outliers. Matrix approach to linear regression, Variance-Covariance matrix, ANOVA in regression analysis, quantifying regression fits of experimental data, Extra sum of squares approach, confidence intervals on regression coefficients, lack of fit analysis.

Unit-V: Response Surface Methodology: Method of steepest ascent, first and second order models, identification of optimal process conditions

References:

1. Hanneman, Robert A., Kposowa, Augustine J., Riddle, Mark D. (2012). Research Methods for the Social Sciences: Basic Statistics for Social Research. John Wiley & Sons.

2. Saunders, Mark, Brown, Reva Berman (2007). Dealing with Statistics: What You Need to Know. McGraw-Hill Education.

3. Cowles, Michael (2000). Statistics in Psychology: An Historical Perspective (2nd Edition). Lawrence Erlb

Outcomes: At the end of this course, students are able to:

1. Plan experiments for a critical comparison of outputs
2. Include statistical approach to propose hypothesis from experimental data
3. Implement factorial and randomized sampling from experiments
4. Estimate parameters by multi-dimensional optimization

CHPE 52 **COMPUTER AIDED DESIGN**

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives:

1. To understand importance and applications of CAD in the field of chemical engineering
2. To understand the basic structure and components of CAD software
3. To understand the underlying thermodynamic and physical principles To give insight into the approaches used in the simulation of flow sheets
4. To understand flow charts, computer languages and numerical methods used for writing algorithms

Unit I :;;Introduction

Introduction to CAD, Scope and applications in chemical Engineering, Mathematical methods used in flow sheeting and simulation, Introduction to solution methods for linear and non-linear algebraic equations, solving one equation one unknown, solution methods for linear and nonlinear equations, general approach for solving sets of differential equations, solving sets of sparse non-linear equations.

Unit II: Properties Estimation

Physical properties of compounds, Thermodynamic properties of gases and binary mixtures, Viscosity, Vapour pressure, Latent heat, Bubble point and drew point calculation, phase equilidria, Vapour-liquid equilibria, Liquid phase activity coefficients, K-values, Liquid phase activity coefficients, K-values, Liquid-Liquid equilidria, Gas solutions.

Unit III : Equipment Design

Computer aided Design of Equipment: Design of Shell and Tube Heat exchangers; Design of Evaporators; Design of Distillation columns; Design of Reactors, Design of adsorption columns. Distillation columns (specific attention to multi components systems. Heat exchangers)

Unit IV : Computer Aided Flow Sheet Synthesis

Computerized physical property systems – physical property calculations, degrees of freedom in process design, degrees of freedom for a unit, degrees of freedom in a flow sheet, steady state flow sheeting and process design, approach to flow sheeting systems, introduction to sequential modular approach, simultaneous modular approach and equation solving approach, sequential modular approach to flow sheeting, examples. Tear streams, convergence of tear streams, partitioning and tearing of a flow sheet, partitioning and precedence ordering, tearing a group of units. Flow sheeting by equation solving methods based on tearing.

Unit V : Dynamic Simulation

Numerical recipes in CLinear and nonlinear equations, Ordinary and partial differential equations, Dynamic simulation of stirred tanks system with heating Multi component system, Reactors, Absorption and distillation columns, Application of orthogonal collocation and weighted residuals techniques in heat and mass transfer systems, Introduction to special software for steady and dynamic simulation of Chemical engineering systems. Introduction to various commercial design software and optimizers used in field of chemical engineering.

References

1. Douglas James M., “Conceptual design of Chemical Processes", McGraw -Hill Book Company, New York, 1988
2. Remirez, W.F. - " Computational methods for Process Simulations ", Butterworths, New York, 1989
3. Sinnott R.K. "Chemical Engineering”, Volume 6, Pergamon Press, New York, 1989
4. Westerberg A.W., et al, “Process Flow Sheeting”, Cambridge University Press
5. Biegler Lorenz T, et al, “Systematic method of Chemical Process Design”, Prentice Hall
6. Crowe C.M., et al, “Chemical Plant Simulation-An Introduction to Computer Aided Steady State Analysis”, Prentice Hall
7. Anil Kumar, “Chemical Process Synthesis and Engineering Design”,TMH,1981

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

1. Students get the knowledge about computer Aided Flow Sheet Synthesis
2. Computer aided equipment design of Evaporators; Distillation columns; Reactors, adsorption columns.

CHPE 53 **CLEANER PRODUCTION**

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives

1. To give student an understanding about the concept of cleaner production.
2. To understand in detail, the methodologies involved
3. Financial evaluation of cleaner production technologies
4. To study the practical applications of cleaner production technologies

Unit I : Introduction

Cleaner production definition: Evaluation of cleaner production, Cleaner production network, Area covered by cleaner production (what is not cleaner production?).Difference between cleaner production and other methods, End of the pipe treatment to curb pollution, prerequisites of cleaner production.

Unit II : Cleaner production technique

Waste reduction at source, (a) Good housekeeping, (b) Process changes: change in raw material,

batter process, control, equipment modification and technology changes, Recycling: on site recovery and reuse creation of useful byproducts, Product modification.

Unit III : Cleaner production methodology

Methods of environmental protection -- preventive strategy, Methods of environmental protection -- preventive strategy, making team for cleaner production, Analyzing process steps, Generating C.P opportunities

Selection of C.P solution, Implementing C.P solution

Unit IV : Concept of cleaner production

Overview of CP Assessment Steps and skills, Preparing for the site visit, Information Gathering, and process flow diagram, material balance, CP Option Generation Technical and Environmental feasibility analysis-Economic valuation of alternatives fuels, Total cost analysis-CP Financing-Establishing a program-Organizing a program preparing a program plan-Measuring progress-pollution prevention and cleaner production Awareness plan -Waste audit-Environmental Statement. Energy audit related tocleaner production, Energy audit's need and scope, Types of energy audit. Preliminary or walk through energy audit. Detailed energy audit, Methodology of energy audit, Energy balance and identifying the energy conservation opportunities.

Unit V : Financial analysis of cleaner production

Gathering base line information, Determining the capital or investment cost, Establishing lifetime of equipment and annual depreciation, Determine revenue implication of the project.

Estimating change in operating cost, Calculating incremental cash flow, Assessing project's viability.

Case studies and Cleaner Production applications

Application (Industrial application of CP,LCA,EMS and Environmental Audits. C.P in chemical process industry, Practical ways & means to save material loss in loading/unloading and unit operations equipment like distillation column, drying and other equipments like heat exchanger, vacuum unit, conveying, etc. Practical ways & means for energy saving in industries. Case Studies of cleaner production.

References

1. "Cleaner Production Worldwide", 1993, United Nations Environment Programme, Industry and Environment, Paris, France, 1993
2. "Cleaner Production: Training Resource Package", UNEP IE, Paris, 1996
3. "Clean Technology for manufacture of Specialty Chemicals", Editor-W. Hoyle and M. Lancaster, Royal Society of Chemistry, U.K
4. Randall Paul M, "Engineers Guide to Cleaner Production Technologies".
5. Ahluvalia V. K., "Green Chemistry: Environmentally Benign Reactions".
6. Sanders R.E., "Chemical Process Safety: Learning from case Histories", Oxford Butter Worth Publication
7. "Training Manual Package" by NCPC

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

1. Explain the concept and principles of cleaner production.
2. Suggest different unit operations in industrial production process to minimize pollutions.
3. Plan good housekeeping practices for Industry/other places with concern of safety, hygiene and waste reduction.
4. Suggest basic methods and techniques of pollution prevention during production.
5. Suggest cleaner production methods for a given situation which will also lead to cost reduction in long run

CHPE 54 **FUEL CELL SYSTEMS**

Instruction : 4 Hr/week Credits : 4 Assessment : 40 + 60

Course Objectives ; Students will have to learn the following

1) Understand the Thermodynamic Aspects of Electrochemical Energy Conversion
2) Learn the Working Principle of Fuel Cell and Mechanisms of Electrode Reactions
3) Understand the Technology of Phosphoric acid and Solid Oxide Fuel Cells
4) Learn the Non Catalytic Aspects and Engineering Aspects of DMFC
5) Develop Modeling for PEMFC

UNIT-I

Introduction – Fuel Cells- Relevance and Importance – Historical Highlights - Difference from Batteries – Fuel Choice – Classification

Electrochemistry – Thermodynamic Aspects of Electrochemical(EC) Energy Conversion – Theoretical Efficiency of Heat of a Reaction to Mechanical Energy – Efficiency of EC Energy Conversion – Factors Affecting Efficiency of EC Energy Conversion Electrode Kinetics of EC Energy Conversion

UNIT-II

Alkaline Fuel Cells – Description – Working Principle – Components - Modules – Fuel Cell Stacks – General Performance Characteristics – Advancements – System Issues – Ammonia as AFC Fuel

Molten Carbonate Fuel Cells – General Principle – Cell Components – Mechanisms of Electrode Reactions- Status

UNIT-III

Phosphorus Acid Fuel Cells- Technology- Electrode Materials and Manufacturing – Stacks and Systems

Solid Oxide Fuel Cells – History – Advantages and Limitations- Cell Components – Electrode Materials – Interconnects – Fuel – Configuration and Performance – Environmental Impact – Applications

UNIT-IV

Direct Methanol Fuel Cells – Technology Evolution – The Noble Metal Issue- The Catalyst – Electro-oxidation of Methanol – The Electrolyte – Non Catalytic Aspects – Methanol Cross over to DMFC – catalyst Optimization and Scale up – Engineering Aspects

UNIT-V

Proton Exchange Membrane Fuel Cells – Basic Scientific aspects- Challenges – Technology Development – Fuel Processing – Modeling Studies of PEMFC Performance – Applications – Challenges to High Temperature Operations – Technological and Economic Challenges

Text Book :

1. Fuel Cell : Principles and Applications – B.Viswanathan and M. Aulice Scibioh – Universities Press - 2006

Course Outcomes : Students will be able to

1) Classify Fuel Cells, and understand factors affecting efficiency of electrochemical energy
2) Construct, operate AFC & MCFC
3) Gain knowledge on manufacturing and materials, environmental impacts and applications of PAFC & SOFC
4) Gain knowledge on electrode- oxidation of methanol and crossover to DMF and Engineering Aspects
5) Gain knowledge on Technological and Economical Challenges on PEMFC

CHPE 56 **BIOPROCESS ENGINEERING**

Instruction , hours/week : 3 Credits : 3 Assessment : 40 + 60

Objectives

1. To learn the principles of bioprocessing for traditional chemical engineering in the design and development of processes involving biocatalyst.
2. To study engineering principles in the development of products based on living cells or subcomponents of such cells.
3. To learn and develop quantitative models and approaches related to bioprocesses
4. To learn mechanisitic models for enzyme catalyzed reactions for large scale production of bioproducts

Unit I : Introduction:

Biotechnology and bioprocessing. An overview of biological basics. Basics of enzyme and microbial kinetics. Operating considerations for bioreactors: cultivation method, modifying batch and continuous reactors, immobilized cell systems, solid state fermentations.

Unit II : Advance Enzyme Kinetics

Models for complex enzyme kinetics, modeling of effect of pH and temperature, models for insoluble substrate, models for immobilized enzyme systems, diffusion limitations in immobilized enzyme system, electrostatic and steric effects.

Unit III : Bioreactors

Selection, scale-up, operation and control of bioreactors: Scale-up and its difficulties, bioreactor instrumentation and control, sterilization of process fluids.Modifications of batch and continuous reactors, chemostat with recycle, multistage chemostat, fed-batch operation, perfusion system, active and passive immobilization of cells, diffusional limitations in the immobilized system, solid state fomenters.

Unit IV : Homogeneous and heterogeneous reactions in bioprocesses

Reaction thermodynamics, growth kinetics with Plasmid instability, The Thiele Modulus and effectiveness factor, diffusion and reaction in waste treatment lagoon. Reactors and choice of reactors.

Unit V : Recovery and purification of products:

Strategies to recover and purify products, separation of insoluble products, cell disruption, separation of soluble products.

References

1. Bailey J.E. and Ollis D.F., “Biochemical Engineering Fundamentals”, McGraw-Hill
2. Doran P.M., “Bioprocess Engineering Principles”, Academic Press
3. Shuler M.L., Kargi F., ”Bioprocess Engineering”, Prentice -Hall

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

1. Understand the different cells and their use in biochemical processes.
2. Understand the role of enzymes in kinetic analysis of biochemical reaction.
3. Analyze bioreactors, upstream and downstream processes in production of bio-products
4. Demonstrate the fermentation process and its products for the latest industrial revolution

OPEN ELECTIVES

PGOP 11 **BUSINESS ANALYTICS**

Teaching scheme

Objectives :

1. Understand the role of business analytics within an organization.
2. Analyze data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization.
3. To gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making.
4. To become familiar with processes needed to develop, report, and analyze business data.
5. Use decision-making tools/Operations research techniques.
6. Mange business process using analytical and management tools.
7. Analyze and solve problems from different industries such as manufacturing, service, retail, software, banking and finance, sports, pharmaceutical, aerospace etc.

Unit I :

Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics.

Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.

Unit II :

Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression.

Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.

Unit III :

Organization Structures of Business Analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring. Data Quality, Measuring Contribution of Business Analytics, Managing Changes

Descriptive Analytics, Predictive Analysis, Predictive Modeling, Predictive Analytics Analysis, Data Mining , Data Mining Methodologies, Prescriptive Analysis and its step in the business analytics process, Prescriptive Modeling, Nonlinear Optimization

Unit IV :

Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model.

Unit V : Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making

Unit V : Recent Trends in : Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism

References :

1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.
2. Business Analytics by James Evans, persons Education.

Outcomes :

1. Students will demonstrate knowledge of data analytics.
2. Students will demonstrate the ability of think critically in making decisions based on data and deep analytics.
3. Students will demonstrate the ability to use technical skills in predicative and prescriptive modeling to support business decision-making.
4. Students will demonstrate the ability to translate data into clear, actionable insights.

PGOP 13 OPERATIONS RESEARCH

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

1. Students should able to apply the dynamic programming to solve problems of discreet and continuous variables.
2. Students should able to apply the concept of non-linear programming
3. Students should able to carry out sensitivity analysis
4. Student should able to model the real world problem and simulate it.

Unit 1:

Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models

Unit 2

Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming

Unit 3:

Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT

Unit 4

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

Unit 5

Competitive Models, Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation

References:

1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009

5. Pannerselvam, Operations Research: Prentice Hall of India 2010

6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010

PGOP 14 COST MANAGEMENT IN ENGINEERING PROJECTS

Introduction and Overview of the Strategic Cost Management Process

Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution : conception to commissioning. Project execution as conglomeration of technical and non technical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team : Role of each member. Importance Project site : Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process

Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

References:

1. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi

2. Charles T. Horngren and George Foster, Advanced Management Accounting
3. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
4. Ashish K. Bhattacharya, Principles & Practices of CostAccounting A. H. Wheeler publisher
5. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

PGOP15 **COMPOSITE MATERIALS**

UNIT–I: INTRODUCTION: Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

UNIT – II: REINFORCEMENTS: Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

UNIT – III: Manufacturing of Metal Matrix Composites: Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.

UNIT–IV: Manufacturing of Polymer Matrix Composites: Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.

UNIT – V: Strength: Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

TEXT BOOKS:

1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.

References:

1. Hand Book of Composite Materials-ed-Lubin.
2. Composite Materials – K.K.Chawla.
3. Composite Materials Science and Applications – Deborah D.L. Chung.
4. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi.

PGOP16 **WASTE TO ENERGY**

Unit-I: Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors **Unit-II:** Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

Unit-III: Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

Unit-IV: Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

Unit-V: Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

References:

1. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.

PGPA 13 SANSKRIT FOR TECHNICAL KNOWLEDGE

Course Objectives

1. To get a working knowledge in illustrious Sanskrit, the scientific language in the world
2. Learning of Sanskrit to improve brain functioning
3. Learning of Sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power
4. The engineering scholars equipped with Sanskrit will be able to explore the huge knowledge from ancient literature

Syllabus

Alphabets in Sanskrit, Past/Present/Future Tense, Simple Sentences

Order, Introduction of roots, Technical information about Sanskrit Literature

Technical concepts of Engineering-Electrical, Mechanical Architecture, Mathematics

Suggested reading

1. "Abhyaspustakam" – Dr.Vishwas, Samskrita-Bharti Publication, New Delhi

2. "Teach Yourself Sanskrit" Prathama Deeksha-Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication

3. "India's Glorious Scientific Tradition" Suresh Soni, Ocean books (P) Ltd., New Delhi.

Course Output

Students will be able to

1. Understanding basic Sanskrit language
2. Ancient Sanskrit literature about science & technology can be understood
3. Being a logical language will help to develop logic in students

PGPA 14 VALUE EDUCATION

Course Objectives

Students will be able to

1**.**Understand value of education and self- development

2. Imbibe good values in students

3. Let the should know about the importance of character

Syllabus

Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of Moral and non- moral valuation., Standards and principles humanism. Value judgments.

Importance of cultivation of values, Sense of Duty, Devotion, Reliance, .Confidence, Concentration,

Truthfulness, Cleanliness, Honesty ,Humanity, Power of faith, National Unity, Patriotism, Love for nature , Discipline

Personality and Behaviour Development - Soul and Scientific attitude, .Positive Thinking. Integrity and discipline Punctuality, Love and Kindness

Avoid fault Thinking Free from anger, Dignity of labour Universal brotherhood and religious tolerance True friendship Happiness Vs suffering, love for truth Aware of self-destructive habits, Doing best for saving nature

Character and Competence –Holy books vs Blind faith Self-management and Good health

Science of reincarnation. Equality ,Non violence ,Humility, Role of Women. All religions and same message Mind your Mind ,Self-control Honesty, Studying effectively

S**uggested reading**

1 Chakroborty , S.K. "Values and Ethics for organizations Theory and practice", Oxford University Press ,New Delhi

Course outcomes ; Students will be able to

1.Knowledge of self-development 2.Learn the importance of Human values

3.Developing the overall personality

PGPA 21 **CONSTITUTION OF INDIA**

Course Objectives: Students will be able to:

1. Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.

2. To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism

3. To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution

History of Making of the Indian Constitution - : History - Drafting Committee, (Composition & Working

Philosophy of the Indian Constitution - Preamble - Salient Features

Contours of Constitutional Rights & Duties - Fundamental Rights - Right to Equality - Right to Freedom - Right against Exploitation- ight to Freedom of Religion -Cultural and Educational Rights Right to Constitutiona Remedies Directive Principles of State Policy Fundamental Duties

Organs of Governance Parliament Composition Qualifications and Disqualifications Powers and Functions Executive President Governor Council of Ministers Judiciary, Appointment and Transfer of Judges, Qualifications Powers & Functions

Local Administration – Districts, Administration Head Role & Importance,

Municipalities – Introduction , Mayor and Role of Elected Representatives, CEO of Municipal Corporation,

Panchayat Raj, Introduction, PRI, Zilla Parishad,

Elected Officials and their roles, CEO Zillaparishad, Position and Role

Block Level – Organizational Heirarchy (Different Departments)

Village Level – Role of Elected and appointed Officials

Importance of Grass Root Democracy

Election Commission Election Commission: Role and Functioning Chief Election Commissioner

and Election Commissioners

Suggested reading

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

Course Outcomes:

Students will be able to:

1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.

2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.

3. Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.

4. Discuss the passage of the Hindu Code Bill of 1956.

PGPA 22 PEDAGOGY STUDIES

Course Objectives: Students will be able to:

1. Review existing evidence on the review topic to inform programme design and policy making undertaken by the DfID, other agencies and researchers.
2. Identify critical evidence gaps to guide the development

Introduction and Methodology: Aims and rationale, Policy background, Conceptual framework and terminology Theories of learning, Curriculum, Teacher education. Conceptual framework, Research questions**.** Overview of methodology and Searching

Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries Curriculum, Teacher education.

Evidence on the effectiveness of pedagogical practices Methodology for the in depth stage: quality assessment of included studies How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? Theory of change. Strength and nature of the body of evidence for effective pedagogical practices Pedagogic theory and pedagogical approaches Teachers' attitudes and beliefs and Pedagogic strategies.

Professional development: alignment with classroom practices and follow- up support Peer support Support from the head teacher and the community Curriculum and assessment Barriers to learning: limited resources and large class sizes

Research gaps and future directions Research design Contexts Pedagogy Teacher education Curriculum and assessment Dissemination and research impact

Suggested reading

1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2): 245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361-379.
3. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272–282.

5. Alexander RJ (2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.
6. Chavan M (2003) Read India: A mass scale, rapid, 'learning to read' campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf.

Course Outcomes:

Students will be able to understand:

1.What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?

2. What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?

3. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

PGPA 24 PERSONALITY DEVELOPMENT THROUGH LIFE ENHANCEMENT SKILLS

Course Objectives

1. To learn to achieve the highest goal happily
2. To become a person with stable mind, pleasing personality and determination
3. To awaken wisdom in students

Syllabus

Neetisatakam-Holistic development of personality Verses- 19,20,21,22 (wisdom) Verses- 29,31,32 (pride & heroism) Verses- 26,28,63,65 (virtue) Verses- 52,53,59 (dont's)m Verses- 71,73,75,78 (do's)

Approach to day to day work and duties.- Shrimad Bhagwad Geeta: Chapter 2-Verses 41,47,48 Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,1723, 35, Chapter 18-Verses 45, 46, 48.

Statements of basic knowledge Shrimad Bhagwad Geeta : Chapter2-Verses 56, 62, 68 Chapter 12 -Verses 13, 14, 15, 16,17, 18 Personality of Role model. Shrimad Bhagwad Geeta Chapter2-Verses 17,Chapter 3-Verses 36,37,42 Chapter 4-Verses 18, 38,39 Chapter18 – Verses 37,38,63

Suggested reading

1. "Srimad Bhagavad Gita" by Swami Swarupananda Advaita Ashram (Publication Department), Kolkata

2. Bhartrihari's Three Satakam (Niti-sringar-vairagya) by P.Gopinath, Rashtriya Samskrit Sansthanam, New Delhi.

Course Outcomes

Students will be able to

1. Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life

2. The person who has studied Geeta will lead the nation and mankind to peace and prosperity
3. Study of Neetishatakam will help in developing versatile personality of students.

****