UNIVERSITY OF MUMBAI
No. UG/146of 2016-17

CIRCULAR:-

A reference is invited to the syllabi relating to the Master of Engineering (Chemical Engineering) degree course **vide** this office Circular No.UG/137 of 2012-13, dated 2nd February, 2013 and the Principals of affiliated Colleges in Engineering are hereby informed that the recommendation made by Ad-hoc Board of Studies in Electrical Engineering at its meeting held on 8th July, 2016 has been accepted by the Academic Council at its meeting held on 14th July, 2016 **vide** item No. 4.20 and that in accordance therewith, the revised syllabus as per Choice Based Credit System for Master of Engineering (Chemical Engineering) (Sem. I to IV), which is available on the University's web site (www.mu.ac.in) and that the same has been brought into force with effect from the academic year 2016-17.

9/11/16

MUMBAI – 400 032
9 November, 2016

(Dr.M.A.Khan)
REGISTRAR

To,

The Principals of affiliated Colleges in Engineering.

A.C/ 4.20/14/07/2016.

****

No. UG/146-A of 2016 MUMBAI-400 032 9 November, 2016

Copy forwarded with compliments for information to:-

1. The Dean, Faculty of Technology,
2. The Chairmen, Ad-hoc Board of the Studies in Electrical Engineering
3. The Director, Board of College and University Development,
4. The Controller of Examinations,
5. The Co-Ordinator, University Computerization Centre.

9/11/16.

(Dr.M.A.Khan)
REGISTRAR

... PTO

AC-14/07/2016
Item No.- 4.20

UNIVERSITY OF MUMBAI

Revised Syllabus for the

M. E. (Chemical Engineering)
Program: M.E.
(Semester I, II, III and IV)

Course: Chemical Engineering

Under

Faculty of Technology

(As per Choice Based Credit and Grading System
With Effect from Academic Year 2016-2017)

From Coordinator's Desk

To meet the challenge of ensuring excellence in engineering education, the issue of quality needs to be addressed, debated taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education. The major emphasis of accreditation process is to measure the outcomes of the program that is being accredited. In line with this Faculty of Technology of University of Mumbai has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development.

Faculty of Technology, University of Mumbai, in one of its meeting unanimously resolved that, each Board of Studies shall prepare some Program Educational Objectives (PEO's) give freedom to affiliated Institutes to add few (PEO's) course objectives course outcomes to be clearly defined for each course, so that all faculty members in affiliated institutes understand the depth approach of course to be taught, which will enhance learner's learning process. It was also resolved that, maximum senior faculty from colleges experts from industry to be involved while revising the curriculum. I am happy to state that, each Board of studies has adhered to the resolutions passed by Faculty of Technology, developed curriculum accordingly. In addition to outcome based education, **Choice Based Credit and Grading System** is also introduced to ensure quality of engineering education.

Choice Based Credit and Grading System enables a much-required shift in focus from teacher-centric to learner-centric education since the workload estimated is based on the investment of time in learning not in teaching. It also focuses on continuous evaluation which will enhance the quality of education. University of Mumbai has taken a lead in implementing the system through its affiliated Institutes Faculty of Technology has devised a transparent credit assignment policy adopted ten points scale to grade learner's performance. Credit grading based system is implemented for First Year of M.E. in Chemical Engineering from the academic year 2016-2017. Subsequently this system will be carried forward for Second Year of M.E. in Chemical Engineering in the academic year 2017-2018.

Dr. S. K. Ukarande
Co-ordinator,
Faculty of Technology,
Member - Academic Council
University of Mumbai, Mumbai

Preamble to the Revision of Syllabus in Chemical Engineering

Today Chemical Engineering has advanced in various areas like nontechnology, nuclear engineering, and biotechnology, apart from traditional areas like petroleum, polymer and pharmaceutical Industry. To match the increasing pace of development in all fields including Chemical Engineering and Biotechnology there is demand on academician to upgrade the curriculum in Education. There is also an incredible amount of content, in a variety of formats, available on the net. The availability of free software such as Scilab and COCO vastly expands our boundaries of learning. Hence, the Postgraduate Curriculum in Chemical Engineering must provide the necessary foundation for a Chemical Engineer to be able to specialize in any area as and when the need and opportunity arise.

The Curriculum must integrate knowledge of the basic and advanced sciences with problem solving abilities. It must cultivate a willingness to face open-ended problems with adequate data. The Curriculum must be broad enough to cover all areas from design to operation of Process plants. It should be deep enough to enable the learners to carry out research and develop products to meet rapidly changing needs and demands.

With these objectives, inputs from experts from leading institutions and faculty teaching the post graduate courses, a meeting was organized at Mahatma Gandhi Mission College of Engineering Kamotee on 13th of June 2016. The program objectives and outcomes were thoroughly discussed in this meeting and the core structure of the syllabus was formulated keeping in mind choice based semester based credit and grading system curriculum to be introduced in this revised syllabus for M.E. (Chemical Engineering) for semester I, II, II and IV. Views from experts and PG teachers were taken into consideration and final draft was prepared with the consent of all the members involved.

Dr. Kalpana S. Deshmukh,
Chairman, Board of Studies in Chemical Engineering (Adhoc),
University of Mumbai,
Mumbai.

University of Mumbai
Program Structure for M.E. Chemical Engineering (Revised 2016-2017)

Semester I

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Practical	Theory	Practical	Total
CHC101	Advanced Fluid Dynamics	4	--	4	--	4
CHC102	Advanced Chemical Reaction Engineering	4	--	4	--	4
CHC103	Advanced Thermodynamics	4	--	4	--	4
CHDLO101X	Department Level Optional Course-I	4	--	4	--	4
ILO101X	Institute Level Optional Course-I	3	--	3	--	3
CHL101	Laboratory-I	--	2	--	1	1
CHL102	Laboratory-II	--	2	--	1	1
Total		**19**	**4**	**19**	**2**	**21**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract /Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in hrs)			
		Test 1	Test 2	Avg					
CHC101	Advanced Fluid Dynamics	20	20	20	80	3	--	--	**100**
CHC102	Advanced Chemical Reaction Engineering	20	20	20	80	3	--	--	**100**
CHC103	Advanced Thermodynamics	20	20	20	80	3	--	--	**100**
CHDLO101X	Department Level Optional Course-I	20	20	20	80	3	--	--	**100**
ILO101X	Institute Level Optional Course-I	20	20	20	80	3	--	--	**100**
CHL101	Laboratory-I	--	--	--		--	25	25	**50**
CHL102	Laboratory-II	--	--	--		--	25	25	**50**
Total		100	100	**100**	**400**	**--**	**50**	**50**	**600**

Semester II

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Practical	Theory	Practical	Total
CHC201	Process Heat Transfer	4	--	4	--	4
CHC202	Advanced Mass Transfer Operation	4	--	4	--	4
CHC203	Advanced Process Control And Dynamics	4	--	4	--	4
CHDLO202X	Department Level Optional Course-II	4	--	4	--	4
ILO202X	Institute Level Optional Course-II	3	--	3	--	3
CHL201	Laboratory-III	--	2	--	1	1
CHL202	Laboratory-IV	--	2	--	1	1
Total		**19**	**4**	**19**	**2**	**21**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract /Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in hrs)			
		Test 1	Test 2	Avg					
CHC201	Process Heat Transfer	20	20	20	80	3	--	--	**100**
CHC202	Advanced Mass Transfer Operation	20	20	20	80	3	--	--	**100**
CHC203	Advanced Process Control And Dynamics	20	20	20	80	3	--	--	**100**
CHDLO202X	Department Level Optional Course-II	20	20	20	80	3	--	--	**100**
ILO202X	Institute Level Optional Course-II	20	20	20	80	3	--	--	**100**
CHL201	Laboratory-III	--	--	--	--	--	25	25	**50**
CHL202	Laboratory-IV	--	--	--	--	--	25	25	**50**
Total		100	100	**100**	**400**	**--**	**50**	**50**	**600**

Departmental Level Optional Subject (DLO):

Every student is required to take Departmental level optional course one each in semester I and II. Different sets of courses will run in both the semesters.

Institute Level Optional Subject (ILO):

Every student is required to take Institute level optional course one each in semester I and II which is closely allied to their disciple. Different sets of courses will run in both the semesters.

Departmental Level Optional Course		**Institute Level Optional Course**	
Course Code	**Course Name**	**Course Code**	**Course Name**
Semester I			
CHDLO1011	Advanced Computer Aided Design	ILO1011	Product Lifecycle Management
CHDLO1012	Corrosion in Industries and its control	ILO1012	Reliability Engineering
CHDLO1013	Process Intensification in Chemical Plant	ILO1013	Management Information System
CHDLO1014	Industrial Solid Waste Management	ILO1014	Design of Experiments
CHDLO1015	Bio Process Engineering	ILO1015	Operation Research
		ILO1016	Cyber Security and Laws
		ILO1017	Disaster Management and Mitigation Measures
		ILO1018	Energy Audit and Management
Semester II			
CHDLO2021	Industrial Safety and Hazard Control	ILO2021	Project Management
CHDLO2022	Heterogeneous Catalysis and Reactor Design	ILO2022	Finance Management
CHDLO2023	Advanced Process Modeling, Simulation and Optimization	ILO2023	Entrepreneurship Development and Management
CHDLO2024	Green Chemistry And Engineering	ILO2024	Human Resource Management
CHDLO2025	Industrial Pollution Control and Prevention	ILO2025	Professional Ethics and CSR
		ILO2026	Research Methodology
		ILO2027	IPR and Patenting
		ILO2028	Digital Business Management
		ILO2029	Environmental Management

Semester III

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Practical	Theory	Practical	Total
CHS301	Special Topic Seminar	--	06	--	3	3
CHD302	Dissertation - I	--	24	--	12	12
Total		**--**	**30**	**--**	**15**	**15**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract /Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in hrs)			
		Test 1	Test 2	Avg					
CHS301	Special Topic Seminar	--	--	--	--	--	50	50	**100**
CHD302	Dissertation - I	--	--	--	--	--	100	--	**100**
Total							**150**	**50**	**200**

Semester IV

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Practical	Theory	Practical	Total
CHD401	Dissertation - II	--	30	--	15	15
Total		**--**	**30**	**--**	**15**	**15**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract /Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in hrs)			
		Test 1	Test 2	Avg					
CHD401	Dissertation - II	--	--	--	--	--	100	100	**200**
Total							**100**	**100**	**200**

Note:
For the calculation of load of a teacher;
In case of Seminar, 01hour/week/student should be considered.
In case of Dissertation I, 02/week/student should be considered.
In case Of Dissertation II, 02/hour/week/student should be considered.

Course Code	Course Name	Credits
CHC101	Advanced Fluid Dynamics	4

Prerequisite

- Basic Fluid Flow Concepts: Dimensions and Units, Velocity and Stress Fields, surface tension, Viscosity and Non-Newtonian viscosity.
- Dimensional Analysis (Buckingham PI theorem), Types of flows, Fluid Statics.

Course-objective

- To learn the flow behavior of Newtonian and non-Newtonian fluid through different dimensional passages.
- To study flow behavior of compressible fluids and multiphase mixtures
- To learn the design of stirred tank and different types of mixing equipments.
- Study of mechanism of fluidization and flow through Jet and nozzle.
- To understand the principles of computational fluid dynamics and develop CFD model for different types of fluid mixing.

Module	Contents	Contact Hours
1	**Introduction:** Equation of continuity, equation of motion, Navier Stokes equation, Euler equation, Bernoulli equation, Momentum boundary layer theory (Laminar boundary theory & turbulent boundary layer theory), dimensionless number and its significance. **Non-Newtonian Fluids**: Classification of fluid behavior, Laminar flow(Fluid with a yield stress)-Laminar flow in cylindrical tubes, Laminar flow between parallel plates, Laminar flow in annuli (Newtonian fluids, Bingham Plastic Fluids), Laminar flow(fluids without a yield stress), Power law fluids.	10
2	**Compressible fluids**: Flow through variable area-conduits, Flow of gas through a nozzle or orifice (isothermal flow, non isothermal flow), Flow in a pipe (Energy balance for flow of ideal gas, isothermal flow of an ideal gas in a horizontal pipe, Flow with fixed upstream pressure and variable downstream pressure, Non- isothermal flow of an ideal gas in a horizontal pipe, Adiabatic flow of an ideal gas in a horizontal pipe).	08
3	**Agitation and Mixing:** Agitation of Liquids, Mixing mechanisms (Laminar mixing, Turbulent mixing), Circulation, Velocities in stirred tanks, Flow patterns in stirred tanks, Power consumptions in stirred vessels, Mixing Equipments (Impellers. Propellers Turbines, Extruders, Baffles).	10
4	**Flow of multiphase mixtures:** Two phase gas vapor liquid flow, horizontal and vertical flows of gas -liquids, liquid, gas – solid mixtures, slip and hold up effects, phase separation and settling behavior, pressure, momentum and energy relations, practical methods for evaluating pressure drop. **Motion in the fluidized bed:-**conditions for fluidization, behavior of the fluidized bed, minimum fluidization velocity, different types of fluidization, particulate fluidization, bubbling fluidization, semi-fluidization, mixing and segregation in fluidized bed, application of fluidization **Jets and Sprays-**Jet ejector, jet mixer, spray nozzle, high velocity spray nozzle.	08
5	**Computational fluid dynamics:-**Introduction of CFD, Governing equations of fluid dynamics and there physical meaning, Mathematical behavior of governing equations and the impact on CFD simulations, Simple CFD techniques and CFL (Courant-Friedrichs-Lewy) condition. Numerical methods in CFD, Grid generation, Introduction to turbulence modeling, multiphase modeling, chemical fluid mixing modeling and post processing of CFD models.	12

Assessment

Internal:

Assessment consists of two tests out of which; one should be compulsory class test and the other is either a class test or assignment on live problems or course project.

End Semester Theory Examination:

Some guidelines for setting up the question paper:

- Minimum 80% syllabus should be covered in question papers of end semester examination.
- Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.
- Question paper will comprise of total six question
- All question carry equal marks
- Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
- Only Four question need to be solved.

Reference

1. "The Flow of Complex Mixtures in Pipes" by Govier and Aziz
2. "Non Newtonian Flow and Heat Transfer" by A. H. P. Skelland.
3. "Chemical Engineering" by Coulson and Richardson, Volume I.
4. "Computational Fluid Dynamics: The Basics with Applications" by Anderson John D.
5. "Fundamentals of Grid Generation" by Knupp Patrick and Steinberg Stanly.
6. "Turbulence Modeling for CFD" by Wilcox D.C.

Course Code	Course Name	Credits
CHC102	Advanced Chemical Reaction Engineering	4

Prerequisites

- Undergraduate level chemical reaction engineering, mass transfer, and thermodynamics.

Course Objectivesˆ

- Residence time analysis of real chemical reactors.
- Complex chemical reaction mechanisms and kinetics.
- Rate processes in heterogeneous reacting systems
- Transport effects in multiphase reactive systems.
- Design of fluid-fluid and fluid-solid reactors.
- Advanced reactor design and stability, including consideration of the energy balance.

Course Outcome

- On completion of the course, the student should be able to design/analyze a variety of complex reacting systems in chemical engineering.

Module	Contents	Contact Hours
1	**Performance Characteristics, kinetics and design of multiple reaction:** Successive irreversible reactions of different orders, Reversible reactions- series or parallel reactions. Series parallel reactions. Quantitative treatment of multiple reactions in Plug flow or Batch reactor and Mixed reactors. Application for polymerization reaction, fermentation reaction.	06
2	**RTD for Chemical Reactors:** General characteristics, Measurement of RTD characteristics, RTD in ideal Reactors, Zero Parameter Models, Segregation Model.	06
	Analysis of Non-Ideal reactors: One parameter Models- The tank in the series Models, Dispersion model. Two parameter model. Testing the model and determining its parameters. Other models of the non ideal reactors using the CSTR's and PFR's using the RTD	06
4	**Rate equation for Fluid-Solid reactions**: Rate of the adsorption, desorption, surface reaction, synthesizing rate law, mechanism and rate limiting steps, design of the reactors for the gas solid reactions, heterogeneous data analysis for the reacto r designs, catalysts deactivation, moving bed reactors.	06
5	**External diffusion effects on the Heterogeneous Reactions:** Binary diffusion, External resistance to Mass Transfer, The shrinking core model.	06
6	**Diffusion and Reaction in Porous Catalysts:** Diffusion and Reactions in spherical catalyst pellets, Internal effectiveness factor, Falsified kinetics, Overall effectiveness factor, Estimation of diffusion and reaction limited regimes, mass transfer and reaction in packed bed, The deter mination of limiting situation from reaction data.	06
7	**Design of Heterogeneous Catalytic Reactors**: Isothermal and adiabatic fixed bed reactors, Non-Isothermal, Non-adiabatic fixed bed reactors, slurry reactors, and trickle bed reactors.	06
8	**Fluid-Fluid reactions:** Design of towers for fast reactions, for slow reactions, mixer settles, semi batch contacting patterns. Reactive distillation and extractive reactions.	06

Assessment

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Assessment consists of two tests out of which; one should be compulsory class test and the other is either a class test or assignment on live problems or course project.

End Semester Theory Examination:

Some guidelines for setting up the question paper:

- Minimum 80% syllabus should be covered in question papers of end semester examination.
- Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.
- Question paper will comprise of total six question
- All question carry equal marks
- Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
- Only Four question need to be solved.

Reference

1. J. M. Smith, "Chemical Engineering Kinetics" McGraw-Hill Book Company.
2. H. S. Fogler, "Elements of Chemical reaction engineering" Prentice - Hall of India.
3. J.J. Carberry, "Chemical and catalytic reaction Engineering", Dover Publications.
4. Hill C.G., Chemical Reaction Engineering
5. O. Levenspiel, Chemical Reaction Engineering, 3rd edition, John Wiley & Sons, 2004.

Course Code	Course Name	Credits
CHC103	Advanced Thermodynamics	4

Prerequisites

- Basic course in mathematics, thermodynamics, physical Chemistry, kinetic theory of gases, ideal gas law, vapor pressure and Raoult's law.

Course Objectives

- To learn advanced topics of classical thermodynamics with emphasis on basic concepts, laws, and thermodynamic relationships.
- To familiarize students with knowledge of advanced thermodynamics especially in chemical engineering related fields
- To educate students to apply these thermodynamic principles to solve problems encountered in chemical engineering and related researches.

Course Outcomes

- Upon completing the course, the student should be able tocalculate various thermodynamic properties of solutions.
- Calculate equilibrium compositions in vapor-liquid and liquid-liquid using various equations and theories

Module	Contents	Contact Hours
1	**Classical Thermodynamics of Phase Equilibria:** Gibbs - Duhem equation, chemical potential, fugacity and activity coefficient. Partial Molar Properties.	06
2	**Thermodynamic Properties from Volumetric Data:** Thermodynamic properties with independent variables P & T, fugacity of a component in a mixture at moderate pressures, thermodynamic properties with independent variables V and T, fugacity of component in a mixture according to Vander Waals equation.	10
3	**Fugacities in Gas mixtures:** Lewis fugacity rule, Equation of State,Virial equations of state, Extension to mixtures, fugacities from virial equation, calculation of virial coefficients from potential functions, third virial coefficients, Virial coefficients from corresponding states correlation, fugacities from generalized charts for pure components, fugacities from an empirical equation of state.	12
4	**Fugacities in Liquid mixtures:** Excess functions and fundamental relations of Excess function , activity and activity coefficient, activity coefficients from excess functions in binary mixtures, application of Gibbs Duhum equation , testing of equilibrium data, Wohl's expansion for excess Gibbs energy, equations of Van der Waal, Wilson and Renon equations, Margules equations, Van Laar equation, UNIQUAC and UNIFAC methods for estimation of activity coefficient. Thermodynamic criteria of miscibility. Azeotropes and their existence.	10
5	**Fugacities in Liquid Mixtures- Models and Theories of Solutions:** Theory of Van laar, Scat chard – Hildelrand theory, Lattic theory Wilson's empirical extension of the Flory – Huggin's equation, two liquid theory, chemical theory.	10

Assessment

Internal:

Assessment consists of two tests out of which; one should be compulsory class test and the other is either a class test or assignment on live problems or course project.

End Semester Theory Examination:

Some guidelines for setting up the question paper:

- Minimum 80% syllabus should be covered in question papers of end semester examination.
- Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus**.**

- Question paper will comprise of total six question
- All question carry equal marks
- Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
- Only Four question need to be solved.

Reference

1. J.M. Prausnitz
2. Van Ness and Smith
3. Narayanan

Course Code	Course Name	Credits
CHDLO1011	Advanced Computer Aided Design	4

Prerequisite

- Unit Operations, Process Equipment Design, Computer Programming

Course-objective

- To understand the design of chemical process equipment
- To understand the application of computational software for the design of chemical process equipment

Course Outcome

- The student will be able to develop the design procedure/algorithm with relevant equations for the design of chemical process equipment
- The student will be able to appreciate the use of computational software for the design of chemical process equipment

Module	Contents	Contact Hours
1	**Physical and Thermodynamic Properties of Liquids and Gases** Introduction, Estimation of Physical Properties of Liquids and Gases, Diffusion Coefficients (Diffusivities), Compressibility Z-Factor of Natural Gases.	08
2	**Sizing of Vertical and Horizontal Separators** Introduction, Sizing of Vertical and Horizontal Separators, Sizing of Partly Filled Vessels and Tanks.	08
3	**Design of Cyclone Separators and Gas Dryers** Cyclone Separator Design, Methods for Gas Dehydration, Gas Dryer (Dehydration) Design.	08
4	**Mass Transfer Equipment Design** Determination of Plates in Fractionating Columns by the Smoker Equations for Binary Mixtures, Multicomponent Distribution and Estimation of Minimum Trays in Distillation Columns.	08
5	**Introduction to Computer Software Packages used for Chemical Process Equipment Design** Types and Characteristics of various Computer Software Packages used for Chemical Process Equipment Design such as Aspen / Aspen Plus / ChemCad / Hysis (UniSim).	04
6	**Application of Computer Software Packages and Use of Computer Programs for Chemical Process Equipment Design** Case studies involving the application of Computer Software Packages such as Aspen /Aspen Plus / ChemCad / Hysis (UniSim) and the use of Computer Programs for Design of Chemical Process Equipment.	12

Assessment

Internal:

Assessment consists of two tests out of which; one should be compulsory class test and the other is either a class test or assignment on live problems or course project.

End Semester Theory Examination:

Some guidelines for setting up the question paper:

- Minimum 80% syllabus should be covered in question papers of end semester examination.
- Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.
- Question paper will comprise of total six question
- All question carry equal marks

- Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
- Only Four question need to be solved.

Reference

1. Coulson and Richardson's Chemical Engineering Vol.6 – Design, R.K. Sinnott (Ed.) Butterworth-Heinemann, New Delhi, 2000.
2. Process Modeling, Simulation and Control for Chemical Engineers, W. Luyben, Second Edition, McGraw-Hill, 1990.
3. Process Modeling and Simulation, R.W. Gaikwad and Dr. Dhirendra, Third Edition, Bennet and Co., 2010.
4. Process Simulation and Control using Aspen, A.K. Jana, Prentice Hall of India.
5. Fortran Programs for Chemical Process Design, Analysis and Simulation, A. Kayode Coker, Gulf Publishing Co., 1995.

Course Code	Course Name	Credits
CHDLO1012	Corrosion in Industry and its control	4

Prerequisite

- Material science and engineering and advanced materials.

Course-objective

- To understand the knowledge of corrosion prevention methods for designing process industries.

Course Outcome

- The student will be able to apply the corrosion prevention methods to design corrosion free processes.

Module	Contents	Contact Hours
1	Introduction: The economics aspects of corrosion. Case studies. Some examples of catastrophic corrosion failures**.**	**06**
2	Design aspects to minimize the corrosion, Temporary corrosion prevention methods and use of inhibitors in industry.	**06**
3	Design of cathodic and anodic protection systems. Selection of the material for sacrificial anodes –anodes for impressed current methods of protection. Corrosion in pipe lines, internal and external protection of pipe line**.**	**08**
4	Corrosion of Stainless Steel, Plastics and Elastomers Principal engineering materials for equipment, Corrosion control using the exotic materials. Fabrication of special alloys, Stainless Steel, less common metals, composite materials. Welding techniques and corrosion behavior of weld metals, Plastics and Corrosion of Plastics and Elastomers**.**	**10**
5	Corrosion inspection, instrumentation and monitoring, Corrosion testing. Use of DSA in electrochemical industries, Electrochemical Machining, Chemical cleaning of equipment.	**08**
6	Corrosion and Control methods for water supply systems, cooling systems heavy water systems, underground and marine environments, Biological corrosion. Corrosion nuclear reactors and boilers. Corrosion of reinforcements concrete structure. Corrosion control in industrial Environments	**10**

Assessment

Internal:

Assessment consists of two tests out of which; one should be compulsory class test and the other is either a class test or assignment on live problems or course project.

End Semester Theory Examination:

Some guidelines for setting up the question paper:

- Minimum 80% syllabus should be covered in question papers of end semester examination.
- Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.
- Question paper will comprise of total six question
- All question carry equal marks
- Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
- Only Four question need to be solved.

Reference

1. M.G.Fontana, Corrosion Engineering, Tata McGraw-Hill (New Delhi), 3rd Ed.
2. G.L.Shvartz and M.M.Kristal, Corrosion of Chemical Apparatus (1959) Chapman Hall Ltd. London.

Course Code	Course Name	Credits
CHDLO1013	Process Intensification In Chemical Plants	4

Prerequisites

- Basics of Unit Chemical Engineering

Course Objectives

- To provide an understanding of the concept of Process Intensification.
- To provide knowledge and understanding of application of intensification techniques to a range of processes e.g. heat and mass transfer, separation processes
- To provide an understanding of basic operating principles of a variety of intensified process equipment such as spinning disc reactor, rotary packed beds, oscillatory flow reactors, compact heat exchangers and micro-reactors etc

Course Outcome

- Apply process intensification in industrial processes.
- Implement methodologies for process intensification
- Understand scale up issues in the chemical process.
- Gain the scientific background, techniques and applications of intensification in the process industries.
- Identify and solve process challenges using intensification technologies

Module	Contents	Contact Hrs
1	**History, philosophy and principles of process intensification (PI):** Introduction, philosophy and opportunities of PI, Types of PI equipments, Equipments and methods.	09
2	**High gravity in chemical processing:** Historical development, Fundamentals, mechanical design, applications, scale - up and commercial use, future, The spinning disc reactor.	10
3	**Multifunctional heat exchanger-** Introduction, Compact heat exchanger technology, Single phase flow, Heat transfer and mass transfer, applications.	10
4	**Microreaction technology:** Microtechnology, effect of miniaturization, micro fabrication, implementation.	10
5	**Structured catalysis and reactors:** Introduction, overview of structured reactors, Gas phase reactions, multiphase reactions.	09

Assessment

Internal:

Assessment consists of two tests out of which; one should be compulsory class test and the other is either a class test or assignment on live problems or course project.

End Semester Theory Examination:

Some guidelines for setting up the question paper:

- Minimum 80% syllabus should be covered in question papers of end semester examination.
- Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.
- Question paper will comprise of total six question
- All question carry equal marks
- Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
- Only Four question need to be solved.

Reference

1. Reengineering the chemical processing plant, Andrej stankiewiez, Jacob A., Moulin, Marcel Dekker Inc. New York, Basel.
2. Compact brazed plate heat exchanger. J.M., Navarro, A., Bailly, Elsvier, Paris. 1994.
3. Compact heat exchanger for the process industry. R.K., Shah, Begell House, 1997.
4. Microreactors, Ehrfeld W., Hessel V., Lowe, H., Weinheim: Willey-VCH, 2000.
5. Conceptual design of chemical processes. J.M., Douglas, McGraw- Hill, New York

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Course Code	Course Name	Credits
CHDLO1014	Industrial Solid Waste Management	4

Pre-requisite

- Management and engineering for waste disposal.
- Waste treatment cycles.

Course Objective

- Identify key sources, typical qualities generated, composition and properties of solid and hazardous wastes.
- Identify waste disposal or transformation techniques (landfill).
- Recognize the relevant, regulations that apply for facilities used for disposal and destruction of waste.
- Identify and design solid and hazardous waste landfills including closure , post closure and rehab uses.
- Estimate typical waste disposal costs.
- Identify recycling and reuse option (composting, source separation and reuse of shredded tyres, recycled glass, fly ash).

Course Outcome

- In order to manage economical and comply with environmental regulation one would manage municipal, commercial and industrial solid waste that is generated in India and all over the world.All environmental, civil, chemical and agricultural engineers can be benefited.

Module	Contents	Contact Hours
1	**Introduction:** What is solid waste. Why it is called waste and classification of solid waste. Importance of solid waste disposal, engineering principles and management.	08
2	Sources, quantities generated and physicochemical properties of MSW and hazardous waste. Solid waste management pyramid, key technologies for SWM. (Collection, transformation, landfills, composting).	08
3	Types of landfills, basic geotechnical considerations, earthen liners for waste disposal. Clay mineralogy, factors controlling hydraulic conductivity, methods to measure K in the lab and field, compatibility of liner materials to chemicals in leachate.	08
4	Containment and liquid tansport in soil liners for RCRA liners (Advection and diffusion). Geosynthesis for waste disposal. Overview, geomembrane leakage, transport and structural stability. Geosynthetic clay liners (GCLS).	08
5	Design of leachate, Collection system for landfills, Use of gravel and GDLs. Operational aspects of MSW landfills (daily cover , leachate disposal , GW monitoring)MSW to energy (production of biogas).	**08**
6	System landfill gas collection and leachate recirculation system design. Landfill final cap design and water balance (demonstration of HELP Model) modelling. Review problems.	08

Assessment

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End Semester Theory Examination:

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- Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

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- All question carry equal marks
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- Only Four question need to be solved.

Reference

1. Integrated solid waste management by Tehobanoglous/Thusen/Vigil publisher McGraw Hill.
2. Hazardous waste management, 2nd Edition MD LaGrega, PL Buckingham and J.C.Evans McGraw Hill publisher.

Course Code	Course Name	Credits
CHDLO1015	Bio Process Engineering	4

Pre-requisite

- Application of unit operations in microbes.
- Alternate of chemical reactions to bioreactions from cost and quality point of view.
- Alternate of synthetic products by natural products.

Course Objective

- To establish the reaction kinetics model for all types of chemical reaction through bioroute.
- To replace the chemical catalyst by bio-catalyst to reduce the cost of production.
- To study the cell structure, type of cells, self fractionation of centrifugation.
- Design aspects of bio-reactor versus chemical reactor.
- Effect of aeration and agitation during the course of processes.
- Cell doctrine and biophysics study.

Course Outcome

Student will be able to apply the knowledge of bioprocess engineering to convert chemical processes into bio processes using unit separation for cost of reduction and quality improvement.

Module	Contents	Contact Hours
1	**Introduction:** Definition of BPE and its importance to chemical engineers, industrial operations etc. What is bio process engineer, bio-technology and bio-process engineering. Bio process regulation constraints. History of Pencillin. How biologists and engineers work together.	06
2	**Basic concept of Biology:** An engineer's prospective, an overview of biological basics, biophysics and cell doctrine. The structure of all, pro-caryotic cells, Eucaryotic cells, self fractionation, example: analysis of particle motion in any centrifugation. Important cell types , bacteria yeast , moles , algae and protozoa , animal and plant cells, cell construction and cell nutrients.	06
3	**Chemicals of life:** Lipid, fatty acids and related lipids, fats soluble vitamins steroids and other liquids, sugars and poly sacchraides. D glucose and the mono saccharides. Disaccharides to poly saccharides, cellulose and starch, amino acids and proteins. Amino acids building blocks and polypeptides.	06
4	**Kinetics of enzyme catalysed reaction:** The enzyme substrate complex and enzyme action. Simple enzyme kinetics with one and two substrate. Michaelis- Menten kinetics evaluation of parameters in Michaelis-Menten equation. Kinetics for reversible reaction, two substrate reactions and cofactor activation. Determination of elementary step rate constant, other patterns of substrate concentrate dependence , modulation and regulation of enzymatic activity , other influences on enzyme activities , effect of pH and temperature on enzyme and its kinetics. Enzyme deactivation.	08
5	**Metabolic stoichiometry and energetics:** Thermodynamics principles, metabolic reaction coupling, ATP and NAD carbon catabolism, different pathways. Respiration cycles and chains. Bio synthesis of small molecule and macromolecule, transport across cell membrane.	**06**
6	Kinetics of substrate utilization, product formation and biomass production in cell	08

	culture. Ideal reactors for kinetics measurement, ie ideal batch CSTR , CSTR in series, FED back plug flow, kinetics of balanced growth, transient growth kinetics, product formation kinetics. Structured kinetic module, product formation kinetics.	
7	Transport phenomena in bioprocess system, gas liquid mass transfer in cellular system, determination of oxygen transfer rate. Mass transfer for freely raising or falling bodies. Forced convection mass transfer. Correlation for mass transfer coefficient and interfacial area. Overall KLA estimates and power requirement for sparged and agitated vessel, mass transfer across free surfaces, other factors affecting KLA, non Newtonian fluids. Scaling of mass transfer equipments. Heat transfer co-relations, power consumption and mass transfer in non Newtonian fluid and sterilization of gases and liquids by filtration. Design and analysis of biologival reactor, instrumentation and control in bio process.	08

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- Only Four question need to be solved.

Reference

1. Biochemical Engineering Fundamentals by James E Bailey and David F Ollis. Edition 2nd . Tata McGraw Hill.

2. Bioprocess Engineering Basic concepts by Michael L Shuler and FikretKargi. Edition 2nd. PHI Learning Private Limited.

Course Code	Course Name	Credits
ILO1011	Product Life Cycle Management	03

Objectives

- To familiarize the students with the need, benefits and components of PLM
- To acquaint students with Product Data Management & PLM strategies
- To give insights into new product development program and guidelines for designing and developing a product
- To familiarize the students with Virtual Product Development

Outcomes

Learner will be able to…

- Gain knowledge about phases of PLM, PLM strategies and methodology for PLM feasibility study and PDM implementation.
- Illustrate various approaches and techniques for designing and developing products.
- Apply product engineering guidelines / thumb rules in designing products for moulding, machining, sheet metal working etc.
- Acquire knowledge in applying virtual product development tools for components, machining and manufacturing plant

Module	Detailed Contents	Contact Hrs
01	**Introduction to Product Lifecycle Management (PLM):**Product Lifecycle Management (PLM), Need for PLM, Product Lifecycle Phases, Opportunities of Globalization, Pre-PLM Environment, PLM Paradigm, Importance & Benefits of PLM, Widespread Impact of PLM, Focus and Application, A PLM Project, Starting the PLM Initiative, PLM Applications **PLM Strategies:** Industrial strategies, Strategy elements, its identification, selection and implementation, Developing PLM Vision and PLM Strategy, Change management for PLM.	10
02	**Product Design:** Product Design and Development Process, Engineering Design, Organization and Decomposition in Product Design, Typologies of Design Process Models, Reference Model, Product Design in the Context of the Product Development Process, Relation with the Development Process Planning Phase, Relation with the Post design Planning Phase, Methodological Evolution in Product Design, Concurrent Engineering, Characteristic Features of Concurrent Engineering, Concurrent Engineering and Life Cycle Approach, New Product Development (NPD) and Strategies, Product Configuration and Variant Management, The Design for X System, Objective Properties and Design for X Tools, Choice of Design for X Tools and Their Use in the Design Process.	09
03	**Product Data Management (PDM):**Product and Product Data, PDM systems and importance, Components of PDM, Reason for implementing a PDM system, financial justification of PDM, barriers to PDM implementation.	05
04	**Virtual Product Development Tools:** For components, machines, and manufacturing plants, 3D CAD systems and realistic rendering techniques, Digital mock-up, Model building, Model analysis, Modeling and simulations in Product Design, Examples/Case studies.	05
05	**Integration of Environmental Aspects in Product Design:** Sustainable Development, Design for Environment, Need for Life Cycle Environmental Strategies, Useful Life Extension Strategies, End-of-Life Strategies, Introduction of Environmental Strategies into the Design Process, Life Cycle Environmental Strategies and Considerations for Product Design.	05
06	**Life Cycle Assessment and Life Cycle Cost Analysis:** Properties, and Framework of Life Cycle Assessment, Phases of LCA in ISO Standards, Fields of Application and Limitations of Life Cycle Assessment, Cost Analysis and the Life Cycle Approach, General Framework for LCCA, Evolution of Models for Product Life Cycle Cost Analysis.	05

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- All question carry equal marks
- Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
- Only Four question need to be solved.

References

1. John Stark, "Product Lifecycle Management: Paradigm for 21st Century Product Realisation", Springer-Verlag, 2004. ISBN: 1852338105

2. Fabio Giudice, Guido La Rosa, Antonino Risitano, "Product Design for the environment-A life cycle approach", Taylor & Francis 2006, ISBN: 0849327229

3. Saaksvuori Antti, Immonen Anselmie, "Product Life Cycle Management", Springer, Dreamtech, ISBN: 3540257314

4. Michael Grieve, "Product Lifecycle Management: Driving the next generation of lean thinking", Tata McGraw Hill, 2006, ISBN: 0070636265

Course Code	Course Name	Credits
ILO1012	Reliability Engineering	03

Objectives

- To familiarize the students with various aspects of probability theory
- To acquaint the students with reliability and its concepts
- To introduce the students to methods of estimating the system reliability of simple and complex systems
- To understand the various aspects of Maintainability, Availability and FMEA procedure

Outcomes

Learner will be able to…

- Understand and apply the concept of Probability to engineering problems
- Apply various reliability concepts to calculate different reliability parameters
- Estimate the system reliability of simple and complex systems
- Carry out a Failure Mode Effect and Criticality Analysis

Module	Detailed Contents	Contact Hrs
01	**Probability theory:** Probability: Standard definitions and concepts; Conditional Probability, Baye's Theorem. **Probability Distributions:** Central tendency and Dispersion; Binomial, Normal, Poisson, Weibull, Exponential, relations between them and their significance. **Measures of Dispersion:** Mean Median, Mode, Range, Mean Deviation, Standard Deviation, Variance, Skewness and Kurtosis.	08
02	**Reliability Concepts:** Reliability definitions, Importance of Reliability, Quality Assurance and Reliability, Bath Tub Curve. **Failure Data Analysis:** Hazard rate, failure density, Failure Rate, Mean Time To Failure (MTTF), MTBF, Reliability Functions. **Reliability Hazard Models:** Constant Failure Rate, Linearly increasing, Time Dependent Failure Rate, Weibull Model. Distribution functions and reliability analysis.	08
03	**System Reliability:** System Configurations: Series, parallel, mixed configuration, k out of n structure, Complex systems.	05
04	**Reliability Improvement:** Redundancy Techniques: Element redundancy, Unit redundancy, Standby redundancies. Markov analysis. System Reliability Analysis – Enumeration method, Cut-set method, Success Path method, Decomposition method.	08
05	**Maintainability and Availability:** System downtime, Design for Maintainability: Maintenance requirements, Design methods: Fault Isolation and self-diagnostics, Parts standardization and Interchangeability, Modularization and Accessibility, Repair Vs Replacement. Availability – qualitative aspects.	05
06	**Failure Mode, Effects and Criticality Analysis:** Failure mode effects analysis, severity/criticality analysis, FMECA examples. Fault tree construction, basic symbols, development of functional reliability block diagram, Fau1t tree analysis and Event tree Analysis	05

Assessment

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End Semester Theory Examination:

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- Only Four question need to be solved.

References

1. L.S. Srinath, "Reliability Engineering", Affiliated East-Wast Press (P) Ltd., 1985.
2. Charles E. Ebeling, "Reliability and Maintainability Engineering", Tata McGraw Hill.
3. B.S. Dhillion, C. Singh, "Engineering Reliability", John Wiley & Sons, 1980.
4. P.D.T. Conor, "Practical Reliability Engg.", John Wiley & Sons, 1985.
5. K.C. Kapur, L.R. Lamberson, "Reliability in Engineering Design", John Wiley & Sons.
6. Murray R. Spiegel, "Probability and Statistics", Tata McGraw-Hill Publishing Co. Ltd.

Course Code	Course Name	Credits
ILO1013	Management Information System	03

Objectives

- The course is blend of Management and Technical field.
- Discuss the roles played by information technology in today's business and define various technology architectures on which information systems are built
- Define and analyze typical functional information systems and identify how they meet the needs of the firm to deliver efficiency and competitive advantage
- Identify the basic steps in systems development

Outcomes Learner will be able to…

- Explain how information systems Transform Business
- Identify the impact information systems have on an organization
- Describe IT infrastructure and its components and its current trends
- Understand the principal tools and technologies for accessing information from databases to improve business performance and decision making
- Identify the types of systems used for enterprise-wide knowledge management and how they provide value for businesses

Module	Detailed Contents	Contact Hrs
01	Introduction To Information Systems (IS): Computer Based Information Systems, Impact of IT on organizations, and Importance of IS to Society. Organizational Strategy, Competitive Advantages and IS.	4
02	Data and Knowledge Management: Database Approach, Big Data, Data warehouse and Data Marts, Knowledge Management. Business intelligence (BI): Managers and Decision Making, BI for Data analysis and Presenting Results	7
03	Ethical issues and Privacy: Information Security. Threat to IS, and Security Controls	7
04	Social Computing (SC): Web 2.0 and 3.0, SC in business-shopping, Marketing, Operational and Analytic CRM, E-business and E-commerce – B2B B2C. Mobile commerce.	7
05	Computer Networks Wired and Wireless technology, Pervasive computing, Cloud computing model.	6
06	Information System within Organization: Transaction Processing Systems, Functional Area Information System, ERP and ERP support of Business Process. Acquiring Information Systems and Applications: Various System development life cycle models.	8

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- Only Four question need to be solved.

References

1. Kelly Rainer, Brad Prince, Management Information Systems, Wiley
2. K.C. Laudon and J.P. Laudon, Management Information Systems: Managing the Digital Firm, 10th Ed., Prentice Hall, 2007.
3. D. Boddy, A. Boonstra, Managing Information Systems: Strategy and Organization, Prentice Hall, 2008

Course Code	Course Name	Credits
ILO1014	Design of Experiments	03

Objectives

- To understand the issues and principles of Design of Experiments (DOE)
- To list the guidelines for designing experiments
- To become familiar with methodologies that can be used in conjunction with experimental designs for robustness and optimization

Outcomes

Learner will be able to…

- Plan data collection, to turn data into information and to make decisions that lead to appropriate action
- Apply the methods taught to real life situations
- Plan, analyze, and interpret the results of experiments

Module	Detailed Contents	Contact Hrs
01	**Introduction** 1.1 Strategy of Experimentation 1.2 Typical Applications of Experimental Design 1.3 Guidelines for Designing Experiments 1.4 Response Surface Methodology	06
02	**Fitting Regression Models** 2.1 Linear Regression Models 2.2 Estimation of the Parameters in Linear Regression Models 2.3 Hypothesis Testing in Multiple Regression 2.4 Confidence Intervals in Multiple Regression 2.5 Prediction of new response observation 2.6 Regression model diagnostics 2.7 Testing for lack of fit	08
03	**Two-Level Factorial Designs and Analysis** 3.1 The 2^2 Design 3.2 The 2^3 Design 3.3 The General2^k Design 3.4 A Single Replicate of the 2^k Design 3.5 The Addition of Center Points to the 2^k Design, 3.6 Blocking in the 2^k Factorial Design 3.7 Split-Plot Designs	07
04	**Two-Level Fractional Factorial Designs and Analysis** 4.1 The One-Half Fraction of the 2^k Design 4.2 The One-Quarter Fraction of the 2^k Design 4.3 The General 2^{k-p} Fractional Factorial Design 4.4 Resolution III Designs 4.5 Resolution IV and V Designs 4.6 Fractional Factorial Split-Plot Designs	07
05	**Conducting Tests** 5.1 Testing Logistics 5.2 Statistical aspects of conducting tests 5.3 Characteristics of good and bad data sets 5.4 Example experiments 5.5 Attribute Vs Variable data sets	07

06	**Taguchi Approach** 6.1 Crossed Array Designs and Signal-to-Noise Ratios 6.2 Analysis Methods 6.3 Robust design examples	04

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- Only Four question need to be solved.

References

1. Raymond H. Mayers, Douglas C. Montgomery, Christine M. Anderson-Cook, Response Surface Methodology: Process and Product Optimization using Designed Experiment, 3rd edition, John Wiley & Sons, New York, 2001
2. D.C. Montgomery, Design and Analysis of Experiments, 5th edition, John Wiley & Sons, New York, 2001
3. George E P Box, J Stuart Hunter, William G Hunter, Statics for Experimenters: Design, Innovation and Discovery, 2nd Ed. Wiley
4. W J Dimond, Peactical Experiment Designs for Engineers and Scintists, John Wiley and Sons Inc. ISBN: 0-471-39054-2
5. Design and Analysis of Experiments (Springer text in Statistics), Springer by A.M. Dean, and D. T. Voss
6. Phillip J Ross, "Taguchi Technique for Quality Engineering," McGraw Hill
7. Madhav S Phadke, " Quality Engineering using Robust Design," Prentice Hall

Course Code	Course Name	Credits
ILO1015	Operations Research	03

Objectives

- Formulate a real-world problem as a mathematical programming model.
- Understand the mathematical tools that are needed to solve optimization problems.
- Use mathematical software to solve the proposed models.

Outcomes

Learner will be able to…

- Understand the theoretical workings of the simplex method, the relationship between a linear program and its dual, including strong duality and complementary slackness.
- Perform sensitivity analysis to determine the direction and magnitude of change of a model's optimal solution as the data change.
- Solve specialized linear programming problems like the transportation and assignment problems, solve network models like the shortest path, minimum spanning tree, and maximum flow problems.
- Understand the applications of integer programming and a queuing model and compute important performance measures

Module	Detailed Contents	Contact Hrs
01	**Introduction to Operations Research**: Introduction, , Structure of the Mathematical Model, Limitations of Operations Research **Linear Programming**: Introduction, Linear Programming Problem, Requirements of LPP, Mathematical Formulation of LPP, Graphical method, Simplex Method Penalty Cost Method or Big M-method, Two Phase Method, Revised simplex method, **Duality**, Primal – Dual construction, Symmetric and Asymmetric Dual, Weak Duality Theorem, Complimentary Slackness Theorem, Main Duality Theorem, Dual Simplex Method, Sensitivity Analysis **Transportation Problem**: Formulation, solution, unbalanced Transportation problem. Finding basic feasible solutions – Northwest corner rule, least cost method and Vogel's approximation method. Optimality test: the stepping stone method and MODI method. **Assignment Problem**: Introduction, Mathematical Formulation of the Problem, Hungarian Method Algorithm, Processing of n Jobs Through Two Machines and m Machines, Graphical Method of Two Jobs m Machines Problem Routing Problem, Travelling Salesman Problem **Integer Programming Problem**: Introduction, Types of Integer Programming Problems, Gomory's cutting plane Algorithm, Branch and Bound Technique. Introduction to Decomposition algorithms.	14
02	**Queuing models**: queuing systems and structures, single server and multi-server models, Poisson input, exponential service, constant rate service, finite and infinite population	05
03	**Simulation**: Introduction, Methodology of Simulation, Basic Concepts, Simulation Procedure, Application of Simulation Monte-Carlo Method: Introduction, Monte-Carlo Simulation, Applications of Simulation, Advantages of Simulation, Limitations of Simulation	05
04	**Dynamic programming**. Characteristics of dynamic programming. Dynamic programming approach for Priority Management employment smoothening, capital budgeting, Stage Coach/Shortest Path, cargo loading and Reliability problems.	05
05	**Game Theory**. Competitive games, rectangular game, saddle point, minimax (maximin) method of optimal strategies, value of the game. Solution of games with saddle points, dominance principle. Rectangular games without saddle point – mixed strategy for 2 X 2 games.	05
06	**Inventory Models**: Classical EOQ Models, EOQ Model with Price Breaks, EOQ with Shortage, Probabilistic EOQ Model,	05

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- Only Four question need to be solved.

References

1. Taha, H.A. "Operations Research - An Introduction", Prentice Hall, (7th Edition), 2002.
2. Ravindran, A, Phillips, D. T and Solberg, J. J. "Operations Research: Principles and Practice", John Willey and Sons, 2nd Edition, 2009.
3. Hiller, F. S. and Liebermann, G. J. "Introduction to Operations Research", Tata McGraw Hill, 2002.
4. Operations Research, S. D. Sharma, KedarNath Ram Nath-Meerut.
5. Operations Research, KantiSwarup, P. K. Gupta and Man Mohan, Sultan Chand & Sons.

Course Code	Course Name	Credits
ILO1016	Cyber Security and Laws	03

Objectives

- To understand and identify different types cybercrime and cyber law
- To recognized Indian IT Act 2008 and its latest amendments
- To learn various types of security standards compliances

Outcomes

Learner will be able to…

- Understand the concept of cybercrime and its effect on outside world
- Interpret and apply IT law in various legal issues
- Distinguish different aspects of cyber law
- Apply Information Security Standards compliance during software design and development

Module	Detailed Contents	Contact Hrs
01	**Introduction to Cybercrime:** Cybercrime definition and origins of the world, Cybercrime and information security, Classifications of cybercrime, Cybercrime and the Indian ITA 2000, A global Perspective on cybercrimes.	4
02	**Cyber offenses & Cybercrime:** How criminal plan the attacks, Social Engg, Cyber stalking, Cyber café and Cybercrimes, Botnets, Attack vector, Cloud computing, Proliferation of Mobile and Wireless Devices, Trends in Mobility, Credit Card Frauds in Mobile and Wireless Computing Era, Security Challenges Posed by Mobile Devices, Registry Settings for Mobile Devices, Authentication Service Security, Attacks on Mobile/Cell Phones, Mobile Devices: Security Implications for Organizations, Organizational Measures for Handling Mobile, Devices-Related Security Issues, Organizational Security Policies and Measures in Mobile Computing Era, Laptops	9
03	**Tools and Methods Used in Cyberline** Phishing, Password Cracking, Keyloggers and Spywares, Virus and Worms, Steganography, DoS and DDoS Attacks, SQL Injection, Buffer Over Flow, Attacks on Wireless Networks, Phishing, Identity Theft (ID Theft)	6
04	**The Concept of Cyberspace** E-Commerce , The Contract Aspects in Cyber Law ,The Security Aspect of Cyber Law ,The Intellectual Property Aspect in Cyber Law , The Evidence Aspect in Cyber Law , The Criminal Aspect in Cyber Law, Global Trends in Cyber Law , Legal Framework for Electronic Data Interchange Law Relating to Electronic Banking , The Need for an Indian Cyber Law	8
05	**Indian IT Act.** Cyber Crime and Criminal Justice: Penalties, Adjudication and Appeals Under the IT Act, 2000, IT Act. 2008 and its Amendments	6
06	**Information Security Standard compliances** SOX, GLBA, HIPAA, ISO, FISMA, NERC, PCI.	6

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- Only Four question need to be solved.

References

1. Nina Godbole, SunitBelapure, *Cyber Security*, Wiley India, New Delhi
2. The Indian Cyber Law by Suresh T. Vishwanathan; Bharat Law House New Delhi
3. The Information technology Act, 2000; Bare Act- Professional Book Publishers, New Delhi.
4. Cyber Law & Cyber Crimes By Advocate Prashant Mali; Snow White Publications, Mumbai
5. Nina Godbole, *Information Systems Security*, Wiley India, New Delhi
6. Kennetch J. Knapp, *Cyber Security &Global Information Assurance* Information Science Publishing.
7. William Stallings, *Cryptography and Network Security*, Pearson Publication
8. Websites for more information is available on : The Information Technology ACT, 2008- TIFR : https://www.tifrh.res.in
9. Website for more information , A Compliance Primer for IT professional : https://www.sans.org/reading-room/whitepapers/compliance/compliance-primer-professionals-33538

Course Code	Course Name	Credits
ILO1017	Disaster Management and Mitigation Measures	03

Objectives

- To understand physics and various types of disaster occurring around the world
- To identify extent and damaging capacity of a disaster
- To study and understand the means of losses and methods to overcome /minimize it.
- To understand role of individual and various organization during and after disaster
- To understand application of GIS in the field of disaster management
- To understand the emergency government response structures before, during and after disaster

Outcomes

Learner will be able to…

- Get to know natural as well as manmade disaster and their extent and possible effects on the economy.
- Plan of national importance structures based upon the previous history.
- Get acquainted with government policies, acts and various organizational structures associated with an emergency.
- Get to know the simple do's and don'ts in such extreme events and act accordingly.

Module	Detailed Contents	Contact Hrs
01	**Introduction:** Definition of Disaster, hazard, global and Indian scenario, general perspective, importance of study in human life, Direct and indirect effects of disasters, long term effects of disasters. Introduction to global warming and climate change.	03
02	**Natural Disaster and Manmade disasters:** Natural Disaster: Meaning and nature of natural disaster, Flood, Flash flood, drought, cloud burst, Earthquake, Landslides, Avalanches, Volcanic eruptions, Mudflow, Cyclone, Storm, Storm Surge, climate change, global warming, sea level rise, ozone depletion Manmade Disasters: Chemical, Industrial, Nuclear and Fire Hazards. Role of growing population and subsequent industrialization, urbanization and changing lifestyle of human beings in frequent occurrences of manmade disasters.	09
03	**Disaster Management, Policy and Administration:** Disaster management: meaning, concept, importance, objective of disaster management policy, disaster risks in India, Paradigm shift in disaster management. Policy and administration: Importance and principles of disaster management policies, command and co-ordination of in disaster management, rescue operations-how to start with and how to proceed in due course of time, study of flowchart showing the entire process.	06
04	**Institutional Framework for Disaster Management in India:** Importance of public awareness, Preparation and execution of emergency management programme. Scope and responsibilities of National Institute of Disaster Management (NIDM) and National disaster management authority (NDMA) in India. Methods and measures to avoid disasters, Management of casualties, set up of emergency facilities, importance of effective communication amongst different agencies in such situations. Use of Internet and softwares for effective disaster management. Applications of GIS, Remote sensing and GPS in this regard.	06
05	**Financing Relief Measures:** Ways to raise finance for relief expenditure, role of government agencies and NGO's in this process, Legal aspects related to finance raising as well as overall management of disasters. Various NGO's and the works they have carried out in the past on the occurrence of various disasters, Ways to approach these teams. International relief aid agencies and their role in extreme events.	09
06	**Preventive and Mitigation Measures:**	06

	Pre-disaster, during disaster and post-disaster measures in some events in general structural mapping: Risk mapping, assessment and analysis, sea walls and embankments, Bio shield, shelters, early warning and communication Non Structural Mitigation: Community based disaster preparedness, risk transfer and risk financing, capacity development and training, awareness and education, contingency plans. Do's and don'ts in case of disasters and effective implementation of relief aids.	

Assessment

Internal:

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End Semester Theory Examination:

Some guidelines for setting up the question paper:

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- Question paper will comprise of total six question
- All question carry equal marks
- Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
- Only Four question need to be solved.

References

1. 'Disaster Management' by Harsh K.Gupta, Universities Press Publications.
2. 'Disaster Management: An Appraisal of Institutional Mechanisms in India' by O.S.Dagur, published by Centre for land warfare studies, New Delhi, 2011.
3. 'Introduction to International Disaster Management' by Damon Copolla, Butterworth Heinemann Elseveir Publications.
4. 'Disaster Management Handbook' by Jack Pinkowski, CRC Press Taylor and Francis group.
5. 'Disaster management & rehabilitation' by Rajdeep, Dasgupta, Mittal Publications, New Delhi.
6. 'Natural Hazards and Disaster Management, Vulnerability and Mitigation – R B Singh, Rawat Publications
7. Concepts and Techniques of GIS –C.P.Lo Albert, K.W. Yonng – Prentice Hall (India) Publications.

(Learners are expected to refer reports published at national and International level and updated information available on authentic web sites)

Course Code	Course Name	Credits
ILO1018	Energy Audit and Management	03

Objectives

- To understand the importance energy security for sustainable development and the fundamentals of energy conservation.
- To introduce performance evaluation criteria of various electrical and thermal installations to facilitate the energy management
- To relate the data collected during performance evaluation of systems for identification of energy saving opportunities.

Outcomes

Learner will be able to…

- To identify and describe present state of energy security and its importance.
- To identify and describe the basic principles and methodologies adopted in energy audit of an utility.
- To describe the energy performance evaluation of some common electrical installations and identify the energy saving opportunities.
- To describe the energy performance evaluation of some common thermal installations and identify the energy saving opportunities
- To analyze the data collected during performance evaluation and recommend energy saving measures

Module	Detailed Contents	Contact Hrs
01	**Energy Scenario:** Present Energy Scenario, Energy Pricing, Energy Sector Reforms, Energy Security, Energy Conservation and its Importance, Energy Conservation Act-2001 and its Features. Basics of Energy and its various forms, Material and Energy balance	04
02	**Energy Audit Principles:** Definition, Energy audit- need, Types of energy audit, Energy management (audit) approach-understanding energy costs, Bench marking, Energy performance, Matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution. Elements of monitoring& targeting; Energy audit Instruments; Data and information-analysis. Financial analysis techniques: Simple payback period, NPV, Return on investment (ROI), Internal rate of return (IRR)	08
03	**Energy Management and Energy Conservation in Electrical System:** Electricity billing, Electrical load management and maximum demand Control; Power factor improvement, Energy efficient equipments and appliances, star ratings. **Energy efficiency measures in lighting system, Lighting control:** Occupancy sensors, daylight integration, and use of intelligent controllers. Energy conservation opportunities in: water pumps, industrial drives, induction motors, motor retrofitting, soft starters, variable speed drives.	10
04	**Energy Management and Energy Conservation in Thermal Systems:** Review of different thermal loads; Energy conservation opportunities in: Steam distribution system, Assessment of steam distribution losses, Steam leakages, Steam trapping, Condensate and flash steam recovery system. General fuel economy measures in Boilers and furnaces, Waste heat recovery, use of insulation-types and application. HVAC system: Coefficient of performance, Capacity, factors affecting Refrigeration and Air Conditioning system performance and savings opportunities.	10
05	**Energy Performance Assessment:** On site Performance evaluation techniques, Case studies based on: Motors and variable speed drive, pumps, HVAC system calculations; Lighting System: Installed Load Efficacy Ratio (ILER) method, Financial Analysis.	04

06	**Energy conservation in Buildings:** Energy Conservation Building Codes (ECBC): Green Building, LEED rating, Application of Non-Conventional and Renewable Energy Sources	03

Assessment

Internal:

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End Semester Theory Examination:

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- Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.
- Question paper will comprise of total six question
- All question carry equal marks
- Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
- Only Four question need to be solved.

References

1. Handbook of Electrical Installation Practice, Geofry Stokes, Blackwell Science
2. Designing with light: Lighting Handbook, By Anil Valia, Lighting System
3. Energy Management Handbook, By W.C. Turner, John Wiley and Sons
4. Handbook on Energy Audits and Management, edited by A. K. Tyagi, Tata Energy Research Institute (TERI).
5. Energy Management Principles, C.B.Smith, Pergamon Press
6. Energy Conservation Guidebook, Dale R. Patrick, S. Fardo, Ray E. Richardson, Fairmont Press
7. Handbook of Energy Audits, Albert Thumann, W. J. Younger, T. Niehus, CRC Press
8. www.energymanagertraining.com
9. www.bee-india.nic.in

Course Code	Course Name	Credits
CHC201	Process Heat Transfer	4

Prerequisites

- Basic course in Fluid flow and heat transfer.
- Basics of Heat Transfer Mathematics
- Design of heat transfer equipments.

Course Objectives

- To learn advanced topics of heat transfer with emphasis on basic concepts and laws.
- To familiarize students with knowledge of advanced heat transfer especially in chemical engineering related fields.
- To educate students to apply these concepts to solve problems encountered in chemical engineering and related researches.

Course Outcomes

Student should be able to:

- Calculate heat transfer coefficient of non Newtonian fluids.
- Calculate the size requirements of reboilers, condensers and evaporators.
- Design a fluidized bed system for different applications.

Module	Contents	No. of Hours
1	Introduction and importance of the subject, Relevance of subject in industrial environment, Techniques of heat transfer, Dissipation of energy in industry, Concept of flow patterns and its uses in industry, Analogy between momentum and heat transfer	08
2	Comparative study of Newtonian and non-Newtonian fluid in context with heat transfer, Newtonian and non-Newtonian heat transfer in circular tube, coils and other configuration, Non-Newtonian fluid heat transfer in PFR, CSTR and Concept of vibrating / oscillating heat transfer.	10
3	Detailed study of Air cooled condensers. Regenerators and heat transfer in agitated vessel.	10
4	Design aspects of condensers, reboilers and evaporators.	10
5	Mechanisms of heat transfer in packed, fluidized and moving bed reactor, heat transfer in dilute phase transport, heat transfer in furnaces, design methods for furnaces, pipe still, thermo siphoning and other industries.	10

Assessment

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End Semester Theory Examination:

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- Question paper will comprise of total six question
- All question carry equal marks
- Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
- Only Four question need to be solved.

References

1. Knudson D.G. and Katz D.L., Fluid dynamics & heat transfer, McGraw Hill (NY) (1958)
2. Hewitt G F, Shires G L, Bott T R, Process heat transfer CRC process (NY) (1994)
3. Max. Leva, Fluidization, John Wiley & Sons (NY) (1956)
4. Harison& Davidson, Fluidization engg, McGraw Hill (1968)
5. Skelland A H P, Non-Newtonian flow and heat transfer, Gesner Goizdl, Moscow (1984)

Course Code	Course Name	Credits
CHC202	Advanced Mass Transfer	4

Prerequisite

- Knowledge of chemistry, physics, physical chemistry and mathematics.
- Knowledge of unit operations
- Knowledge of Distillation, Advance Topics in distillation.
- Knowledge of membrane separation process

Course-objective

- To give insight of mass transfer basic principle and mass transfer mechanisms.
- To understand design methods for distillation columns.
- To understand design of Absorption equipments.
- To understand membrane separation process.

Course Outcomes

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

- understand equilibrium in all separation process,
- describe the mass transfer equipments,
- design distillation column,
- choose the separation operation which will be economical for the process,
- Understand membrane separation processes principle and working.

Module	Contents	No. of Hours
1	Multi Component Distillation - Selection of operating pressure, Equilibrium for Multi component System, Methods for Multi Component Distillation, Design of Batch Distillation for Multi component with Rectification with constant reflux & constant over head component.	08
2	Continuous distillation of multi component system, Energy Conservation in Distillation column, Advance topics in distillation.	08
3	Membrane Separation Techniques - Basic Equation for membrane separation for permeable & semi permeable membrane, Membrane types & their selection criteria, Technology based Membrane separation like Micro filtration, Ultra filtration, Reverse Osmosis, Nano filtration.	10
4	Absorption - Criteria for selection of packed tower, tray tower, Spray chamber, Venturi Scrubber etc. Design of Falling Film Absorption, Design of Spray Chamber, Design of Venturi Scrubber, Advantage of Falling Film Absorber.	10
5	Degree of Freedom for Different Equipments, such as distillation column, reactor, heat exchanger, pump etc.	06
6	Super heated steam Drying, Introduction, Numericals	06

Assessment

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End Semester Theory Examination:

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- Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.
- Question paper will comprise of total six question
- All question carry equal marks

- Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
- Only Four question need to be solved.

References

1. Introduction to Process Engineering and design by S.B.Thakore& B.I. Bhatt
2. Chemical Engineering Handbook 7th edition by R.H.Perry& Green D.
3. Mass Transfer Operation 3rd Edition by R.E.Treybal
4. B.D. Smith, Design of Equilibrium Staged Processes, McGraw Hill.
5. Van Winkle, Distillation, McGraw Hill.

Course Code	Course Name	Credits
CHC203	Advanced Process Dynamics and Control	4

Prerequisite

- Mathematics course involving Laplace Transform and its application in solving mathematical equations.
- Basic course in Linear Open-Loop systems (Response of first and higher-order systems, interacting, non-interacting systems and transportation lag).
- Linear Closed-Loop Systems (The control system, final control element, Block diagram development of a chemical-reactor control system, Transient response of control system, stability, Root-Locus), Frequency response.

Course-objective

- To do controller tuning using approximate process models.
- To analyze and design multi-loop control systems.
- To design complex control structures for processes with difficult dynamics
- Design of multi-variable controllers.
- Dynamic analysis of discrete time systems.
- To understand the principles of model predictive control and design of digital controllers

Module	Contents	Contact Hours
1	**Conventional Feed Back Controller design:** Preliminary consideration, Controller design principles, controller tuning with fundamental process models, Controller tuning using approximate process models, controller tuning using frequency response models, Nyquist stability criterion, Bode stability criterion, controller tuning without a model.	05
2	**Design of more complex control structures :**Process with significant disturbance, cascade control, feed forward control, feedback augmented feed forward control, ratio control, processes with multiple outputs controlled by a single input (Override controllers, Auctioneering control), Process with single output controlled with multiple input (Split range control, multiple input for improved dynamics), antireset windup.	06
3	**Controller design for with processes with difficult dynamics**:Characteristics of difficult process dynamics, non minimum phase system, Time delay system, time delay compensation, inverse response system, inverse response compensation, open loop unstable systems.	05
4	**Controller design for non linear systems**:Nonlinear controller design philosophies, linearization and classical approach, adaptive control principles (Scheduled adaptive control, model reference adaptive control, self tuning adaptive control), variable transformations.	05
5	**Multivariable Regulatory Control Systems:**Nature of multivariable systems, multivariable process model, multivariable transfer functions and open loop dynamic analysis, interaction analysis and loop pairing, relative gain array, loop pairing using RGA, loop paring for nonlinear systems, loop pairing for nonsquare systems, controller design procedure, Decoupling, feasibility of steady state decoupler design, steady state decoupling by singular value decomposition.	09
6	**Sampled Data Systems:**sampling and conditioning of continuous signals, signal conditioning, continuous signal reconstruction, mathematical description of discrete–time system, theoretical modeling of discrete time systems.**Discrete time system analysis:**Basic concepts of z–transforms, inverting z –transforms, Pulse transfer functions, characteristics of open-loop pulse transfer functions, block diagram analysis of sampled data systems, stability.	10
7	**Design of digital controllers:**The digital controller and its design, discrete PID controller from the continuous domain, other digital controller based on continuous domain strategies, digital Controllers based on discrete domain strategies.**Model Predictive Control:**General principles of model predictive control, Model algorithmic control, commercial model predictive control schemes, academic and other contributions, nonlinear model predictive control, closing remarks.	08

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End Semester Theory Examination:

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- All question carry equal marks
- Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
- Only Four question need to be solved.

Reference

1. "Process Dynamics, Modeling, and Control" by Babatunde A. Ogunnaike, W. Harmon Ray.
2. "Chemical Process Control" by George Stephanopoulos.
3. "Process Control" by Thomas E. Marlin.

Course Code	Course Name	Credits
CHDLO2021	Industrial Safety and Hazard Control	4

Prerequisite

- Knowledge of Unit Operations (Heat and Mass Transfer); Basic Chemical Kinetics.
- General awareness about socio-Industrial culture.

Objective

- To develop awareness about the control measures for Industrial safety and hazards.
- Various aspects of safety during industrial operations.
- Potential hazards of chemical industries.
- Knowledge of various rules and regulations related to safety hazards management.

Outcome

- The students will be well aware of various aspects of industrial safety i.e. safe mode of operating chemical plants, consequences of unsafe operations.
- Potential hazards of various chemicals.
- Hazardous waste management.
- Management practices and various methods of disposing hazardous waste.

Module	Contents	Contact Hours
1	**Introduction:** Aspects of Industrial safety, Importance of safety at working places, List of legislations in Chemical industries. The hazardous Wastes (Management and handling) rules, 1989 (2000).	04
2	**Chemical Plant Safety:** Chemical plant – Fire, Explosion, toxicity, process and corrosion hazards, Plant inspection – check list, Safety audit (IS-14489: 1998), Electrical equipment hazardous area classification, Area classification for instruments, Color codification for identification of pipe lines (IS-2379), Indian Standard on safety and health, ILO conventions and recommendations on occupational safety and health.	08
3	**Safety Management:** The safety management function, Line verses staff authority, Industrial and organized safety, Safety responsibility and accountability, The practice of safety management: The significance of risk acceptability, limitations on standard remedies, safety authority. The problems of holding management's concern: management view of cost, safety and efficiency.	06
4	**Hazardous Waste Management:** Fundamentals: working definitions, Historical routes, Regulatory initiatives, Classifications, generation, contaminated sites, future endeavors; Legal frame work: Environmental law, Federal hazardous waste Regulations under RCRA, International perspectives.	08
5	**Process Fundamentals:** A Little chemistry, Physical chemical properties, Energy and mass balance, Reactions and Reactors, Contaminants release, Transportation of contaminants in sub surface; Toxicity: Exposure and toxic effects.	06
6	**Treatment and Disposal of Hazardous Wastes:** Physical- chemical processes, Biological processes, Stabilization and solidification of waste, Thermal methods- combustion regulations gases and vapors, liquid injection incinerators, solid waste incinerators, storage and feed system, Flue gas temperature reduction,, Air	08

	pollution control, Instrumentation, continuous emission monitor, Land disposal/land fill operations.	
7	**Management Practices:** Environment audit, program planning, pre-audit preparations, Onsite audit, Evaluation and presentation, other types of audit, Pollution prevention: general considerations, management strategies, life cycle analysis, volume reduction, recycling.	**08**

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End Semester Theory Examination:

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- Only Four question need to be solved.

References

1. "Safety Legislations in Chemical Industries" by S. S. Manakar, Published by Mrs. Jyoti S Manakar, New Panvel
2. " Safety Management" by John V. Grimaldi, Rollin H. Simonds; 5th Edition, Published by All India traveler Book Seller, Krishan Nagar, Delhi- 110051.
3. "Hazardous Waste Management" by Michael D. LaGrega, Phillips L. Bukingham, Jeffrey C. Evans and Environmental Resource Management, McGraw- Hill International Edition.

Course Code	Course Name	Credits
CHDLO2022	Heterogeneous Catalysis and Reactor Design	4

Prerequisites

- Students should know basic Chemistry pertaining to Chemical Reactions, Chemical formula.
- They are required to be aware of Chemical processes and unit operations used for the manufacturing of chemical products.
- Simple to complex numerical methods of solving one and two dimensional Mathematical models

Course Objectives

- Development of Kinetic model for Heterogeneous reactions giving emphasis on catalytic reactions in isothermal, adiabatic or non-isothermal conditions.
- Development of design strategy for Heterogeneous reactions considering different types of reactors for example fixed bed tubular reactor, fluidized bed reactor, packed bed reactors etc. Reactor design for reactions operating under isothermal, adiabatic or non-isothermal conditions.

Course Outcome

- Students will be able to apply the knowledge they have gained to find the model equation and use this model to design the reactors used for heterogeneous reactions taking place in isothermal or non-isothermal conditions.

Module	Contents	Contact Hours
1	Heterogeneous catalytic processes, types of heterogeneous reactions. Absorption, absorption isotherms, rates of absorption, Physisorption and chemisorptions. Solid catalysis, types of catalysts, catalyst formulations and Preparation methods.	06
2	Catalysts Characterization methods: Surface area and pore volume determinations, XRD, various Spectroscopic techniques, Temperature programmed reduction & oxidation, Electron microscopy.	08
3	Testing of catalysts, various types of reactors, activity and selectivity studies. Effect of external transport processes on observed rate of reactions. Effect of internal transport processes: reactions and diffusion in porous catalysts.	06
4	Mechanism of catalytic reactions, Rates of adsorption, desorption, surface reactions, rate determining steps. Kinetic modeling and Parameter estimations, Model discriminations, Design of reactors for heterogeneous catalytic reactions	06
5	Catalysts promoters, Inhibitors, catalyst deactivations, kinetics of catalyst deactivations.	06
6	Industrial processes involving heterogeneous solid catalysts.	06
7	New development in solid catalysis, monolith catalysts, nanocatalysts, Fuel cell catalysts, Environmental catalysts, Insitu characterization.	06
8	Design of catalysts	04

Assessment

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End Semester Theory Examination:

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- Question paper will comprise of total six question
- All question carry equal marks

- Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
- Only Four question need to be solved.

Reference

6. G. Ertl, H. Knozinger and J. Weitkamp, "Handbook of Heterogeneous Catalysis" Vol. 1-5, Wiley - VCH.
7. B. Viswanathan, S. Sivasanker, A.V. Ramaswamy, "Catalysis: Principles and Applications", CRC Press.
8. J. M. Smith, "Chemical Engineering Kinetics", McGraw-Hill Book Company.
9. J. M. Thomas and W. J. Thomas, "Principles and Practice of Heterogeneous Catalysis", Wiley- VCH.
10. H. S. Fogler, "Elements of Chemical Reaction Engineering", Prentice - Hall of India.
11. J.J. Carberry, "Chemical and Catalytic Reaction Engineering", Dover Publications.
12. C. H. Bartholomew and R. J. Farrauto, "Fundamentals of Industrial Catalytic Processes", Wiley- VCH.
13. Hill C.G., Chemical Reaction Engineering.

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Course Code	Course Name	Credits
CHDLO2023	Advanced Process Modeling and Simulation	4

Prerequisite

- Basic knowledge of chemical engineering subjects such as Mass transfer, Heat Transfer, Fluid Flow Operation, Chemical Reaction Engineering, Reaction Kinetics and Transport Phenomena.
- Mathematics knowledge on numerical methods for solution of linear algebraic equations and differential equations

Course-objective

- To formulate equations for modeling a process
- To solve numerically the derived equations
- To gain knowledge of using software ASPEN.

Module	Contents	Contact Hours
1	Introduction and fundamentals of process modeling and simulation; industrial usage of process modeling and simulation; Macroscopic mass, energy and momentum balances. Incorporation of fluid thermodynamics, chemical equilibrium, reaction kinetics and feed/ product property estimation in mathematical models.	08
2	Simulation of steady state lumped systems including simultaneous solution, modular solution, nested inside- out algorithms. Partitioning and tearing with reference to chemical process equipments like reactors; distillation, absorption, extraction columns; evaporators; furnaces; heat exchangers; flash vessels etc.	08
3	Unsteady state lumped systems and dynamic simulation.	08
4	Commercial steady state and dynamic simulators; Computer algorithms for numerical solution of steady state and unsteady state models; Microscopic balances for steady state and dynamic simulation.	08
5	Process modelling of distributed systems; axial mixing; micromixing; diffusion etc.	08
6	Computer algorithms for microscopic models; Simulation of process flow sheets and Boolean digraph algorithms; Modelling and simulation of complex industrial systems in petroleum, petrochemicals, polymer, basic chemical industries.	08

Assessment

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End Semester Theory Examination:

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- Question paper will comprise of total six question
- All question carry equal marks
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- Only Four question need to be solved.

Reference Book

1. 'Process Modeling, Simulation, and Control for Chemical Engineers' by William L. Luyben
2. 'Fundamentals and Modeling of Separation Processes' by C. D. Holland.

Course Code	Course Name	Credits
CHDLO2024	Green Chemistry and Engineering	4

Prerequisite

- Engineering Chemistry, Chemical Technology

Course-objective

- To understand the principles of Green Chemistry and Engineering
- To understand the development of environmentally friendly processes for the manufacture of industrially important products with minimal formation of waste

Course Outcomes

- The student will be able to apply the principles of Green Chemistry and Engineering to Chemical and Biochemical Processes
- The student will be able to design and develop processes which are environmentally friendly and produce the desired product with minimal formation of waste

Module	Contents	Contact Hours
1	**Principles of Green Chemistry and Engineering** Concept of E Factors and Atom Economy, Principles of Green Chemistry, Waste Minimization, Reduction of Material Use and Energy Requirement, Reduction of Risk and Hazard.	06
2	**Green Chemistry and Catalysis** Solid Acids and Bases as Catalysts, Catalytic Reductions and Oxidations, Biocatalysis, Phase Transfer Catalysis	10
3	**Novel Reaction Media for Green Chemistry and Catalysis** Choice of Solvent, Alternative Reaction Media and Multiphasic systems, Supercritical Fluids including Supercritical Carbon Dioxide, Ionic Liquids.	08
4	**Chemicals from Renewable Raw Materials** Application of Green Chemistry and Engineering in Manufacture of Industrially Important Chemicals such as Ethanol, Lactic Acid, 1,3-Propanediol, Ascorbic Acid, Biodiesel and Green Polymers.	12
5	**Process Intensification for Green Processes** Spinning Disc Reactors, Microreactors, Intensified Cross-corrugated Multifunctional Membrane, Applications of Ultrasound, Microwaves and Photochemistry for Environmentally Benign Processes, Electrochemistry and Sustainability, Fuel Cells.	10
6	**Life-Cycle Assessment for More Sustainable Products and Processes** Life-Cycle Assessment (LCA) Methodology, Applications of LCA.	02

Assessment

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- Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus**.**
- Question paper will comprise of total six question
- All question carry equal marks
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- Only Four question need to be solved.

Reference

6. Handbook of Green Chemistry and Technology, James Clark and Duncan Macquarrie, Blackwell Science Ltd., 2002.
7. Green Chemistry and Catalysis, Roger Sheldon, Isabel Arends and Ulf Hanefeld, Wiley-VCH Verlag GmbH and Co., 2007.

Course Code	Course Name	Credits
CHDLO2025	Industrial Pollution Control and Prevention	4

Prerequisite

- Environmental Engineering and atmospheric pollution.
- Advanced method of waste treatment.
- Study and minimization of Industrial pollution and its control.

Course-objective

- To establish the process of industrial pollution.
- To design the water and air pollution equipment.
- To establish the waste treatment processes as a productive operating plant
- Effect of air and water pollution on human health and establish the standard norms.

Course Outcomes

- Understand the different types of wastes generated in an industry, their effects on living and non-living things.
- Understand environmental regulatory legislations and standards and climate changes.
- Understand about the quantification and analysis of wastewater and treatment.
- Understand the different unit operations and unit processes involved in conversion of highly polluted water to potable standards.
- Understand about analysis and quantification of hazardous and nonhazardous solid waste wastes, treatment and disposal.

Module	Contents	Contact Hours
1	**Introduction:** Introduction and concept of industrial pollution, what is industrial pollution, how many types of pollution occur in industry explain by industrial examples, why it is important to prevent pollution. Different act for water and air pollution together with noise and nuclear pollution	06
2	**Measurement of industrial pollution:** Details of water and air pollution created by different industries, various method for measurement of water and air pollution in a given industrial sample. Define COD, BOD, DO, TSS, TDS, MLVSS, VSS etc. Determination of industrial pollution norms with their practical aspects.	06
3	**Water treatment**: Introduction, coagulation, softening, reactors mixing and flocculation, sedimentation, filtration, adsorption, water plant waste management, numerical problems based on industrial waste water treatment.	06
4	**Water quality management**: Water pollution and their sources in different industries, discharge norms of industrial waste water, viz. to water bodies. Zero discharge norms for different industries i.e. petroleum, fertilizer, sugar, polymer etc. Recycle of waste water in industry and its application in prevention of pollution.	06
5	**Waste water treatment:** Waste water microbiology, characteristics of industrial waste water, applications of unit operations in primary secondary and tertiary treatment. Advanced methods waste water treatment based on different unit operations. Design of different equipments used for physical chemical and biological treatment of industrial waste water.	06
6	**Air pollution:** Fundamentals of physical and chemical air pollution, air pollutants and their threshold limit, effect of air pollution in environment ultimately on human health, removal of mercury, ammonia, urea, particulate matters, SO_2 oxide on nitrogen organic vapor from effluent gases.	06

7	**Pollution control processes and their economics:** Pollution control in selective process industries, pollution control in chemical industries from gaseous considerations, advanced processes which can made the treatment plan a productive plant. Pollution control and its prevention in pulp and paper industry. Pollution control and prevention in miscellaneous process industries. Detailed economics of prevention pollution from different industry	**06**

Assessment

Internal:

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End Semester Theory Examination:

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- Only Four question need to be solved.

Reference

4. "Air pollution" by R K Bhatia,
5. "Pollution control in process industry" by S P Mahajan.
6. "Introduction to environmental engineering" by David A Cornwell and Mackenzie L Davis.

Course Code	Course Name	Credits
ILO2021	Project Management	03

Objectives

- To familiarize the students with the use of a structured methodology/approach for each and every unique project undertaken, including utilizing project management concepts, tools and techniques.
- To appraise the students with the project management life cycle and make them knowledgeable about the various phases from project initiation through closure.

Outcomes

Learner will be able to…

- Apply selection criteria and select an appropriate project from different options.
- Write work break down structure for a project and develop a schedule based on it.
- Identify opportunities and threats to the project and decide an approach to deal with them strategically.
- Use Earned value technique and determine & predict status of the project.
- Capture lessons learned during project phases and document them for future reference

Module	Detailed Contents	Contact Hrs
01	**Project Management Foundation:** Definition of a project, Project Vs Operations, Necessity of project management, Triple constraints, Project life cycles (typical & atypical) Project phases and stage gate process. Role of project manager. Negotiations and resolving conflicts. Project management in various organization structures. PM knowledge areas as per Project Management Institute (PMI).	5
02	**Initiating Projects:** How to get a project started, Selecting project strategically, Project selection models (Numeric /Scoring Models and Non-numeric models), Project portfolio process, Project sponsor and creating charter; Project proposal. Effective project team, Stages of team development & growth (forming, storming, norming & performing), team dynamics.	6
03	**Project Planning and Scheduling:** Work Breakdown structure (WBS) and linear responsibility chart, Interface Co-ordination and concurrent engineering, Project cost estimation and budgeting, Top down and bottoms up budgeting, Networking and Scheduling techniques. PERT, CPM, GANTT chart. Introduction to Project Management Information System (PMIS).	8
04	**Planning Projects:** Crashing project time, Resource loading and leveling, Goldratt's critical chain, Project Stakeholders and Communication plan. Risk Management in projects: Risk management planning, Risk identification and risk register. Qualitative and quantitative risk assessment, Probability and impact matrix. Risk response strategies for positive and negative risks	6
05	**5.1 Executing Projects:** Planning monitoring and controlling cycle. Information needs and reporting, engaging with all stakeholders of the projects. Team management, communication and project meetings. **5.2 Monitoring and Controlling Projects:** Earned Value Management techniques for measuring value of work completed; Using milestones for measurement; change requests and scope creep. Project audit. **5.3 Project Contracting** Project procurement management, contracting and outsourcing,	8
06	**6.1 Project Leadership and Ethics:** Introduction to project leadership, ethics in projects. Multicultural and virtual projects. **6.2 Closing the Project:** Customer acceptance; Reasons of project termination, Various types of project terminations	6

	(Extinction, Addition, Integration, Starvation), Process of project termination, completing a final report; doing a lessons learned analysis; acknowledging successes and failures; Project management templates and other resources; Managing without authority; Areas of further study.	

Assessment

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End Semester Theory Examination:

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- Only Four question need to be solved.

References

1. Jack Meredith & Samuel Mantel, Project Management: A managerial approach, Wiley India, 7thEd.
2. A Guide to the Project Management Body of Knowledge (PMBOK® Guide), 5th Ed, Project Management Institute PA, USA
3. Gido Clements, Project Management, Cengage Learning.
4. Gopalan, Project Management, , Wiley India
5. Dennis Lock, Project Management, Gower Publishing England, 9 th Ed.

Course Code	Course Name	Credits
ILO2022	Finance Management	03

Objectives

- Overview of Indian financial system, instruments and market
- Basic concepts of value of money, returns and risks, corporate finance, working capital and its management
- Knowledge about sources of finance, capital structure, dividend policy

Outcomes

Learner will be able to…

- Understand Indian finance system and corporate finance
- Take investment, finance as well as dividend decisions

Module	Detailed Contents	Contact Hrs
01	**Overview of Indian Financial System:** Characteristics, Components and Functions of Financial System. **Financial Instruments:** Meaning, Characteristics and Classification of Basic Financial Instruments — Equity Shares, Preference Shares, Bonds-Debentures, Certificates of Deposit, and Treasury Bills. **Financial Markets:** Meaning, Characteristics and Classification of Financial Markets — Capital Market, Money Market and Foreign Currency Market **Financial Institutions:** Meaning, Characteristics and Classification of Financial Institutions — Commercial Banks, Investment-Merchant Banks and Stock Exchanges	06
02	**Concepts of Returns and Risks:** Measurement of Historical Returns and Expected Returns of a Single Security and a Two-security Portfolio; Measurement of Historical Risk and Expected Risk of a Single Security and a Two-security Portfolio. **Time Value of Money:** Future Value of a Lump Sum, Ordinary Annuity, and Annuity Due; Present Value of a Lump Sum, Ordinary Annuity, and Annuity Due; Continuous Compounding and Continuous Discounting.	06
03	**Overview of Corporate Finance:** Objectives of Corporate Finance; Functions of Corporate Finance—Investment Decision, Financing Decision, and Dividend Decision. **Financial Ratio Analysis:** Overview of Financial Statements—Balance Sheet, Profit and Loss Account, and Cash Flow Statement; Purpose of Financial Ratio Analysis; Liquidity Ratios; Efficiency or Activity Ratios; Profitability Ratios; Capital Structure Ratios; Stock Market Ratios; Limitations of Ratio Analysis.	09
04	**Capital Budgeting:** Meaning and Importance of Capital Budgeting; Inputs for Capital Budgeting Decisions; Investment Appraisal Criterion—Accounting Rate of Return, Payback Period, Discounted Payback Period, Net Present Value(NPV), Profitability Index, Internal Rate of Return (IRR), and Modified Internal Rate of Return (MIRR) **Working Capital Management:** Concepts of Meaning Working Capital; Importance of Working Capital Management; Factors Affecting an Entity's Working Capital Needs; Estimation of Working Capital Requirements; Management of Inventories; Management of Receivables; and Management of Cash and Marketable Securities.	10
05	**Sources of Finance:** Long Term Sources—Equity, Debt, and Hybrids; Mezzanine Finance; Sources of Short Term Finance—Trade Credit, Bank Finance, Commercial Paper; Project Finance. **Capital Structure:** Factors Affecting an Entity's Capital Structure; Overview of Capital Structure Theories and Approaches— Net Income Approach, Net Operating Income Approach; Traditional Approach, and Modigliani-Miller Approach. Relation between Capital Structure and Corporate Value; Concept of Optimal Capital Structure	05
06	**Dividend Policy:** Meaning and Importance of Dividend Policy; Factors Affecting an Entity's Dividend Decision; Overview of Dividend Policy Theories and Approaches—Gordon's Approach, Walter's Approach, and Modigliani-Miller Approach	03

Assessment

Internal:

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End Semester Theory Examination:

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- All question carry equal marks
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- Only Four question need to be solved.

References

1. Fundamentals of Financial Management, 13th Edition (2015) by Eugene F. Brigham and Joel F. Houston; Publisher: Cengage Publications, New Delhi.
2. Analysis for Financial Management, 10th Edition (2013) by Robert C. Higgins; Publishers: McGraw Hill Education, New Delhi.
3. Indian Financial System, 9th Edition (2015) by M. Y. Khan; Publisher: McGraw Hill Education, New Delhi.
4. Financial Management, 11th Edition (2015) by I. M. Pandey; Publisher: S. Chand (G/L) & Company Limited, New Delhi.

Course Code	Course Name	Credits
ILO2023	Enterpreneurship Development and Management	03

Objectives

- To acquaint with entrepreneurship and management of business
- Understand Indian environment for entrepreneurship
- Idea of EDP, MSME

Outcomes

Learner will be able to…

- Understand the concept of business plan and ownerships
- Interpret key regulations and legal aspects of entrepreneurship in India
- Understand government policies for entrepreneurs

Module	Detailed Contents	Contact Hrs
01	**Overview Of Entrepreneurship:** Definitions, Roles and Functions/Values of Entrepreneurship, History of Entrepreneurship Development, Role of Entrepreneurship in the National Economy, Functions of an Entrepreneur, Entrepreneurship and Forms of Business Ownership Role of Money and Capital Markets in Entrepreneurial Development: Contribution of Government Agencies in Sourcing information for Entrepreneurship	04
02	**Business Plans And Importance Of Capital To Entrepreneurship:** Preliminary and Marketing Plans, Management and Personnel, Start-up Costs and Financing as well as Projected Financial Statements, Legal Section, Insurance, Suppliers and Risks, Assumptions and Conclusion, Capital and its Importance to the Entrepreneur **Entrepreneurship And Business Development:** Starting a New Business, Buying an Existing Business, New Product Development, Business Growth and the Entrepreneur Law and its Relevance to Business Operations	09
03	Women's Entrepreneurship Development, Social entrepreneurship-role and need, EDP cell, role of sustainability and sustainable development for SMEs, case studies, exercises	05
04	**Indian Environment for Entrepreneurship:** key regulations and legal aspects , MSMED Act 2006 and its implications, schemes and policies of the Ministry of MSME, role and responsibilities of various government organisations, departments, banks etc., Role of State governments in terms of infrastructure developments and support etc., Public private partnerships, National Skill development Mission, Credit Guarantee Fund, PMEGP, discussions, group exercises etc	08
05	**Effective Management of Business:** Issues and problems faced by micro and small enterprises and effective management of M and S enterprises (risk management, credit availability, technology innovation, supply chain management, linkage with large industries), exercises, e-Marketing	08
06	**Achieving Success In The Small Business:** Stages of the small business life cycle, four types of firm-level growth strategies, Options – harvesting or closing small business Critical Success factors of small business	05

Assessment

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End Semester Theory Examination:

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- Only Four question need to be solved.

References

1. Poornima Charantimath, Entrepreneurship development- Small Business Enterprise, Pearson
2. Education Robert D Hisrich, Michael P Peters, Dean A Shapherd, Entrepreneurship, latest edition, The McGrawHill Company
3. Dr TN Chhabra, Entrepreneurship Development, Sun India Publications, New Delhi
4. Dr CN Prasad, Small and Medium Enterprises in Global Perspective, New century Publications, New Delhi
5. Vasant Desai, Entrepreneurial development and management, Himalaya Publishing House
6. Maddhurima Lall, Shikah Sahai, Entrepreneurship, Excel Books
7. Rashmi Bansal, STAY hungry STAY foolish, CIIE, IIM Ahmedabad
8. Law and Practice relating to Micro, Small and Medium enterprises, Taxmann Publication Ltd.
9. Kurakto, Entrepreneurship- Principles and Practices, Thomson Publication
10. Laghu Udyog Samachar
11. www.msme.gov.in
12. www.dcmesme.gov.in
13. www.msmetraining.gov.in

Course Code	Course Name	Credits
ILO2024	Human Resource Management	03

Objectives

- To introduce the students with basic concepts, techniques and practices of the human resource management.
- To provide opportunity of learning Human resource management (HRM) processes, related with the functions, and challenges in the emerging perspective of today's organizations.
- To familiarize the students about the latest developments, trends & different aspects of HRM.
- To acquaint the student with the importance of inter-personal & inter-group behavioral skills in an organizational setting required for future stable engineers, leaders and managers.

Outcomes

Learner will be able to…

- Understand the concepts, aspects, techniques and practices of the human resource management.
- Understand the Human resource management (HRM) processes, functions, changes and challenges in today's emerging organizational perspective.
- Gain knowledge about the latest developments and trends in HRM.
- Apply the knowledge of behavioral skills learnt and integrate it with in inter personal and intergroup environment emerging as future stable engineers and managers.

Module	Detailed Contents	Contact Hrs
01	**Introduction to HR** Human Resource Management- Concept, Scope and Importance, Interdisciplinary Approach Relationship with other Sciences, Competencies of HR Manager, HRM functions. Human resource development (HRD): changing role of HRM – Human resource Planning, Technological change, Restructuring and rightsizing, Empowerment, TQM, Managing ethical issues.	5
02	**Organizational Behavior (OB)** Introduction to OB Origin, Nature and Scope of Organizational Behavior, Relevance to Organizational Effectiveness and Contemporary issues Personality: Meaning and Determinants of Personality, Personality development, Personality Types, Assessment of Personality Traits for Increasing Self Awareness Perception: Attitude and Value, Effect of perception on Individual Decision-making, Attitude and Behavior. Motivation: Theories of Motivation and their Applications for Behavioral Change (Maslow, Herzberg, McGregor); Group Behavior and Group Dynamics: Work groups formal and informal groups and stages of group development. Team Effectiveness: High performing teams, Team Roles, cross functional and self-directed team. Case study	7
03	**Organizational Structure &Design** Structure, size, technology, Environment of organization; Organizational Roles & conflicts: Concept of roles; role dynamics; role conflicts and stress. Leadership: Concepts and skills of leadership, Leadership and managerial roles, Leadership styles and contemporary issues in leadership. Power and Politics: Sources and uses of power; Politics at workplace, Tactics and strategies.	6
04	**Human resource Planning** Recruitment and Selection process, Job-enrichment, Empowerment - Job-Satisfaction, employee morale. Performance Appraisal Systems: Traditional & modern methods, Performance Counseling, Career Planning.	5

	Training & Development: Identification of Training Needs, Training Methods	
05	**Emerging Trends in HR** Organizational development; Business Process Re-engineering (BPR), BPR as a tool for organizational development , managing processes & transformation in HR. Organizational Change, Culture, Environment Cross Cultural Leadership and Decision Making**:** Cross Cultural Communication and diversity at work**,** Causes of diversity, managing diversity with special reference to handicapped, women and ageing people, intra company cultural difference in employee motivation.	6
06	**HR & MIS** Need, purpose, objective and role of information system in HR, Applications in HRD in various industries (e.g. manufacturing R&D, Public Transport, Hospitals, Hotels and service industries **Strategic HRM** Role of Strategic HRM in the modern business world, Concept of Strategy, Strategic Management Process, Approaches to Strategic Decision Making; Strategic Intent – Corporate Mission, Vision, Objectives and Goals **Labor Laws & Industrial Relations** Evolution of IR, IR issues in organizations, Overview of Labor Laws in India; Industrial Disputes Act, Trade Unions Act, Shops and Establishments Act	10

Assessment

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End Semester Theory Examination:

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- Only Four question need to be solved.

References

1. Stephen Robbins, Organizational Behavior, 16th Ed, 2013
2. V S P Rao, Human Resource Management, 3rd Ed, 2010, Excel publishing
3. Aswathapa, Human resource management: Text & cases, 6th edition, 2011
4. C. B. Mamoria and S V Gankar, Dynamics of Industrial Relations in India, 15th Ed, 2015, Himalaya Publishing, 15thedition, 2015
5. P. Subba Rao, Essentials of Human Resource management and Industrial relations, 5th Ed, 2013, Himalaya Publishing
6. Laurie Mullins, Management & Organizational Behavior, Latest Ed, 2016, Pearson Publications

Course Code	Course Name	Credits
ILO2025	Professional Ethics and Corporat Social Responsibility (CSR)	03

Objectives

- To understand professional ethics in business
- To recognized corporate social responsibility

Outcomes

Learner will be able to…

- Understand rights and duties of business
- Distinguish different aspects of corporate social responsibility
- Demonstrate professional ethics
- Understand legal aspects of corporate social responsibility

Module	Detailed Contents	Contact Hrs
01	**Professional Ethics and Business:** The Nature of Business Ethics; Ethical Issues in Business; Moral Responsibility and Blame; Utilitarianism: Weighing Social Costs and Benefits; Rights and Duties of Business	04
02	**Professional Ethics in the Marketplace:** Perfect Competition; Monopoly Competition; Oligopolistic Competition; Oligopolies and Public Policy **Professional Ethics and the Environment:** Dimensions of Pollution and Resource Depletion; Ethics of Pollution Control; Ethics of Conserving Depletable Resources	08
03	**Professional Ethics of Consumer Protection:** Markets and Consumer Protection; Contract View of Business Firm's Duties to Consumers; Due Care Theory; Advertising Ethics; Consumer Privacy **Professional Ethics of Job Discrimination:** Nature of Job Discrimination; Extent of Discrimination; Reservation of Jobs.	06
04	**Introduction to Corporate Social Responsibility:** Potential Business Benefits—Triple bottom line, Human resources, Risk management, Supplier relations; Criticisms and concerns—Nature of business; Motives; Misdirection. Trajectory of Corporate Social Responsibility in India	05
05	**Corporate Social Responsibility:** Articulation of Gandhian Trusteeship Corporate Social Responsibility and Small and Medium Enterprises (SMEs) in India, Corporate Social Responsibility and Public-Private Partnership (PPP) in India	08
06	**Corporate Social Responsibility in Globalizing India:** Corporate Social Responsibility Voluntary Guidelines, 2009 issued by the Ministry of Corporate Affairs, Government of India, Legal Aspects of Corporate Social Responsibility—Companies Act, 2013.	08

Assessment

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- Only Four question need to be solved.

References

1. Business Ethics: Texts and Cases from the Indian Perspective (2013) by Ananda Das Gupta; Publisher: Springer.
2. Corporate Social Responsibility: Readings and Cases in a Global Context (2007) by Andrew Crane, Dirk Matten, Laura Spence; Publisher: Routledge.
3. Business Ethics: Concepts and Cases, 7th Edition (2011) by Manuel G. Velasquez; Publisher: Pearson, New Delhi.
4. Corporate Social Responsibility in India (2015) by BidyutChakrabarty, Routledge, New Delhi.

Course Code	Course Name	Credits
ILO2026	Research Methodology	03

Objectives

- To understand Research and Research Process
- To acquaint students with identifying problems for research and develop research strategies
- To familiarize students with the techniques of data collection, analysis of data and interpretation

Outcomes

Learner will be able to…

- Prepare a preliminary research design for projects in their subject matter areas
- Accurately collect, analyze and report data
- Present complex data or situations clearly
- Review and analyze research findings

Module	Detailed Contents	Contact Hrs
01	**Introduction and Basic Research Concepts** **1.1** Research – Definition; Concept of Construct, Postulate, Proposition, Thesis, Hypothesis, Law, Principle. Research methods vs Methodology **1.2** Need of Research in Business and Social Sciences **1.3** Objectives of Research **1.4 Issues** and Problems in Research **1.5** Characteristics of Research:Systematic, Valid, Verifiable, Empirical and Critical	**09**
02	**Types of Research** **2.1**. Basic Research **2.2**. Applied Research **2.3.** Descriptive Research **2.4.** Analytical Research **2.5**. Empirical Research **2.6** Qualitative and Quantitative Approaches	**07**
03	**Research Design and Sample Design** **3.1** Research Design – Meaning, Types and Significance **3.2** Sample Design – Meaning and Significance Essentials of a good sampling Stages in Sample Design Sampling methods/techniques Sampling Errors	**07**
04	**Research Methodology** **4.1** Meaning of Research Methodology **4.2**. Stages in Scientific Research Process: **a.** Identification and Selection of Research Problem **b.** Formulation of Research Problem **c.** Review of Literature **d.** Formulation of Hypothesis **e.** Formulation of research Design **f**. Sample Design **g.** Data Collection **h.** Data Analysis **i.** Hypothesis testing and Interpretation of Data **j.** Preparation of Research Report	**08**
05	**Formulating Research Problem** **5.1** Considerations: Relevance, Interest, Data Availability, Choice of data, Analysis of data, Generalization and Interpretation of analysis	**04**
06	**Outcome of Research** **6.1** Preparation of the report on conclusion reached **6.2** Validity Testing & Ethical Issues	**04**

	6.3 Suggestions and Recommendation	

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- Only Four question need to be solved.

References

1. Dawson, Catherine, 2002, Practical Research Methods, New Delhi, UBS Publishers Distributors.
2. Kothari, C.R., 1985, Research Methodology-Methods and Techniques, New Delhi, Wiley Eastern Limited.
3. Kumar, Ranjit, 2005, Research Methodology-A Step-by-Step Guide for Beginners, (2nded), Singapore, Pearson Education

Course Code	Course Name	Credits
ILO2027	IPR and Patenting	03

Objectives:

1. To understand intellectual property rights protection system
2. To promote the knowledge of Intellectual Property Laws of India as well as International treaty procedures
3. To get acquaintance with Patent search and patent filing procedure and applications

Outcomes: Learner will be able to…

1. understand Intellectual Property assets
2. assist individuals and organizations in capacity building
3. work for development, promotion, protection, compliance, and enforcement of Intellectual Property and Patenting

Module	Detailed Contents	Contact Hr
01	**Introduction to Intellectual Property Rights (IPR)**: Meaning of IPR, Different category of IPR instruments - Patents, Trademarks, Copyrights, Industrial Designs, Plant variety protection, Geographical indications, Transfer of technology etc. **Importance of IPR in Modern Global Economic Environment:** Theories of IPR, Philosophical aspects of IPR laws, Need for IPR, IPR as an instrument of development	05
02	**Enforcement of Intellectual Property Rights:** Introduction, Magnitude of problem, Factors that create and sustain counterfeiting/piracy, International agreements, International organizations (e.g. WIPO, WTO) active in IPR enforcement **Indian Scenario of IPR:** Introduction, History of IPR in India, Overview of IP laws in India, Indian IPR, Administrative Machinery, Major international treaties signed by India, Procedure for submitting patent and Enforcement of IPR at national level etc.	07
03	**Emerging Issues in IPR:** Challenges for IP in digital economy, e-commerce, human genome, biodiversity and traditional knowledge etc.	05
04	**Basics of Patents:** Definition of Patents, Conditions of patentability, Patentable and non-patentable inventions, Types of patent applications (e.g. Patent of addition etc), Process Patent and Product Patent, Precautions while patenting, Patent specification Patent claims, Disclosures and non-disclosures, Patent rights and infringement, Method of getting a patent	07
05	**Patent Rules:** Indian patent act, European scenario, US scenario, Australia scenario, Japan scenario, Chinese scenario, Multilateral treaties where India is a member (TRIPS agreement, Paris convention etc.)	08
06	**Procedure for Filing a Patent (National and International):** Legislation and Salient Features, Patent Search, Drafting and Filing Patent Applications, Processing of patent, Patent Litigation, Patent Publication etc, Time frame and cost, Patent Licensing, Patent Infringement **Patent databases:** Important websites, Searching international databases	07

Assessment

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End Semester Theory Examination:

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- Only Four question need to be solved.

References

1. Rajkumar S. Adukia, 2007, A Handbook on Laws Relating to Intellectual Property Rights in India, The Institute of Chartered Accountants of India
2. Keayla B K, Patent system and related issues at a glance, Published by National Working Group on Patent Laws
3. T Sengupta, 2011, Intellectual Property Law in India, Kluwer Law International
4. Tzen Wong and Graham Dutfield, 2010, Intellectual Property and Human Development: Current Trends and Future Scenario, Cambridge University Press
5. Cornish, William Rodolph & Llewelyn, David. 2010, Intellectual Property: Patents, Copyrights, Trade Marks and Allied Right, 7th Edition, Sweet & Maxwell
6. Lous Harns, 2012, The enforcement of Intellectual Property Rights: A Case Book, 3rd Edition, WIPO
7. Prabhuddha Ganguli, 2012, Intellectual Property Rights, 1st Edition, TMH
8. R Radha Krishnan & S Balasubramanian, 2012, Intellectual Property Rights, 1st Edition, Excel Books
9. M Ashok Kumar and mohdIqbal Ali, 2-11, Intellectual Property Rights, 2nd Edition, Serial Publications
10. Kompal Bansal and Praishit Bansal, 2012, Fundamentals of IPR for Engineers, 1st Edition, BS Publications
11. Entrepreneurship Development and IPR Unit, BITS Pilani, 2007, A Manual on Intellectual Property Rights,
12. Mathew Y Maa, 2009, Fundamentals of Patenting and Licensing for Scientists and Engineers, World Scientific Publishing Company
13. N S Rathore, S M Mathur, Priti Mathur, Anshul Rathi**,** IPR: Drafting, Interpretation of Patent Specifications and Claims**,** New India Publishing Agency
14. Vivien Irish, 2005, Intellectual Property Rights for Engineers, IET
15. Howard B Rockman, 2004, Intellectual Property Law for Engineers and scientists, Wiley-IEEE Press

Course Code	Course Name	Credits
ILO2028	**Digital Business Management**	**03**

Objectives

- To familiarize with digital business concept
- To acquaint with E-commerce
- To give insights into E-business and its strategies

Outcomes

The learner will be able to …..

- Identify drivers of digital business
- Illustrate various approaches and techniques for E-business and management
- Prepare E-business plan

Module	Detailed content	Contact Hours
1	**Introduction to Digital Business-** Introduction, Background and current status, E-market places, structures, mechanisms, economics and impacts. Difference between physical economy and digital economy. **Drivers of digital business**- Big Data & Analytics, Mobile, Cloud Computing, Social media, BYOD, and Internet of Things (digitally intelligent machines/services). Opportunities and Challenges in Digital Business,	09
2	**Overview of E-Commerce** **E-Commerce-** Meaning, Retailing in e-commerce-products and services, consumer behavior, market research and advertisement. B2B-E-commerce-selling and buying in private e-markets, public B2B exchanges and support services, e-supply chains, Collaborative Commerce, Intra business EC and Corporate portals. ther E-C models and applications, innovative EC System-From E-government and learning to C2C, mobile commerce and pervasive computing. EC Strategy and Implementation-EC strategy and global EC, Economics and Justification of EC, Using Affiliate marketing to promote your e-commerce business, Launching a successful online business and EC project, Legal, Ethics and Societal impacts of EC.	06
3	**Digital Business Support services**: ERP as e –business backbone, knowledge Tope Apps, Information and referral system **Application Development:** Building Digital business Applications and Infrastructure	06
4	**Managing E-Business**-Managing Knowledge, Management skills for e-business, Managing Risks in e –business. Security Threats to e-business -Security Overview, Electronic commerce Threats, Encryption, Cryptography, Public Key and Private Key Cryptography, Digital signatures, Digital Certificates, Security Protocols over Public Networks: HTTP, SSL, Firewall as Security Control, Public Key Infrastructure (PKI) for Security, Prominent Cryptographic Applications	06
5	**E-Business Strategy**-E-business Strategic formulation- Analysis of Company's Internal and external environment, Selection of strategy, E-business strategy into Action, challenges and E-Transition(Process of Digital Transformation)	04
6	**Materializing e-business: From Idea to Realization**-Business plan preparation. **Case Studies and presentations**	08

Assessment

Internal:

Assessment consists of two tests out of which; one should be compulsory class test and the other is either a class test or assignment on live problems or course project.

End Semester Theory Examination:

Some guidelines for setting up the question paper:

- Minimum 80% syllabus should be covered in question papers of end semester examination.

- Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.
- Question paper will comprise of total six question
- All question carry equal marks
- Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
- Only Four question need to be solved.

References

1. A textbook on E-commerce**,** Er Arunrajan Mishra, Dr W K Sarwade, Neha Publishers & Distributors, 2011
2. E-commerce from vision to fulfilment, Elias M. Awad, PHI-Restricted, 2002
3. Digital Business and E-Commerce Management, 6th Ed, Dave Chaffey, Pearson, August 2014
4. Introduction to E-business-Management and Strategy, Colin Combe, ELSVIER, 2006
5. Digital Business Concepts and Strategy, Eloise Coupey, 2nd Edition, Pearson
6. Trend and Challenges in Digital Business Innovation, Vinocenzo Morabito, Springer
7. Digital Business Discourse Erika Darics, April 2015, Palgrave Macmillan
8. E-Governance-Challenges and Opportunities in : Proceedings in 2nd International Conference theory and practice of Electronic Governance
9. Perspectives the Digital Enterprise –A framework for Transformation, TCS consulting journal Vol.5
10. Measuring Digital Economy-A new perspective -DOI:10.1787/9789264221796-enOECD Publishing

Course Code	Course Name	Credits
ILO2029	Environmental Management	03

Objectives

- Understand and identify environmental issues relevant to India and global concerns
- Learn concepts of ecology
- Familiarise environment related legislations

Outcomes

Learner will be able to…

- Understand the concept of environmental management
- Understand ecosystem and interdependence, food chain etc.
- Understand and interpret environment related legislations

Module	Detailed Contents	Contact Hrs
01	Introduction and Definition of Environment: Significance of Environment Management for contemporary managers, Career opportunities. Environmental issues relevant to India, Sustainable Development, and The Energy scenario.	10
02	Global Environmental concerns : Global Warming, Acid Rain, Ozone Depletion, Hazardous Wastes, Endangered life-species, Loss of Biodiversity, Industrial/Man-made disasters, Atomic/Biomedical hazards, etc.	06
03	Concepts of Ecology: Ecosystems and interdependence between living organisms, habitats, limiting factors, carrying capacity, food chain, etc.	05
04	Scope of Environment Management, Role & functions of Government as a planning and regulating agency. Environment Quality Management and Corporate Environmental Responsibility	10
05	Total Quality Environmental Management, ISO-14000, EMS certification.	05
06	General overview of major legislations like Environment Protection Act, Air (P & CP) Act, Water (P & CP) Act, Wildlife Protection Act, Forest Act, Factories Act, etc.	03

Assessment

Internal:

Assessment consists of two tests out of which; one should be compulsory class test and the other is either a class test or assignment on live problems or course project.

End Semester Theory Examination:

Some guidelines for setting up the question paper:

- Minimum 80% syllabus should be covered in question papers of end semester examination.
- Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.
- Question paper will comprise of total six question
- All question carry equal marks
- Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
- Only Four question need to be solved.

References

1. Environmental Management: Principles and Practice, C J Barrow, Routledge Publishers London, 1999
2. A Handbook of Environmental Management Edited by Jon C. Lovett and David G. Ockwell, Edward Elgar Publishing
3. Environmental Management, T V Ramachandra and Vijay Kulkarni, TERI Press

4. Indian Standard Environmental Management Systems — Requirements With Guidance For Use, Bureau Of Indian Standards, February 2005
5. Environmental Management: An Indian Perspective, S N Chary and Vinod Vyasulu, Maclillan India, 2000
6. Introduction to Environmental Management, Mary K Theodore and Louise Theodore, CRC Press
7. Environment and Ecology, MajidHussain, 3rd Ed. Access Publishing.2015

Course Code	Course Name	Credit
CHL101	LABORATORY-I	1
Laboratory-I should have six experiments based on the courses Advanced Fluid Dynamics, Advanced Chemical Reaction Engineering and one software based Problem		

Course Code	Course Name	Credit
CHL102	LABORATORY-II	1
Laboratory-II –Consists of Presenting a seminar and submitting the report on industry based problem 1.		

Course Code	Course Name	Credit
CHL201	LABORATORY-I	1
Laboratory-III should have six experiments based on the courses Process Heat Transfer, Advanced Mass Transfer Operation, Advanced Process Dynamics and Control and one software based Problem.		

Course Code	Course Name	Credit
CHL202	LABORATORY-II	1
Laboratory-IV –Consists of Presenting a seminar and submitting the report on industry based problem 2.		

Assessment

Laboratory

Weightage for Laboratory should be 40% in Final Assessment of Laboratory Term Work.

End Semester Examination

Practical/Oral examination is to be conducted by pair of internal and external examiners

Course Code	Course Name	Credits
CHS301	Special Topic Seminar	3

Guidelines for Seminar

- Seminar should be based on thrust areas in Chemical Engineering
- Students should do literature survey and identify the topic of seminar and finalize in consultation with Guide/Supervisor. Students should use multiple literatures and understand the topic and compile the report in standard format and present in front of Panel of Examiners. Appointed by Head of the Department/Institute of respective program.
- Seminar should be assessed based on following points –
    i. Quality of Literature survey and Novelty in the topic.
    ii. Relevance to the specialization.
    iii. Understanding of the topic.
    iv. Quality of Written and Oral Presentation

NOTE:

1. Assessment of Seminar will be carried out by a pair of Internal and External examiner. The external examiner should be selected fromPG recognized Teachers by University of Mumbai, OR faculty from Premier Educational Institutions /Research Organizations such as IIT, NIT, BARC, TIFR, DRDO, etc. OR a person having minimum Post-Graduate qualification with at least five years' experience in Industries.

2. Literature survey in case of seminar is based on the broader area of interest in recent developments and for dissertation it should be focused mainly on identified problem.

3. At least 4-5 hours of course on Research Methodology should be conducted which includes literature survey, identification of problems, analysis and interpretation of results and technical paper writing in the beginning of 3rdsemester.

Course Code	Course Name	Credits
CHD301 / CHD401	Dissertation I and II	12+15

Guidelines for Dissertation

Students should do literature survey and identify the problem for Dissertation and finalize in consultation with Guide/Supervisor. Students should use multiple literatures and understand the problem. Students should attempt solution to the problem by analytical/simulation/experimental methods. The solution to be validated with proper justification and compile the report in standard format.

Guidelines for Assessment of Dissertation I

- Dissertation I should be assessed based on following points:
  i. Quality of Literature survey and Novelty in the problem.
  ii. Clarity of Problem definition and Feasibility of problem solution.
  iii. Relevance to the specialization.
  iv. Clarity of objective and scope
- Dissertation I should be assessed through a presentation by a panel of internal examiners (PG recognized Teachers) appointed by the Head of the Department/Institute of respective Programme.

Guidelines for Assessment of Dissertation II

- Dissertation II should be assessed based on following points ƒ
  i. Quality of Literature survey and Novelty in the problem.
  ii. Clarity of Problem definition and Feasibility of problem solution.
  iii. Relevance to the specialization or current Research / Industrial trends.
  iv. Clarity of objective and scope.
  v. Quality of work attempted.
  vi. Validation of results.
  vii. Quality of Written and Oral Presentation
- Dissertation II should be assessed through a presentation jointly by Internal and External Examiners appointed by the University of Mumbai
- Students should publish at least one paper based on the work in reputed International / National Conference (desirably in Refereed Journal)