Department of Chemical Engineering

Haldia Institute of Technology

M. Tech. Course curriculum under autonomy

M. Tech**. First year (Semester I)**

Theory Papers

Sl No.	Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
1	CHE 01	Adv. Heat Transfer	3 - 0 - 0	3	100	3
2	CHE 02	Adv. Process Control	3 - 0 - 0	3	100	3
3	CHE 03	Adv. Fluid Mechanics	3 - 0 - 0	3	100	3
4	CHE 04	Adv. Num. Methods in Chem. Engineering	3 - 0 - 0	3	100	3
5	CHE 05	Core Elective I	3 - 0 - 0	3	100	3
6	CHE A1	Audit course 1	2 - 0 - 0	0	100	2
Total				15	600	17

Practical/Sessional papers

Sl No.	Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
1	CHE 06	Process Control Lab	0 – 0 - 3	2	100	3
2	CHE 07	Adv Chemical Engg. Lab	0 – 0 - 3	2	100	3
3	CHE 08	Seminar	0 – 0 - 3	2	100	3
Total				6	300	9

Core Elective I:

Any one of the following

Sl No.	Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
1	CHE 05.1	Process Modelling and Simulation	3 - 0 - 0	3	100	3
2	CHE 05.2	Bioprocess Engineering	3 - 0 -0	3	100	3
3	CHE 05.3	Petroleum Refinery Engineering and Petrochemicals	3 - 0 -0	3	100	3
4	CHE 05.4	Cleaner Production	3 - 0 -0	3	100	3

Total credit = 15 + 6 = 21

M. Tech. First year (Semester II)

Theory Papers

Sl No.	Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
1	CHE 09	Adv Reactor Design & Analysis	3 - 0 - 0	3	100	3
2	CHE 10	Adv. Separation Processes	3 - 0 -0	3	100	3
3	CHE 11	Core Elective II	3 - 0 -0	3	100	3
4	CHE 12	Core Elective III	3 - 0 -0	3	100	3
5	CHE 13	Open Elective	3 - 0 -0	3	100	3
6	CHE A2	Audit course 2	2 - 0 -0	0	100	2
Total				15	600	

Practical/ Sessional papers

Sr no.	Course Code	Course title	Hours/week L:T:P	Credit	marks	Total contact hours/week
1	CHE 14.1 Or CHE 14.2	Instrumental Methods of Analysis Lab. Or Petroleum Engg.lab	0 – 0 - 3	2	100	3
2	CHE 15.1 Or CHE 15.2	Env. Engg.& Pollution Con. Lab. Or Adv. Numerical Lab	0 – 0 - 3	2	100	3
Total				4	200	

Core Elective II :

Any one of the following

Sl No.	Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
1	CHE 11.1	Project Engineering	3 - 0 -0	3	100	3
2	CHE 11.2	Fluidization Engineering	3 - 0 -0	3	100	3
3	CHE 11.3	Industrial Pollution Control	3 - 0 -0	3	100	3
4	CHE 11.4	Computer Aided Process Design	3 - 0 -0	3	100	3

Core Elective III:

Any one of the following

Sl No.	Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
1	CHE 12.1	Adv.Energy Engineering and energy management	3 - 0 -0	3	100	3
2	CHE 12.2	Process Plant Design and Flow-sheeting	3 - 0 -0	3	100	3
3	CHE 12.3	Application of Nanotechnology in Chemical Engg.	3 - 0 -0	3	100	3
4	CHE 12.4	Adv. Concepts of Catalysis and	3 - 0 -0	3	100	3

		Surface Phenomenon				

Open Elective:

Any one of the following

Sl No.	Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
1	CHE 13.1	Business Analytics	3 - 0 -0	3	100	3
2	CHE 13.2	Composite Materials	3 - 0 0	3	100	3
3	CHE 13.3	Operations Research	3 - 0 0	3	100	3
4	CHE 13.4	Cost Management of Engineering Projects	3 - 0 0	3	100	3
5	CHE 13.5	Waste to Energy	3 - 0 -0	3	100	3

Total credit = 15 + 4 = 19

M. Tech. Second year (Semester III)

Theory Papers

Sl No.	Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
1	CHE 16	Core Elective IV	3 - 0 - 0	3	100	3
2	CHE 17	Mathematical and Statistical Methods in Chemical Engineering	3 - 0 -0	3	100	3
3	CHE 18	Research Methodology and IPR	2 – 0 - 0	2	100	2
Total				8	300	

Practical/ Sessional papers

Sl No.	Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
1	CHE 19	Project Work –Phase I and Thesis	0 – 0 - 0	8	100	20
2	CHE 20	Project Seminar –Phase I	0 – 0 - 0	2	100	
Total				10	200	

Core Elective IV:

Any one of the following

Sl No.	Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
1	CHE 16.1	Adv. Transport Phenomena	3 - 0 -0	3	100	3
2	CHE 16.2	Safety in Process Industries	3 - 0 -0	3	100	3
3	CHE 16.3	High polymer engg.	3 - 0 -0	3	100	3
3	CHE 16.4	Computational fluid dynamics	3 - 0 -0	3	100	3

Total credit = 10 +8 = 18

M. Tech. Second year (Semester IV)

Practical/ Sessional papers

Sl No.	Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
1	CHE 21	Project Work – Phase II	0 – 0 - 0	10	100	27
2	CHE 22	Project Thesis and Project Viva Voce	0 – 0 - 0	2	100	
3	CHE 23	Comprehensive Viva Voce	0 – 0 - 0	2	100	
Total				14	300	

Total credit = 14

Note: For Lab subjects Five Experiments are to be designed and performed in each course

Total credit

Semester	Theory	Practical/ Sessional	Total
First	15	6	21
Second	15	4	19
Third	10	8	18
Fourth		14	14
Total credit			72

Audit course (CHE A1 and CHE A2)

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

*****

Detailed Syllabus
First semester

Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
CHE 01	Adv. Heat Transfer	3-0-0	3	100	3

Course Objectives:

This course prepares the student to:

- Enhance the understanding of heat transfer processes and their relevance to industrial problems
- Understand the derivation and physical meaning of energy transport equations. Strengthen analytical, numerical and computational skills to solve complex heat transfer problems
- Provide experience in treating multimode heat transfer effects and in solving realistic engineering problems

Course Outcomes:

At the completion of this course, students should be able to:

- Understand the basic concepts of heat transfer and develop the ability to apply the basic principles of classical heat transfer in real engineering application
- Identify the various mechanisms of heat transfer to formulate and build up its mathematical model in different heat transfer mode.
- Apply analytical and numerical methods to solve industrial problems.
- Combine mass transfer and fluid mechanics principles to analyse heat convection, condensation and radiation processes.

.

Contents:

Unit I **10 L**

Steady state conductive heat transfer with heat generation. Unsteady state heat transfer in different coordinates. Solution of unsteady state partial differential heat transfer equation using analytical and numerical methods.

Unit II **10 L**

Free convective heat transfer under different situations and application of dimensional analysis to estimate the convective heat transfer coefficients. Forced convective heat transfer in laminar-transition and turbulent zone. Heat transfer factor: Reynold's no. plot. Analogy equation for Heat Momentum transfer.

Unit III **10 L**

Convective heat transfer in molten method, Boiling heat transfer with particular reference to Nucleate and film boiling and estimation of boiling heat transfer coefficient. Heat transfer from condensing vapours. Nusselt equation for film type condensation of vapors over vertical surfaces and inclined

tubes. Selection and design of condensers, single pass and multipass heat exchangers. Heat transfer in packed bed.

Unit IV **10 L**

Radiation heat transfer. Estimation of view factors and emissivity factors for different situation. Radiation shield and radiation error in pyrometry. Combined conduction, convection and radiation heat transfer. Convection and radiation furnaces – design considerations.

Books Recommended

1. Bird R B, Stewart W E and Light fort R N, "Transport Phenomena", John Wiley and Sons (2002).
2. Welty J R , Wilson R E and Wicks C E , "Fundamentals of Momentum , Heat and Mass Transfer", 4 th ed,John Wiley and Sons (2001).
3. John C Slattery, "Momentum, Energy and Mass transfer in continua", McGraw Hill, Co. (1972).
4. Bennet C U and Myers J E, " Momentum, Heat and Mass Transfer" Tata McGraw Hill Publishing Co. (1975)
5. Robert S Brodkey and Harry C Hersing, " Transport Phenomena a Unified approach" McGraw Hill Book Co. (1988).
6. Holman J P, "Heat Transfer", McGraw Hill Book Co. (1992).
7. Incropera F P and DeWitt D P, "Introduction to Heat Transfer," 2nd Ed John Wiley New York (1996).

*****

Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
CHE 02	**Adv. Process Control**	**3-0-0**	**3**	**100**	**3**

Course Objectives:

This course prepares the students to:

- Analyze of the dynamic behaviour of chemical process systems in terms of block diagram
- Understand the stability of the process using various techniques.
- Understand the control strategies to control the chemical processes

Course Outcomes:

At the completion of this course, students should be able to:

- Get concept of process control in plant operation
- Classify the types of controller and their use for specific problems in chemical industry
- Understand the control of non-linear systems and digital control system
- Design of controllers for interacting multivariable systems

Contents:

Unit I **10L**

Review of dynamic process models - linear, and non-linear, lumped and distributed parameter systems. Control of linear systems - Laplace transforms, review of single-loop feedback control systems, Block diagram Analysis.

Unit II **10 L**

Stability analysis and controller tuning, Smith compensator for systems with large dead-time and inverse response, Multi-loop cascadecontrol, feed-forward control, Ratio control.

Unit III **10L**

Adaptive control,inferential control. Multivariable Control - controllability and observability, alternative control configuration, interaction and decoupling, control of complete plants. Digital control - sampling and reconstruction.

Unit IV **10L**

Discrete-time response and stability, design of controllers, on-line process identification. Introduction to control of non-linear systems.

Books Recommended

1. D.R. Coughanour, 'Process Systems analysis and Control', McGraw-Hill, 2nd Edition, 1991.
2. D.E. Seborg, T.F. Edger, and D.A. Millichamp, 'Process Dynamics and Control', John Wiley and Sons, 2nd Edition, 2004.
3. P. K Sarkar, 'Process Dynamics and Control' PHI, 2014.
4. B.W. Bequette, 'Process Control: Modeling, Design and Simulation', PHI, 2006.
5. S. Bhanot, 'Process Control: Principles and Applications', Oxford University Press, 2008.

*****

Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
CHE 03	**Adv. Fluid Mechanics**	**3-0-0**	**3**	**100**	**3**

Course Objectives:

This course prepares the students to:

- Impart knowledge of boundary layer flows, governing equations of fluid flow for different flow regimes, different geometries under the effect of various boundary conditions.
- Get familiar with turbulent flows and its models.
- Develop design concepts for fluidized operations, mixing and segregation.

Course Outcomes:

At the completion of this course, students should be able to:

- recall the exact solutions to Navier – Stokes equation equations for different geometries

- understand the boundary layer equations for laminar flows and the equations for turbulent flow and its models
- use the equations for Flow of non-Newtonian fluids in laminar and turbulent flow conditions
- recognize the numerical techniques for fluid flow problems and design parameter of fluidization.

Contents:

Unit I: **10L**

Conservation Equations and analysis of finite control volumes, continuity equation – differential form and integral form, stream function, streamlines.

Unit II: **10L**

Rotational and irrotational flow, velocity potential. Momentum theorem : Euler's equation – control volume approach; Navier – stokes equation.

Unit III: **10L**

Creep flow and couette flow, Poiseulli flow. Boundary layer theory, momentum integral analysis, Karman – Pohlhausen method for momentum – integral equation.

Unit IV: **10L**

Turbulent flow : Prandtl's mixing length, universal velocity distribution law, turbulent flow in pipe. Flow of non-Newtonian fluids.

Fluidization: principles, two phase theory. Elutriation. Fast fluidized bed: equation for pressure drop and voidage. Mixing and segregation.

Books Recommended

1. Bird R B, Stewart W E and Light fort R N, "Transport Phenomena", John Wiley and Sons (2002).
2. Welty J R , Wilson R E and Wicks C E , "Fundamentals of Momentum , Heat and Mass Transfer", 4 th ed,John Wiley and Sons (2001).
3. John C Slattery, "Momentum, Energy and Mass transfer in continua", McGraw Hill, Co. (1972).
4. Bennet C U and Myers J E, " Momentum, Heat and Mass Transfer" Tata McGraw Hill Publishing Co. (1975)
5. Robert S Brodkey and Harry C Hersing, " Transport Phenomena a Unified approach" McGraw Hill Book Co. (1988).
6. Knudsen, &Katz "Fluid Dynamics and Heat Trasnfer" McGrawHill Book Co.(1974)
7. McCabe, Smith & Harriat, "Unit Operations of Chemical Engineering"McGraw HillBook Co. (1993)
8. Gupta,Santhosh K, "Momentum Transfer Operative" Tata McGraw Hill

*****

Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
CHE 04	**Adv. Num. Methods in Chem. Engineering**	**3-0-0**	**3**	**100**	**3**

Course Objectives:

This course prepares the students to:

- Understand, apply mathematical tools for chemical engineering problems
- Use different numerical techniques
- Learn mathematical computing tools like Matlab, Scilab, Python etc

Course Outcomes:

At the completion of this course, students should be able to:

- memorize the basic algebraic methods for application in various mathematical problems
- explain the methods for solving Partial Differential Equations (PDE's) and ordinary differential equations (ODE's)
- develop the concept of finite element, use of orthogonal collocation to solve Boundary Value Problem in ODEs
- analyze and interpret the data of chemical engineering problems by numerical methods

Contents:

Unit I: 10L

Matrices, Norms and inner products, Gram-Schmidt ortho normalization, Fredholm alternative, Rayleigh's quotient, Application in the solution of Chemical Engineering problems. Errors and error control; Interpolation and optimization

Unit II: 10L

Linear algebraic equations; Matrix inversion and matrix eigen values estimation Step size selection and stability of Runge-Kutta and predictor corrector methods to solve IVP ordinary differential equations, stiff ODE's and Gear's method.

Unit III: 10L

BVP - shooting methods for linear system, finite difference method, regular perturbation method. Method of weighted residuals and orthogonal collocation to solve first and higher order BVP in ODE's, application to Chemical Engineering Systems, concept of finite element, use of orthogonal collocation and Galerkin technique to solve BVP in ODEs.

Unit IV: 10L

Review of finite difference techniques to solve Partial Differential Equations (PDE's). Similarity transformation, method of weighted residuals, orthogonal collocation, finite element methods to solve PDEs with application to Chemical Engineering Systems.

Books Recommended:

1. S. C. Chapra and R. P. Canale, Numerical Methods for Engineers, McGraw-Hill Education, 2015
2. P. Ghosh, Numerical Methods with Computer Programs in C++, Prentice-Hall of India Private Ltd., 2006
3. J. H. Mathews and K. D. Fink, Numerical Methods Using MATLAB, 4th Edition, Pearson, 2004
4. S. C. Chapra, Applied Numerical Methods with MATLAB for Engineers and Scientists, 3rd Edition, 2012
5. P. Ghosh, Numerical, Symbolic and Statistical Computing for Chemical Engineers Using MATLAB, Prentice-Hall of India Private Limited, 2018
6. S. K. Gupta, Numerical Methods for Engineers, 3rd Edition, New Age International, 2015.
7. W. H. Press, S. A. Teukolsky, W. T. Vellerling and B. P. Flannery, Numerical recipes in FORTRAN 8. FORTRAN: the art of scientific programming, Cambridge University Press, 1992

*****

Core Elective I: CHE 05A/CHE 05B/CHE 05C/ CHE 05D

Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
CHE 05.1	**Process Modelling and Simulation**	**3-0-0**	**3**	**100**	**3**

Course Objectives:

This course prepares the students to:

- Develop the ability in mathematical treatment of chemical engineering processes.
- Understand the basic concepts of process modeling and simulation.
- Impart knowledge of several processes from chemical engineering, where simulation approaches and mathematical tools are discussed

Course Outcomes:

At the completion of this course, students should be able to:

- Understand the basic concepts of process model formulation, analysis of variables, parameter estimation and simulation with mathematical techniques
- Get familiar with common mathematical and computational tools for simulation of different chemical engineering processes
- Develop models for chemical engineering systems.
- Apply the modelling and simulation to complex industrial systems in petroleum, petrochemicals, polymer, basic chemical industries.

Contents:

Unit I: **10L**

Introduction and fundamentals of process modelling and simulation; industrial usage of process modelling and simulation; Macroscopic mass, energy and momentum balances; incorporation of fluid thermodynamics, chemical equilibrium, reaction kinetics and feed/ product property estimation in mathematical models.

Unit II: **10L**

Simulation of steady state lumped systems including simultaneous solution, modular solution, , partitioning and tearing with reference to chemical process equipments like reactors; distillation, absorption, extraction columns; heat exchangers etc.

Unit III: **10L**

Unsteady state lumped systems and dynamic simulation; Commercial steady state and dynamic simulators; Computer algorithms for numerical solution of steady state and unsteady state models;; process modelling with dispersion; axial mixing; micro-mixing; diffusion etc. Computer algorithms for microscopic models; Flowsheeting.

Unit IV: **10L**

Modelling and simulation of complex industrial systems in petroleum, petrochemicals, basic chemical industries. Introduction to application of advanced Artificial intelligence based modelling methods using Artificial Neural Networks, and induced learning algorithms.

Books Recommended:

1. K. M. Hangos and I. T. Cameron, "Process Modelling and Model Analysis", Academic Press, 2001.
2. W.L. Luyben, "Process Modelling, Simulation and Control for Chemical Engineers", 2nd Edn., McGraw Hill Book Co., New York, 1990.
3. Bruce A. Finlayson, 'Introduction to Chemical Engineering Computing', Wiley, 2010.
4. W. F. Ramirez, "Computational Methods for Process Simulation", 2nd ed., Butterworths, 1997.
5. Amiya K. Jana, Chemical Process Modelling and Computer Simulation, Prentice Hall of India, 2nd Edition, 2011
6. Laurene V. Fausett, Applied Numerical Analysis using MATLAB, Second edition, Pearson, 2009

*****

Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
CHE 05.2	**Bioprocess Engineering**	**3-0-0**	**3**	**100**	**3**

Course Objectives:

This course prepares the students to:

- State the enzyme kinetics, various factors regulating catalysis, different models for analyzing the enzyme kinetics, Immobilization and large-scale production of enzyme
- Extend comprehensive knowledge about media constituents, formulations and microbial growth as well as measurement of cell biomass and analysis of mass balance, different methods of sterilization, agitation, oxygen transfer rate and operation of bioreactor
- Gain knowledge about the design of production of bioproducts under aerobic and anaerobic states, process economic and preparation of flow sheet of production process

Course Outcomes:

At the completion of this course, students should be able to:

- State the kinetics of enzyme catalysed reaction in free and immobilized states. They will also able to organise the production of microbial enzymes and operate variables affecting the production process.
- Use medium for microbial growth, solve the mass balance of production process, propose and use the sterilizers for removal of microbial contaminants,
- Experiment the significance of aeration and agitation for synthesis of bio products and modes of operation of Fermenter.
- Select instrumentation and process control- offline and online

Contents:

Unit I: **10L**

Revision of fundamental principles of Bioprocess Engineering. Cellular growth, From Genotype to Phenotype, Transport process (free diffusion, facilitated transport, active transport), Catabolism, Glycolysis, anabolism, secondary metabolism, biotech processes – an overview.

Unit II: **10L**

Enzyme Kinetics: Concepts of Michelis Menten equations and Briggs Haldane equation in terms of mathematical interpretation. Integral and differential methods for finding the intrinsic kinetic parameters. Two substrate reaction, Ping –pong mechanism, Allosteric enzyme, The Adair and Hill equation, MCW model, KNF model, Immobilized enzymes, effect of external and internal mass transfer resistances on the global rate.

Unit III: **10L**

Inhibition studies: Inhibition by foreign substances, substrates (self inhibition) and products. Derivation of kinetic inhibition constants using steady state assumptions.

Unit IV: **10L**

Kinetic cell growth, structured and unstructured, segregated and un-segregated models. Substrate and product inhibition kinetics. Optimum operation of chemostat. Scale up of bioreactor, Basic requirements and reactor type, Physical processes of importance for scale up.

Books Recommended:

1. M.L. Shuler and F. Kargi, "Bio-process Engineering", 2nd Edition, Prentice Hall of India, New Delhi. 2002.
2. J.E. Bailey and D.F. Ollis," Biochemical Engineering Fundamentals", 2nd Edn., McGraw Hill, Publishing Co. New York., 1985.
3. P.Stanbury, A. Whitakar and S.J.Hall, "Principles of Fermentation Technology" 2nd Edn., Elsevier-Pergamon Press, 1995.

*****

Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
CHE 05.3	**Petroleum Refinery Engineering and Petrochemicals**	**3-0-0**	**3**	**100**	**3**

Course Objectives:

This course prepares the students to:

- Know the current scenario of Petroleum Refinery in India, together its present and future feed stocks
- Know the current scenario of petrochemical industry in India, together its present and future feed stocks

- Learn the production techniques and challenges of various intermediate and value added Products.

Course Outcomes:

At the completion of this course, students should be able to:

- Memorize various refining processes for crude oil and distillates and to analyse the application of these for different refining scenarios.
- Discuss the composition of crude oil and its products, along with its properties and characterization methods together with the process of fractionation of crude oil.
- Implement the finishing processes to petroleum products for meeting the market specifications in view of fuel quality and environmental regulations.
- Compare the status of petrochemical industry in India together its present and future feed stocks and their production.

Contents:

Unit I

Origin of petroleum crude oil. Evaluation of crude oil, evaluation and characterization of crude oil : TBP and other distillation tests. Petroleum products, their properties, specification and testing. different properties like flash point, fire point, smoke point, aniline point. carbon residue, kinematic viscosity, pour point, freezing point etc. **10 L**

Unit II

Petroleum refinery distillation, pre-fractionation and atmospheric distillation of crude. Process design for atmospheric distillation. Vacuum distillation of RCO. Vis-breakig, Delayed coking process. FCC unit. Hydrotreatment processes in refining: hydro-desulfurisation, hydrofinishing, Hydrocracking. Reforming of naphtha. **10 L**

Unit III

Petrochemical feedstock; Process of naphtha cracking, Production of olefins, Separation of aromatics, Petrochemicals from C1, C2, C3, C4: Methanol, Formaldehyde, Ethylene Glycol, Isopropanol , Butadiene, Maleic Anhydride etc. **10 L**

Unit IV

Petrochemicals from Aromatics: Cumene, Styrene, LAB, Phthalic Anhydride etc. Thermoset and thermoplastic polymers: polyethylene, polypropylene, polystyrene, PVC, ABS plastic, nylon, polycarbonate, rubber etc. Process intensification & Emerging technologies in petrochemical industry**.**

10L

Books Recommended:

1. Nelson W L, “Petroleum Refinery Engineering”, Mc Graw Hill Book Co., 1985.
2. Watkins R N, “Petroleum Refinery Distillation”, Gulf Publishing Co.
3. Gary J H and Handework G E, “Petroleum Refining Technology and Economics”, Marcel Dekker, Inc., 2001.
4. Jones D S J, “Elements of Petroleum Processing”, John Willey & Sons, 1995 5. Waquier J P, “Petroleum Refining” Vol. I & II Editions, Technip, 1995.
5. Petrochemical processes: Chauvel ,Gulf Publishing
6. A Text on Petrochemicals: B.K.B. Rao, Khanna Publishers

*****

Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
CHE 05.4	Cleaner Production	3-0-0	3	100	3

Course Objectives:

This course prepares the students to:

- Understand the concept of cleaner production and the methodologies involved in detail,
- Familiar with Financial evaluation of cleaner production technologies
- Study the practical applications of cleaner production technologies

Course Outcomes:

Students will be able to:

- Define about the role of C.P. in development in Chemical Industries.
- Explain the Energy conservation via Cleaner Technology Options.
- Plan to do Industrial waste minimization.
- Survey about the Green Processes in Chemical Industries.

Contents:

UNIT I: Introduction **10L**

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.

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 by products, Product modification.

UNIT II: Cleaner production methodology **10L**

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 III: Concept of cleaner production **10L**

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 to cleaner 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 IV: Financial analysis of cleaner production 10L

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.

Books Recommended:

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

*****

Practical/ Sessional papers

Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
CHE 06	**Process Control Lab**	**0-0-3**	**2**	**100**	**3**

Course Objectives:

This course prepares the students to:

- Apply the basics of process control through a hands-on practical experience.
- Learn the Principles of operation of different types controller
- Impart knowledge of transmitters, transducers, converters, control valves, digital and analog components.

Course Outcomes:

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

- recall the various theoretical principles of process control.
- demonstrate the experimental skills.
- use the problem solving method and apply knowledge
- create new ideas and recognizing the skills for technical writing.

Experiments:

1. Study on Responses of First and second-Order Interacting and non-interacting Systems
2. Studies on Characteristics of Control Valve
3. Response of a) Proportional Controller
   b) PI Controller
   c) PID Controller
4. Determination of Dynamic Model from the Response Characteristics of a Thermocouple
5. Studies on dynamics of a) Level,
   b) Temperature,
   c) Mixing
6. Studies on stability and synthesis of controller (using ZN and CC method)

*****

Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
CHE 07	**Adv Chemical Engg. Lab**	**0-0-3**	**2**	**100**	**3**

Course Objectives:

This course prepares the students to:

- Analyze characteristics of a fluidized bed dryer and Estimate efficiency of compact heat exchangers
- Evaluate the performance of a process intensification in catalytic reactions, ultrasound assisted reactions, reactive distillation column, micro reactor and advanced flow reactor
- Design controller for a given process, Characterize electrochemical phenomena such as corrosion

Course Outcomes:

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

- Operate different equipments in chemical plant operation.
- Evaluate the performance of different processes
- Develop experimental skills.
- Develop skills for technical writing.

Experiments:

1. Characteristics of a Fluidized bed dryer
2. Helical Coil heat exchanger

3. Determination of Effective thermal conductivity (ETC) in granular material
4. Plate Type Heat Exchanger
5. Kinetics for solid catalyzed esterification reaction in a batch reactor
6. Reactive distillation in Packed Column
7. Ultrasonic cavitation based reactions
8. Micro-reactor
9. Advanced Flow Reactor
10. Membrane Separation for water purification
11. Corrosion characteristics of a metal in a given electrolyte
12. Control of liquid level in non-interacting systems.
13. Identification and control of a three tank system.
14. pH control in a process.

*****

Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
CHE 08	**Seminar**	**0-0-3**	**2**	**100**	**3**

A Seminar topic will be allotted to individual student according to his/her subject of interest. A thorough report should be prepared based on which seminar presentation and question-answer session will be conducted. Assessment of the student would be done by the faculty members on the basis of presentation, performance in the question - answer session and the report submitted.

Course Outcome:

Students will able to

- memorize technical knowledge gather during the course.
- Students will able to explain their knowledge in a most attractive way.
- Students will able to solve any topic in a shorter time to their audience.
- Students will able to examine their presentation style.

*****

Detailed Syllabus
Second Semester

Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
CHE 09	**Adv Reactor Design & Analysis**	**3-0-0**	**3**	**100**	**3**

Course Objectives:

This course prepares the students to:

- Understand the chemical kinetics for homogeneous and heterogeneous reactions and their applications in design of batch and flow reactors.
- Understand the non-ideal flow,
- Understand the physical properties of solid catalysts, catalytic and non-catalytic heterogeneous systems.

Course Outcomes:

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

- memorize the mechanism of chemical kinetics for various types of reactions including solid catalyzed reaction.
- discuss the non-ideality in the flow reactors and flow models for non-ideal reactors.
- interpret the kinetic data for designing various types of reactors such as packed bed reactor, Fluidized bed reactors, slurry reactors etc.
- analyze the system for optimal operation, stability and dynamic behaviour of reactors

Contents:

Unit I: 10L

RTD of non ideal reactors, interpretation of RTD data, flow models for non-ideal reactors – axial dispersion, N tanks in series, and multiparameter models, diagnosing the ills of reactors, influence of RTD and micromixing on conversion.

Unit II: 10L

Development of rate equations for solid catalyzed fluid phase reactions; Estimation of kinetic parameters. External mass and heat transfer in catalyst particles, catalyst – measurement of surface area and pore size, effectiveness factor, selectivity, catalyst deactivation. Pressure drop in Reactor .Design of packed bed reactor, slurry reactor; trickle bed reactor and fluidized bed reactor.

Unit III: 10L

Optimum operation policy of batch reactor, optimal temperature progression, analysis of multibed adiabatic reactors, autothermal operation, steady state multiplicity in CSTR. Stability and transient behavior of CSTR. Hot spot, runaway criteria.

Unit IV: 10L

Non catalytic gas–solid reaction. Mass transfer with chemical reactions – principles and design. Modelling of multiphase reactors. Dynamic behavior of chemical reactors. Reactor Optimization and scale up.

Books Recommended:

1. Levenspiel O., “Chemical Reaction Engineering”, 3rd Edition, John Wiley & Sons, Singapore, (1999).

2. Fogler H. S., “Elements of Chemical Reaction Engineering”, 3rd Edition, Prentice Hall Inc., (1999)
3. Smith J. M., “Chemical Engineering Kinetics”, 3rd Edition, McGraw Hill, (1981).
4. Hill C. G., “Chemical Engineering Kinetics and Reactor Design”, John Wiley, (1977).
5. Froment, G.F. and Bischoff, K. B., “Chemical Reactor Analysis and Design”, 2nd Edition, John Wiley and Sons, NY, (1990).

*****

Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
CHE 10	Adv. Separation Processes	3-0-0	3	100	3

Course Objectives:

This course prepares the students to:

- Familiarize students with various advanced aspects of separation processes and the selection of separation processes.
- Enable students to understand the principles and processes of adsorption, membrane separation and chromatography and to design an absorber or a membrane unit to achieve a specified separation.
- Introduce them to new trends used in the separation technologies.

Course Outcomes:

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

- Understand and identify different membrane separation processes and assess the life time of membranes under different process environments
- Characterize different types of membranes with the material of construction, advantages and disadvantages of different types of process and its engineering applications.
- Design or modify structure of membrane as per requirements of process and the chemicals involved.
- Gain knowledge about overall concept of membrane separation processes and mathematical modelling of different types of membranes.

Contents:

Unit - I: **10L**

Introduction: Conventional separation processes - Absorption, Adsorption, Conventional separation processes - Distillation, Drying, Conventional separation processes - Extraction, Diffusion, Conventional separation processes - Leaching, Crystalisation, Advances in separation techniques based on size, Advances in separation techniques based on surface properties, Advances in separation techniques based on ionic properties, Cross flow filtration,

Electro filtration, Dual functional filter, Surface based solid-liquid separations involving a second liquid, Sirofloc filter

Unit - II: **10L**

Bubble and Foam Fractionation: Nature of bubbles and foams, stability of foams, foam fractionation techniques, batch, continuous, single stage and multistage columns.

Types and choice of membranes, Plate and frame, spiral wound membranes, Tubular and hollow fibre membrane reactors, Membrane Permeates: Dialysis, Reverse osmosis, Nanofiltration, ultrafiltration, microfiltration, Donnan dialysis, Ceramic membranes

Unit - III: **10L**

Membrane Separation: Characteristics of organic and inorganic membranes, basis of membrane selection, osmotic pressure, partition coefficient and permeability, concentration polarization, electrolyte diffusion and facilitated transport, macro-filtration, ultra-filtration, reverse osmosis, electro-dialysis. Industrial applications.

Unit - IV: **10L**

Special Processes: Liquid membrane separation, super-critical extraction, adsorptive separation-pressure, vacuum and thermal swing, pervaporation and permeation, nano-separation. Freeze-drying/lyophilisation.

Chromatographic Methods of Separation: Gel, solvent, ion and high performance liquid chromatography.

Books Recommended:

1. King C.J., "Separation Processes", Tata McGraw Hill. 1982.
2. Nakagawal, O. V., "Membrane Science and Technology", Marcel Dekker, 1992.
3. Humphrey, J and G. Keller, Separation Process Technology, McGraw-Hill, 1997 Khoury F.M., "Multistage Separation Processes", 3rd Ed., CRC Press. 2004.
4. Wankat P.C., "Separation Process Engineering", 2nd Ed., Prentice Hall.2006.
5. Seader J.D. and Henley E.J., "Separation Process Principles", 2nd Ed.,Wiley.2006
6. Basmadjian D., "Mass Transfer and Separation Processes: Principlesand Applications", 2nd Ed., CRC Press.2007.
7. Rousseau, R. W., "Handbook of Separation Process Technology", John Wiley, New York, 2009.

*****

Core Elective II: CHE 11.1/ CHE 11.2/ CHE 11.3/ CHE 11.4

Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
CHE 11.1	**Project Engineering**	**3-0-0**	**3**	**100**	**3**

Course Objectives:

This course prepares the students to:

- Enable the students to gain experience in organization and implementation of a small project and thus acquire the necessary confidence to carry out the main project in the final year.

- Make the students gain all the knowledge in terms of financial analysis for starting up a new chemical industry.
- Gain knowledge on cost analysis when it comes to start up a new industry after undergoing all major subjects of chemical engineering.
-

Course Outcomes:

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

- Define how a project has to be started, their pre-requirements, flow chart preparation, and economic calculation and so on.
- Identify the balance sheet and Income statement for a particular concern.
- Implement a good knowledge to run an industry in a profitable or without loss/gain of a particular concern.
- Compare between the equipment/instruments of the same function based on both technical and commercial point of view.

Contents:

Unit I: 10L

Basis of chemical plant design: Steps in process development, feasibility survey, pilot and semi commercial plant design, scale up and scale down techniques, plant location and plant lay out, plant utilities, environment and safety clearances. Plant utilities.

Unit II: 10L

Depreciation: Revision of methodology of calculating depreciation, MACRS Costing and project evaluation: different methods of cost estimation for plants, present worth, cash flow and discounted cash flow and rate of return, pay-back period, perpetuity and capitalized costs, sensitivity analysis, alternative investments and replacements. Financial analysis: risk and return, liabilities, importance of ratio analysis, liquidity ratio, defensive interval ratio, capital structure ratio, debt equity ratio, activity ratio, Du-Pont chart.

Unit III: 10L

Optimum Design and Design strategy: Basic principle of Optimum Design, general procedure for determining optimum conditions, Breakeven analysis, Optimum production rate in plant, determination of optimum economic pipe diameter and optimum flow rate in condenser, optimum design in separation columns.

Unit IV: 10L

Bar chart, Gantt chart, Milestone Chart, Concepts of Network Analysis: PERT, CPM, Numbering a network, Statistical distribution associated with PERT network, Earliest Expected time and Latest allowable occurrence time calculation, Slack, determination of critical path, concepts of Float.

Books Recommended:

1. J.M. Coulson, JF Richardson, RK Sinnott Butterworth Heinman, Chemical Engineering Volume 6, Revised Second Edition, Butterworth-Heinemann.
2. M. S. Peters & K. D. Timmerhaus, 'Plant design & Economics for Chemical Engg.' McGraw-Hill Science/ Engineering/Math 5th Ed.
3. Industrial Boilers, and Heat recovery Steam Generators Design, Applications and calculations by V.Ganapathy, Marcel Dekker, Inc,.
4. Sivasubramanian V, "Process Economics and Industrial Management", Galgotia Publications Pvt Ltd...

*****

Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
CHE 11.2	Fluidization Engineering	3-0-0	3	100	3

Course Objectives:

This course prepares the students to:

- Study the phenomenon of fluidization with industrial processing objective
- Study the various regimes of fluidization and their mapping.
- Study the design of equipments based on fluidization technique

Course Outcomes:

Students will be able to:

- Find understanding the behavior of fluidization in fluidized bed.
- Relate pressure drop, bubble size, voidage, heat and mass transfer rates for the fluidized beds.
- Identify the characterization of particles and power consumption in fluidization regimes.
- Analyze the applicability of the fluidized beds in chemical industries.

Contents:

Unit I: **10L**

Introduction to fluidization and applications

Phenomenon of fluidization, behaviour 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

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 II: **10L**

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 III: **10L**

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 IV: **10L**

Fluidized bed reactors, Entrainment and elutriation, Freeboard behaviour, 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 non-catalytic reactors, kinetic models for conversion of solids, models for shrinking particles, conversion of solids of unchanging size

Books Recommended:

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

*****

Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
CHE 11.3	**Industrial Pollution Control**	**3-0-0**	**3**	**100**	**3**

Course Objectives:

This course prepares the students to:

- Understand the importance of industrial pollution and its abatement
- Study the underlying principles of industrial pollution control
- Design complete treatment system

Course Outcomes:

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

- relate consciousness about the methods for a clean environment.
- classify the different pollutions

- plan for the efficient treatment of effluent streams, (liquids, solids and gaseous streams) and design water / sewage treatment systems at an affordable cost.
- list the effective environmental management policies

Contents:

Unit I: **10L**

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. Life cycle (Environmental) Impact Assessment.

Unit II: **10L**

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.

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 III: **10L**

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 IV: **10L**

Solid waste and Hazardous waste management

Sources and classification, properties, public health 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.

Books Recommended:

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 Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
CHE 11.4	**Computer Aided Process Design**	**3-0-0**	**3**	**100**	**3**

Course Objectives:
This course prepares the students to:

- Understand importance and applications of CAD in the field of chemicalengineering
- Understand the underlying thermodynamic and physical principles To give insight into the approaches used in the simulation of flowsheets
- Understand flow charts, computer languages and numerical methods used for writing algorithms

Course Outcomes:

At the end of the course, Students can

- Explain the basic structure of CADsoftware

- Apply knowledge in Computer aided equipment design of Distillation columns, Reactors, heat exchanger etc. and computer Aided Flow SheetSynthesis
- Make experiment on Dynamic simulation of different systems
- Evaluate various commercial design software and optimizers used in field of chemical engineering.

Contents:

Unit I: 10L

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.

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 equilibrium, Vapour-liquid equilibria, K-valuesetc.

Unit II: 10L

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, Heat exchangers.

Unit III: 10L

Computer Aided Flow Sheet Synthesis

Computerized physical property calculations, 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, 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 IV: 10L

Dynamic Simulation

Numerical recipes for Linear and nonlinear equations, Ordinary and partial differential equations, Dynamic simulation of stirred tanks system with heating, Multi component system, Reactors, Absorption and distillation columns, Introduction to various commercial design software and optimizers used in field of chemicalengineering.

Books Recommended:

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 UniversityPress
5. Biegler Lorenz T, et al, “Systematic method of Chemical Process Design”, PrenticeHall
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 EngineeringDesign”,TMH,1981

*****

Core Elective III: CHE 12.1/ CHE 12.2/CHE 12.3/CHE 12.4

Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
CHE 12.1	Modern Energy Engineering and Energy Management	3-0-0	3	100	3

Course Objectives:

- To expose students to the fundamentals of waste energy and to give technical knowhow of operations and waste heat recovery options.
- To let students have get an understating of power cycles , and various principles governing WTE and to develops latest knowledge , and get updated with advanced topics for holistic development
- To develop the capacity for financial analysis of various energy projects and to have good understanding about project viability & financial risk analysis

Course Outcomes:

On completion of this course, the students will be able to:

- Understand the fundamental of conversion processes of any waste
- Recognize the characterization of wastes and analyze technology application and bio-chemical process conversion of any wet waste solid fuel.
- Use the concepts of thermo-chemical conversion process of any energy production from waste plastics and physical Describe a project life cycle, and can skillfully map each stage in the cycle
- Judge the resources needed for each stage, including involved stakeholders, tools and supplementary materials

Contents:

Unit I: **10L**

Concept of "waste to energy"; Thermo-chemical and biochemical conversion of Biomass; Kinetics of incineration, Pyrolysis and Gasification (low and medium Joule) of Biomass and polymeric Wastes;

Unit II: **10L**

Design of incinerator, Green House effect of Incineration; Design of Updraft, downdraft and fluidized bed Gasifiers for Biomass; Design of low temperature pyrolyser and Fast/Flash Pyrolyser; bio-diesel,

Unit III: **10L**

Kinetics of Biogas generation from wastes; Design of Bio-digesters for the generation of Biogas; Gas Turbines and Dual-fuel IC engines for power generation from low and medium Joule gases; use of Natural gas for the substitution of liquid fuels; Dehydration and Desulfurization processes of natural gas; gathering and transport of natural gas and Biogas;

Unit IV: **10L**

Concept and operation of fuel cell. Energy Management & Energy Planning. Definition & Objectives of Energy Management. Duties and responsibilities of energy managers and auditors. Energy Audit and Energy Monitoring. Integrated energy management─ case studies. Maximizing System Efficiency

Books Recommended:

1. Energy Engineering and Management, Amlan Chakraborty, PHI Learning
2. Energy Management and Conservation, Kindle Edition, K V Sharma P Venkataseshaiah
3. Handbook of Energy Audit Kindle Edition, Sonal Desai , Kindle Edition

*****

Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
CHE 12.2	**Process Plant Design and Flow-sheeting**	**3-0-0**	**3**	**100**	**3**

Course Objectives:

This course prepares the students to:

- Understanding of the scope, principles, norms, accountabilities and bounds of contemporary engineering practice in the specific discipline.

- Application of established engineering methods to complex engineering problem solving.
- Application of systematic engineering synthesis and design processes.

Course Outcomes:

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

- list design processes for manufacturing products commercially
- understand and discuss the techniques and knowledge acquired in heat and mass transfer, fluid mechanics, instrumentation and control to design heat exchangers, plate and packed columns and engineering flow diagrams
- apply knowledge of commercial flow sheeting software to simulate processes and design process equipment
- recognize the concept of Optimum Design and Design Strategy and predict fixed and working capitals and operating costs for process plants

Contents:

Unit-I: 10L

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: 10L

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: 10L

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: 10L

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.

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

Books Recommended:

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).

*****

Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
CHE 12.3	**Application of Nanotechnology in Chemical Engg.**	**3-0-0**	**3**	**100**	**3**

Course Objectives:

This course prepares the students to:

- Understand the fundamentals of the preparation and properties of nanomaterials from a chemical engineering perspective.
- Gain knowledge of structure, properties, manufacturing, and applications of various nanomaterials and characterization methods in nanotechnology
- Give a survey of the key processes, principles, and techniques used to build novel nanomaterials and assemblies of nanomaterials

Course Outcomes:

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

- Understanding the different top down and bottom up approaches for nanomaterials synthesis
- Get to know the different characterization techniques of nanomaterials and its applications in chemical engineering field.
- Understand the polymer-based and polymer-filled nanocomposites
- Analyze the societal, health and environmental impacts of these materials.

Contents:

Unit I: 10L

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.

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 II: 10L

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 III: 10L

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 IV: 10L

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. Nanocatalysis.

Books Recommended:

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 Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
CHE 12.4	**Modern Concepts of Catalysis and Surface Phenomenon**	**3-0-0**	**3**	**100**	**3**

Course Objectives:
This course prepares the students to:

- Give the students insight into advances in catalytic reaction engineering
- Study the catalyst characterization techniques
- Understand the principles behind catalyst deactivation and study their models

Course Outcomes:

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

- memorize the concepts of various types of catalytic reaction and surface kinetics.
- classify the types of catalysts and discuss the characterization techniques.
- demonstrate the estimation methods of catalyst pore structure, surface area.
- develop the knowledge in catalysis for industrial applications.

Contents:

Unit I: **10L**

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.

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 II: 10L

Catalyst Characterization

Catalyst Characterization Methods – Their Working Principle and Applications – TGA, BET-BJH, 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 III: 10L

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 IV: 10L

Industrial applications– Case Studies

Industrial processes involving heterogeneous solid catalyst: Synthesis of Methanol, Fischer-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

Books Recommended:

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.

*****

Open Elective: CHE 13 A/ CHE 13 B/ CHE 13 C/ CHE 13 D/ CHE 13 E

Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
CHE 13.1	**Business Analytics**	**3-0-0**	**3**	**100**	**3**

Course objective

- Understand the role of business analytics within an organization.
- Analyze data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization.
- To gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making.
- To become familiar with processes needed to develop, report, and analyze business data. Mange business process using analytical and management tools.

Course Outcomes:

Students will be able to:

- Find the knowledge of data analytics.
- Demonstrate the ability of think critically in making decisions based on data and deep analytics.
- Apply technical skills in predicative and prescriptive modeling to support business decision-making.
- Analyze the data into clear, actionable insights.

Contents:

Unit I: 10L

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.

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 II: 10L

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 analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.

Unit III: 10L

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. 10

Unit IV: 10L

Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making.
Recent Trends in : Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.

Books Recommended:

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.

*****

Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
CHE 13.2	Composite Materials	3-0-0	3	100	3

Course Objectives:

The main objective of this course is to

- Enlarge the students' knowledge in composite materials and their macro/micro mechanical properties.
- Empower the students with the skills needed for the design, manufacture and analysis of composite materials from a material scientist's viewpoint.
- Know the Manufacturing of metal and Polymer Matrix Composites

Course Outcomes:

Students will be able to:

- Find the purpose and the ways to develop new materials upon proper combination of known materials.
- Identify the basic constituents of a composite materials and list the choice of materials available.
- Compare the relative merits of using alternatives for important engineering and other applications.
- Examine insight to the possibility of replacing the existing macro materials with nano-materials.

Contents:

Unit I: 10L

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.

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 Behaviour of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

Unit II: 10L

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 III: **10L**

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 IV: **10L**

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.

Books Recommended:

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

*****

Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
CHE 13.3	**Operations Research**	**3-0-0**	**3**	**100**	**3**

Course Objectives:

The objective of this course is to

- Impart knowledge in concepts and tools of Operations Research
- Understand mathematical models used in Operations Research
- Apply these techniques constructively to make effective business decisions

Course Outcomes:

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

- Students should be proficient in the application of the laws of logic to mathematical statements by selecting appropriate OR methods like Simplex, TP, TS, TSP, Network Analysis to apply to various types of problems in engineering and science inconsideration of the mathematical operations involved, accuracy requirements, and available computational resources
- Realization of journal papers outcomes, and expose them to the world of research. The current research works and publications of the subjects in different fields adopted by the students as per course curriculum in various journals and literature.
- They can explore and enhance research potential explain how the ideas those are adopted can be implemented through projects and demonstrate various models, recent project proposals executing the knowledge adopted from the course.
- An ability to function on multi-disciplinary teams. Lighten on the latest and modern developments in the fields. An understanding of professional, ethical, legal, security and social issues and responsibilities. An ability to analyze the local and global impact of computing on individuals, organizations, and society.

Contents:

Unit I: **10L**

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

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

Unit II: **10L**

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

Unit III: **10L**

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

Unit IV: **10L**

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

Books Recommended:

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

*****

Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
CHE 13.4	**Cost Management of Engineering Projects**	**3-0-0**	**3**	**100**	**3**

Course Objectives:

This purpose of this course is to provide the students with the following capabilities:

- To apply modern software packages to conduct analysis of real world data.
- To understand the technical underpinning of engineering economic analysis.
- The ability to apply the appropriate analytical techniques to a wide variety of real world problems and data sets.

Course outcome:

Students will be able to:

- Know how to prepare contract plans and specifications..

- Demonstrate the quantity take-offs, productivity analyses, cost estimates and schedules for given projects.
- Identify the elements of procurement and bidding strategies.
- Inspect knowledge of liability, insurance and safety/environmental requirements on projects.

Contents:

Unit I: 10L

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.

Unit II: 10L

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

Unit III: 10L

Cost Behaviour 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.

Unit IV: 10L

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

Books Recommended:

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 Cost Accounting A. H. Wheeler publisher
5. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

*****

Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
CHE 13.5	Waste to Energy	3-0-0	3	100	3

Course Objectives:

The objective of this course is to

- Expose students to the fundamentals of waste energy.
- Give technical knowhow of operations and waste heat recovery options. Revise fundamentals of thermodynamics, heat transfer.
- Enable students, get an in-depth understanding of different complex thermal systems, thermodynamics, heat engines, steam technology, thermal power plant & non-conventional energy system

Course Outcomes:

At the end of this course student should be able to

- Recall the fundamental of conversion processes of any waste
- Identify characterization of any characterization of wastes and analyze technology application
- Execute thermo-chemical conversion process of any energy production from waste plastics and bio-chemical process conversion of any wet waste solid fuel.
- Develop skill in the design, construction and operation - Operation of all the biomass combustors

Contents:

Unit-I: 10L

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

Unit-II: 10L

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-III: 10L

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-IV: 10L

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. Hydrolytic deploymerization (hydrolysis) of lignocellulosic biomass for glucose ,and other platform chemicals; bioalcohol; drop-in biofuels.

Books Recommended:

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.

*****

Practical/ Sessional papers

Course Code	Course title	Hours/week L:T:P	Credit	marks	Total contact hours/week
CHE 14.1	**Instrumental Methods of Analysis Lab**	**0 – 0 - 3**	**2**	**100**	**3**

Course Objectives:

The objective of this course is to

- Give basic knowledge on instrumental methods of chemical analysis
- Perform practical work on real samples to get acquainted with instrumentation and equipment which is needed in monitoring of environmental pollution
- Give idea in investigating current environmental processes.

Course Outcomes:

At the end of the course students would be familiar with:

- Proficiency in professional sampling and sample treatment prior to analysis
- Capability of treatment and evaluation of the results of analysis
- Understanding and capability of performing basic chemical processes in an analytical laboratory
- Capability of analyzing measurements on basic analytical instruments (photometers, spectrometers, chromatographs, ion-selective electrodes.

Contents:
At least eight experiments are to be performed

Experiments:

1. Determination of Turbidity of Water using NepheloTurbidity Meter.
2. Construction of standard curve (Absorbance vs. concentration) of a pure protein by Folin's Method using Spectrophotometer.
3. Determination of Fe^{3+} by Colorimeter Method.
4. Study of migration of proteins by electrophoresis.
5. Separation of Mixture of Lipids by Thin Layer Chromatography.
6. Kinetic study of biochemical reaction by UV Spectrophotometer.
7. Estimation of an organic mixture (benzene & toluene) by Abbe refractometer.
8. Determination of any optically active substance in the presence of non-active species by a polarimeter.
9. Demonstration of analysis of gases by gas chromatography.
10. Demonstration of working of HPLC/FTIR.

*****

Course Code	Course title	Hours/week L:T:P	Credit	marks	Total contact hours/week
CHE 14.2	Petroleum Engg. lab	0 – 0 - 3	2	100	3

Course Objectives:
The objective of this course is:

- To introduce various methods of analysis by using sophisticated instruments and analytical equipments to determine various physical properties of crude, natural gas, petroleum products and petro-chemicals.
- On completion of the course the students should be conversant with the theoretical principles for quantitative estimation.
- The students should be conversant with the experimental procedures for quantitative estimation.

Course Outcomes:

- memorize about the variation in properties of the fluids on the basis of aromatics compounds
- identify the knowledge about the formation of carbon deposits at high temperature
- execute the experiment in a manner to estimate the amount of water particles in the petroleum sample.
- organize an awareness about the presence of sulphur content in the fluid sample

At least eight experiments are to be performed

List of Experiments:

1. Carbon residue determination by Conradson Apparatus
2. Carbon residue determination by Ramsbottom Apparatus
3. Determination of calorific value of solid and liquid fuel by Bomb Calorimeter.
4. Foaming characteristics of lube oil
5. Determination of vapour pressure of petroleum product using Reid Apparatus.
6. Determination Pour point of Petroleum Products
7. Determination Smoke point of Petroleum Products
8. Determination Aniline point of Petroleum Products
9. Determination Softening point of Petroleum Products
10. Determination of moisture content of Fuel oil by Dean and Stark Method.

*****

Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total Contact Hours/Week
CHE 15.1	**Env. Engg.& Pollution Con. Lab**	**0-0-3**	**2**	**100**	**3**

Course Objectives:

The objective of this course is to

- Give basic knowledge on pollution methods of environment.
- Perform practical work on real samples to get acquainted with instrumentation and equipment which is needed in monitoring of environmental pollution
- Perform practical work in investigating current environmental processes.

Course Outcomes:

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

- recall physical, chemical and biological characteristics of water and wastewater
- summarize the methodology to determine the polluting elements in water
- interpret the data generated in the experiment to assess the quality of water
- compare the estimated value of the contaminants in water with the permissible value for drinking water.

Detailed Syllabus:

1. Determination of pH.

2. Determination of Conductivity.

3. Determination of Acidity of water.

4. Determination of Alkalinity of Water.

5. Determination of Chlorides.

6. Determination of Hardness of water.

7. Determination of Fluorides.

8. Determination of Available Chlorine in bleaching powder.

9. Conducting Break Point Chlorination Test.

10. Determination of Residual Chlorine.

11. Determination of Dissolved Oxygen.

12. Determination of Chemical Oxygen Demand.

13. Determination of Biochemical Oxygen Demand.

14. Conducting Jar test for determining optimum dosage of coagulant.

15. Determination of Total Solids, Total Dissolved Solids & Settelable Solids.

Books Recommended:

1. Standard methods for the examination of water and wastewater. (2012). 21st Edition, Washington: APHA.

2. Sawyer, C. N., McCarty, P. L., and Perkin, G.F., Chemistry for Environmental Engineering and Science, 5th edition McGraw-Hill Inc., 2002

3. B. Kotaiah and Dr. N. Kumara Swamy, Environmental Engineering Laboratory Manual, Charotar Publishing House Pvt. Ltd., 1st Ed., 2007.

*****

Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total Contact Hours/Week
CHE 15.2	**Adv. Numerical Lab**	**0-0-3**	**2**	**100**	**3**

Course Objectives:

- To learn numerical methods for data analysis, optimisation, linear algebra and ODEs;
- To apply 1,2 to Mathematical problems and obtain solutions;
- To present these solutions in a coherent manner for assessment.

Course Outcome:

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

- Solve problem related to function approximation, Linear Algebra and do the applications;
- Analyse Initial value ordinary differential equations, with applications to chemical engineering; Boundary value problems
- .Execute MATLAB skills in numerical methods, programming and graphics;
- Familiar with different simulators for Chemical Process Design

Contents:

1. A brief introduction to MATLAB
2. Operations and the analysis of data using MATLAB and C/C++.
3. Finding the roots of a nonlinear function and optimisation.
4. Linear Algebra.
5. Heat Exchanger Network design (HEN using GAMS)
6. Flow sheeting Optimization
7. Modelling and Simulation of different chemical engineering process
8. Simulators related to Chemical Process Design and Simulation

Books

- Desmond J. Higham and Nicholas J., "MATLAB Guide", Second Edition, SIAM
- William H. Press, Saul A. Teukolsky, William T. Vetterling, Brian P. Flannery"Numerical Recipes" CUP "NUMERICALRECIPES - The Art of Scientific Computing, Third Edition, CAMBRIDGE UNIVERSITY PRESS, 2007
- A Iserles "A First Course in the Numerical Solution of DEs", CUP
- C.R.MacCluer "Industrial Maths, Modelling in Industry, Science and Government" Prentice Hall.
- C.B. Moler, Numerical Computing with MATLAB, SIAM.
- I.Graham, N.F. Britton and A. Robinson "MATLAB manual and introductory tutorials."
- https://www.gams.com/

Course outline

The course will be based around four assignments, each of which is intended to take two weeks and which contribute 20% each to the final total. The assignments can be completed in your own time, although assistance will be given during the lab workshops and you can ask questions during the problem classes. There will also be a benchmark test during which you will be required to perform certain computational tasks in C/C++, GAMS, and MATLAB in a fixed time period. This will be given as a supervised lab session and will count for 20% of the course.

•

*****

Detail syllabus
Third Semester

Core Elective IV: CHE 16.1/ CHE 16.2/ CHE 16.3/ CHE 16.4

Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
CHE 16.1	**Adv. Transport Phenomena**	**3-0-0**	**3**	**100**	**3**

Course Objectives:

- To familiarize the student with basic concepts of transport phenomena and brief review of mathematics.
- To enable students to understand the equations of change for isothermal flow and for non- isothermal flow.
- To introduce them details of equations of change for multi component systems.

Course Outcomes:

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

- Define and relate analogies among momentum, energy and mass transport.
- Explain the mechanism of momentum, heat and mass transport for steady and unsteady flow.
- Apply momentum, energy and mass balances for a given system at macroscopic and microscopic scale and solve the governing equations to obtain velocity, temperature and concentration profiles.
- Analyze transport problems in simple geometries and derive analytically the concentration, temperature or velocity distribution

Contents:

Unit-I: **10L**

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.

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.

Unit-II: 10L

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.

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-III: 10L

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-IV: 10L

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.

Books Recommended:

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.

*****

Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
CHE 16.2	**Safety in Process Industries**	**3-0-0**	**3**	**100**	**3**

Course Objective:

- To gain knowledge about different process risk involved in the chemical process industry and issues related to hazards & safety.
- To gain knowledge about the wear and Corrosion and their prevention
- To know about the periodic and preventive maintenance.

Course outcome:

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

- find the type of risk involved in a chemical plant operation
- compare the risk and illustrate disaster management options
- organize safety, energy and environmental impact audit
- inference on the root cause/fault tree analysis

Contents:

Unit-I: 10L

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 fire fighting, equipment and methods.

Unit-II: 10L

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-III: **10L**

HAZOP, Fault Tree, Event Tree, FMEA, Dow Fire and Explosion Index, Mond Index, Safety Audits.

Unit-IV: **10L**

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

Books Recommended:

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 Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
CHE 16.3	**High Polymer Engg.**	**3-0-0**	**3**	**100**	**3**

Course Objectives:

- To learn about the production, properties and applications of thermoset and thermoplastic polymers and to study kinetics of chain growth and step growth polymerization
- To learn about the chemistry and manufacturing of flexible and rigid polyurethane foams and to enhance fundamental knowledge of flow behaviour of polymer melts
- To understand the concept of mixing of polymers, different additives and their representative formulations and also to gain knowledge of polymer composite and its basic construction

Course Outcome:

Students will be able to:

- Define the relationships between polymer molecular weight, molecular weight distribution, and the properties of polymeric materials.
- Demonstrate an ability to distinguish different polymerization reactions and their mechanisms /kinetics, and learn how actual polymerization is performed in the laboratory.
- Identify the thermal and mechanical properties of polymers, and demonstrate an ability to predict how the molecular weight will affect these properties.

- Inspect the operation of extrusion and injection molding machines, and to collect and analyze data. This will help them to make connections between the polymer molecular weight, viscoelastic properties, and processing conditions.

Contents:

Unit I: 10L

Polymerization Processes, Polymerization Catalysts, Polymerization Reactors, Polymer Reaction Engineering

Unit II: 10L

Polymer Rheology : Visco-elastic non-Newtonian flow phenomena and material functions, Power law, relaxation & hysteresis, Deformation and fracture behaviour of polymers, Polymer Morphology.

Unit III: 10L

Mixing : Characterization of mixed state, Dispersive and distributive mixing, Importance of processing, Extruders, Extrusion Dies, Film blowing, Multilayer Extrusion, Fibre spinning, Moulding and forming : Injection and Jet moulding, Thermoforming

Unit IV: 10L

Composite Materials : Plastic Composites, Metal-matrix Composites, Ceramic-matrix Composites, Nano-composites; Engineering polymers, Polymer blends, Engineering Ceramics, Engineering alloys; Service Performance : Corrosion and Fatigue.

Books Recommended:

1. Odian, G., (2004) Principles of Polymerization, Wiley-interscience.
2. Gupta B.R., (2004) Applied Rheology in Polymer Processing, Asian Books.
3. Ghosh P., (2010) Polymer Science and Technology of Plastic and Rubber, Tata McGraw Hill.
4. Lutz J.T., (2001), Polymer Modifiers and Additives, Marcel Dekker.
5. Zweifel H., Amos S.E., (2001) Plastics Additives Handbook, Hanser.
6. Paul D.R., Bucknall C.B., (2000) Polymer Blends Vol. 1 & Vol. 2, WileyInterscience.

*****

Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
CHE 16.4	**Computational Fluid Dynamics**	**3-0-0**	**3**	**100**	**3**

Course Objectives

- To make students understand the governing equations of fluid dynamics and their derivation from laws of conservation

- To develop a good understanding in computational skills, including discretisation, accuracy and stability.
- 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.

Course Outcomes:

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

- Memorize the basic principles of mathematics and numerical concepts of fluid dynamics.
- Identify governing equations for a given fluid flow system.
- Implement finite difference techniques for fluid flow models.
- Organize finite difference method for heat transfer problems.

Unit I: **10L**

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 their physical meaning, Mathematical behaviour 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: **10L**

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: **10L**

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: **10L**

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, 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.

Books Recommended:

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.

*****

Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
CHE 17	**Mathematical and Statistical Methods in Chemical Engineering**	**3-0-0**	**3**	**100**	**3**

Course Objectives:

- To give students an insight in various Chemical Engineering Processes using advanced Numerical and Statistical Methods.
- To provide adequate background of Mathematics to deal with Chemical Engineering Problems
- To understand research papers on relevant topics involving advanced Mathematics.

Course Outcomes:

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

- Recite concept of permutation and combination, statistics, field, vector space, polynomial approximation, tri-diagonal matrix and demonstrate computational modeling and applies techniques from areas such as artificial intelligence, data base, chemical engineering, machine learning, image processing.
- Illustrate physical scenario and classify them to recognize the best fit physical and logical models.
- Compare different mathematical results during the process of problem analysis.
- Design models to demonstrate industrial problem for emerging trend in chemical engineering.

Content:

Unit-I: 10L

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-II: 10L

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, Geormtraic 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, Generaic equation forms in transformed problems.

Unit-III: 10L

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 tridiagonal and block tridiagonal 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-IV: **10L**

Solving Nonlinear Algebraic Equations, Method of successive substitutions derivative free iterative solution approaches Secant method, regular 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.

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.

Books Recommended:

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

*****

Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
CHE 18	Research Methodology and IPR	2 – 0 - 0	2	100	2

Course Objectives:

The course should enable the students to:

- Identify an appropriate research problem in their interesting domain.
- Understand ethical issues and understand the Preparation of a research project thesis report.
- Understand the law of patent and copyrights and the Adequate knowledge on IPR

Course Outcomes:

Students will be able to:

- Choose and outline a quality literature review and find the research gap.
- Interpret on Problem Statement & its Validation.
- Demonstrate on literature search, how to prepare the key points and organize research ideas.
- Describe on Intellectual Property rights and analyze principles on National and International Scenario.

Contents:

Unit I: **10L**

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

Effective literature studies approaches, analysis Plagiarism, Research ethics,

Unit II: **10L**

Effective technical writing, how to write report, Paper

Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

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 III: **10L**

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

Unit IV: **10L**

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.

Books Recommended:

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

*****

Practical/ Sessional papers

Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
CHE 19	**Project Work –Phase I and Thesis**	**0 – 0 - 0**	**8**	**100**	**20**

Course Outcomes: (CHE 19)

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

- recall the knowledge and skills previously gained and applied to an in-depth study and execution of new technical problem.
- summarize and detail out specifications, methodology, resources required, critical issues involved in project
- organise the ideas and develop the skill of documentation of a significant piece of work.
- compose the phase wise work distribution, and use the problem solving method to present the findings.

Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
CHE 20	Project Seminar –Phase I	0 – 0 - 0	2	100	

Course Outcomes: (CHE 20)

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

- recall the information of document report comprising of summary of literature survey, detailed objectives, project specifications etc
- summarize and demonstrate the concept/functionality and part results
- predict the record of continuous progress.
- combine the project report and presentation

Detailed syllabus

Fourth Semester

Practical/ Sessional papers

Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
CHE 21	Project Work – Phase II	0 – 0 - 0	10	100	27
CHE 22	Project Thesis and Project Viva Voce	0 – 0 - 0	2	100	
CHE 23	Comprehensive Viva Voce	0 – 0 - 0	2	100	

Practical/ Sessional papers

Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
CHE 21	Project Work – Phase II	0 – 0 - 0	10	100	27

Course Outcomes: (CHE 21)

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

- discover 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
- demonstrate the development and testing of the proposed work as per the schedule.
- organizing the results/contributions/innovations which should be published in terms of research papers in reputed journals and reviewed focused conferences or patents.
- predict a dissertation report as per the specified format, develop system in the form of hardware and/or software, A record of continuous progress.

Practical/ Sessional papers

Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
CHE 22	**Project Thesis and Project Viva Voce**	**0 – 0 - 0**	**2**	**100**	

Course Outcomes: (CHE 22)

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

- recall the technical knowledge gathered during the project work.
- summarize a document report comprising of summary of literature survey, detailed objectives, project specifications, paper and/or computer aided design, proof of concept/functionality, results and recommendations
- predict the overall technical aptitude ,systematic development and documentation of a significant piece of work for industry readiness.
- judge to deliver conclusive and convincing answers.

Project work: Phase – I and Phase – II

Teaching Scheme Project work: 20 and 27 hrs/week for phase I and II respectively

Course Objectives:

The objectives of this subject are to:

- Provide a student the opportunities to apply and integrate his/her knowledge acquired throughout the undergraduate study.
- Develop the capabilities of a student in analyzing and solving complex and possibly real-case problems.
- Train students with skills on systematic development and documentation of a significant piece of work.

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 project stage II is based on a report prepared by the students on project 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 Project Phase – I and II

- As per the AICTE directives, the Project 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

Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
CHE 23	**Comprehensive Viva Voce**	**0 – 0 - 0**	**2**	**100**	

Course Outcome:

Students will able to:

- Recall technical knowledge gather during the course.
- Solve different research oriented technical industrial problems.
- Defend the multiple interviewers and to deliver conclusive and convincing answers.
- Develop various application of Chemical Engineering in industry and real life difficulties.

*****

AUDIT COURSE 1 & 2:

Course Code	Course Title	Hours/week L:T:P	Credit	Marks	Total contact hours/week
CHE A1 & CHE A2	**Audit course 1 & Audit Course 2**	**2-0-0**	**0**	**100**	**2**

1: ENGLISH FOR RESEARCH PAPER WRITING

Course Objectives:

This course prepares the students to:

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

Course Outcomes:

Students will be able to:

- Recall word order to structure paragraphs and sentences.
- Demonstrate different sections of paper and review of literature.

- Apply key skills to write an abstract, title, introduction and different other sections of paper.
- Examine the written paper and compare it with already present literature.

Contents:

1. Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness **(4L)**
2. Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction (**4L)**
3. Review of the Literature, Methods, Results, Discussion, Conclusions, the Final Check.**(4L)**
4. Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature **(4L)**
5. Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions **(4L)**
6. Useful phrases, how to ensure paper is as good as it could possibly be the first- time submission **(4L)**

Books Recommended:

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

*****

2: DISASTER MANAGEMENT

Course Objectives:

This course prepares the students to:

- Understanding Disasters, man-made Hazards and Vulnerabilities
- Understanding disaster management mechanism
- Understanding capacity building concepts and planning of disaster managements

Course Outcomes:

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

- Define a critical understanding of key concepts in disaster risk reduction and humanitarian response.
- Demonstrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
- Develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.

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

Contents:

1. Introduction, Disaster: Definition, Factors and Significance; Difference between Hazard and Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude. **(4L)**
2. 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 **(4L)**
3. Disaster Prone Areas in India Study of Seismic Zones; Areas Prone to Floods and Droughts, Landslides and Avalanches; Areas Prone to Cyclonic and Coastal Hazards with Special Reference to Tsunami; Post-Disaster Diseases and Epidemics **(4L)**
4. 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 **(4L)**
5. 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. **(4L)**
6. 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. **(4L)**

Books Recommended:

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.

*****

3: SANSKRIT FOR TECHNICAL KNOWLEDGE

Course Objectives:

This course prepares the students to:

- Get a working knowledge in illustrious Sanskrit, the scientific language in the world
- Learn Sanskrit to improve brain functioning

- Learn Sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power and to be able to explore the huge knowledge from ancient literature

Course Outcomes:

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

- Recall basic Sanskrit language
- Demonstrate Ancient Sanskrit literature about science & technology
- Develop logic by improve brain functioning being a logical language
- Examine with Sanskrit to explore the huge knowledge from ancient literature .

Contents:

1. Alphabets in Sanskrit, Past/Present/Future Tense, Simple Sentences **(8L)**
2. Order, Introduction of roots, Technical information about Sanskrit Literature **(8L)**
3. Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics **(8L)**

Books Recommended:

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.

*****

4: VALUE EDUCATION

Course Objectives:

This course prepares the students to:

- Understand value of education and self- development
- Imbibe good values in students
- Let the should know about the importance of character

Course Outcomes:

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

- Find of self-development
- Relate the importance of Human values
- Develop overall personality
- Decide Self-control

Contents:

1. Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism, Moral and non- moral valuation, Standards and principles, Value judgements **(6L)**

2. Importance of cultivation of values, Sense of duty. Devotion, Self reliance, Confidence, Concentration, Truthfulness, Cleanliness, Honesty, Humanity, Power of faith, National Unity, Patriotism. Love for nature, Discipline **(6L)**
3. 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, Association and Cooperation, Doing best for saving nature **(6L)**
4. 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 **(6L)**

Books Recommended:

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

*****

5: CONSTITUTION OF INDIA

Course Objectives:

This course prepares the students to:

- Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
- 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.
- 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.

Course Outcomes:

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

- Find the History of Making of the Indian Constitution
- Demonstrate the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
- Identify the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
- Examine 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.

Contents:

1. History of Making of the Indian Constitution: History Drafting Committee, (Composition & Working) **(4L)**
2. Philosophy of the Indian Constitution: Preamble, Salient Features **(4L)**

3. Contours of Constitutional Rights & Duties: **(4L)**
    i) Fundamental Rights
    ii) Right to Equality
    iii) Right to Freedom
    iv) Right against Exploitation
    v) Right to Freedom of Religion
    vi) Cultural and Educational Rights
    vii) Right to Constitutional Remedies
    viii) Directive Principles of State Policy
    ix) Fundamental Duties.
4. Organs of Governance: **(4L)**
    i) Parliament
    ii) Composition
    iii) Qualifications and Disqualifications
    iv) Powers and Functions
    v) Executive
    vi) President
    vii) Governor
    viii) Council of Ministers
    ix) Judiciary, Appointment and Transfer of Judges, Qualifications
    x) Powers and Functions
5. Local Administration: **(4L)**
    i) District's Administration head: Role and Importance,
    ii) Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation.
    iii) Pachayati raj: Introduction, PRI: Zila Pachayat.
    iv) Elected officials and their roles, CEO Zila Pachayat: Position and role.
    v) Block level: Organizational Hierarchy (Different departments),
    vi) Village level: Role of Elected and Appointed officials, Importance of grass root democracy
6. Election Commission: **(4L)**
    i) Election Commission: Role and Functioning.
    ii) Chief Election Commissioner and Election Commissioners.
    iii) State Election Commission: Role and Functioning.
    iv) Institute and Bodies for the welfare of SC/ST/OBC and women.

Books Recommended:

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.

*****

6: PEDAGOGY STUDIES

Course Objectives:

This course prepares the students to:

- Review existing evidence on the review topic to inform programme design and policy making undertaken by the DFID, other agencies and researchers.
- Find the evidence on the effectiveness of pedagogical practices
- Identify critical evidence gaps to guide the development.

Course Outcomes:

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

- Recall of methodology and Searching
- Relate the pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?
- Identify the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
- Examine how can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

Contents:

1. Introduction and Methodology: **(4L)**
    - Aims and rationale, Policy background, Conceptual framework and terminology
    - Theories of learning, Curriculum, Teacher education.
    - Conceptual framework, Research questions.
    - Overview of methodology and Searching.
2. Thematic overview: **(4L)**
    - Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries,
    - Curriculum, Teacher education
3. Evidence on the effectiveness of pedagogical practices **(8L)**
    - 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.
4. Professional development: **(4L)**
    - 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
5. Research gaps and future directions **(4L)**
    - Research design
    - Contexts
    - Pedagogy
    - Teacher education
    - Curriculum and assessment

- Dissemination and research impact.

Books Recommended:

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.

*****

7: STRESS MANAGEMENT BY YOGA

Course Objectives:

This course prepares the students to:

- realize Do`s and Don't's in life
- Achieve overall health of body and mind
- Overcome stress

Course Outcomes:

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

- Define what is Yoga
- Compare Do`s and Don't's in life.
- Choose various yoga poses and their benefits for mind & body.
- Inspect of breathing techniques and its effects

Contents:

1. Definitions of Eight parts of yog. (Ashtanga),Yam and Niyam. Do`s and Don't's in life. **(8L)**
2. i) Ahinsa, satya, astheya, bramhacharya and aparigraha
   ii)Shaucha, santosh, tapa, swadhyay, ishwarpranidhan **(8L)**
3. Asan and Pranayam
   i) Various yog poses and their benefits for mind & body
   ii) Regularization of breathing techniques and its effects-Types of pranayam **(8L)**

Books Recommended:

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

*****

8: PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS

Course Objectives:

This course prepares the students to:

- Learn to achieve the highest goal happily
- Become a person with stable mind, pleasing personality and determination
- Awaken wisdom in students

Course Outcomes:

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

- Recall of Shrimad-Bhagwad-Geeta will help the student in developing his personality .
- Demonstrate of Shrimad-Bhagwad-Geeta will help the student to achieve the highest goal in life.
- The study will build the students in the way to day to day work and duties
- Function to lead the nation and mankind to peace and prosperity

Contents:

1. Neetisatakam-Holistic development of personality **(8L)**
    - Verses- 19,20,21,22 (wisdom)
    - Verses- 29,31,32 (pride & heroism)
    - Verses- 26,28,63,65 (virtue)
    - Verses- 52,53,59 (dont's)
    - Verses- 71,73,75,78 (do's)
2. Approach to day to day work and duties. **(8L)**
    - Shrimad Bhagwad Geeta : Chapter 2-Verses 41, 47,48,
    - Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,17, 23, 35,
    - Chapter 18-Verses 45, 46, 48.
3. Statements of basic knowledge. **(8L)**
    - 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

Books Recommended:

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.

*****