AC: 11-05-2017
Item No. 4.189

UNIVERSITY OF MUMBAI

Revised syllabus (Rev- 2016) from Academic Year 2016 -17

Chemical Engineering

Second Year with Effect from **AY 2017-18**
Third Year with Effect from **AY 2018-19**
Final Year with Effect from **AY 2019-20**
Under

FACULTY OF TECHNOLOGY

As per **Choice Based Credit and Grading System**
With effect from the AY 2016–17

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 was implemented for Second Year of B.E. in Chemical Engineering from the academic year 2017-2018. This system is carried forward for Third Year of B.E. in Chemical Engineering in the academic year 2018-2019 and will be implemented for Fourth Year B.E. in the year 2019-2020 respectively.

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

To match the increasing pace of development in all fields including Chemical Engineering and Biotechnology along with use of softwares for process plant and process engineering, there is demand on academician to upgrade the curriculum in Education. The availability of free software such as Scilab, DW SIM expand the boundaries of learning. Hence, the Undergraduate 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 and inclusion of technological development. 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. The major challenge in the current scenario is to ensure quality to the stakeholders along with expansion. Accreditation is the principal means of quality assurance in higher education and reflects the fact that in achieving recognition, the institution or program of study is committed and open to external review to meet certain minimum specified standards. The major emphasis of this accreditation process is to measure the outcomes of the program that is being accredited. Program outcomes are essentially a range of skills and knowledge that a student will have at the time of graduation from the program.

With these objectives, a meeting was organized at Thadomal Shahani Engineering College Bandra on 17th November 2016 which was attended by Industries experts, heads of the departments and subject faculty of affiliating Institutes. 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 credit and grading system curriculum to be introduced in this revised syllabus for B.E. (Chemical Engineering) for all semesters. Views from experts and UG teachers were taken into consideration and final Academic and Exam scheme was prepared with the consent of all the members involved. Subject wise meetings were held to finalize the detail syllabus in Bharati Vidyapeeth College of Engineering on 13th Jan 2017, SS Jondhale College of Engineering on 27th Jan 2017, Datta Meghe College of Engineering Airoli on 20th February 2017 and 13th April 2017 and in D. J. Sanghavi College of Engineering on 17th April 2017.

The Program Educational Objectives finalized for the undergraduate program in Chemical Engineering are:

1. To prepare the student for mathematical, scientific and engineering fundamentals
2. To motivate the student to use modern tools for solving real life problems
3. To inculcate a professional and ethical attitude, good leadership qualities and commitment to social responsibilities.
4. To prepare the student in achieving excellence in their career in Indian and Global Market.

Dr. Kalpana S. Deshmukh,

Chairman, Board of Studies in Chemical Engineering (Adhoc),

University of Mumbai

General Guidelines

Tutorials

- The number of tutorial batches can be decided based on facilities available in the institution.
- Tutorials can be creative assignments in the form of models, charts, projects, etc.

Term Work

- Term work will be an evaluation of the tutorial/practical done over the entire semester.
- It is suggested that each tutorial/practical be graded immediately and an average be taken at the end.
- A minimum of eight tutorials/ten practical will form the basis for final evaluation.
- The total 25 marks for term work (except project and seminar) will be awarded as follows:

  Tutorial / Practical Journal – 20 marks

  Overall Attendance – 05

  Further, while calculating marks for attendance, the following guidelines shall be adhered to:

  75 % to 80%. – 03 marks

  81% to 90% - 04 marks

  91% onwards – 05 marks

Theory Examination

- In general all theory examinations will be of 3 hours duration.
- Question paper will comprise of total six questions, each of 20 Marks.
- Only four questions need to be solved.
- Question one will be compulsory and based on maximum part of the syllabus.

Note:

In question paper, weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus as far as possible.

Practical Examination:

- Duration for practical examination would be the same as assigned to the respective Lab per week.
- A student becomes eligible for practical examination after completing a minimum of eight experiments out of ten experiments.

Project and Seminar Guidelines

- Project Groups: Students can form groups with minimum 2 (Two) and not more than 3 (Three)

- The load for projects may be calculated proportional to the number of groups, not exceeding two hours per week.

- The load for projects may be calculated as:
  Sem VII: ½ hr for teacher per group.
  Sem VIII: 1 hr for teacher per group.

- Each teacher should have ideally a maximum of three groups and only in exceptional cases four groups can be allotted to the faculty.

- Seminar topics will be the consensus of the project guide and the students. Each student will work on a unique topic.

- The load for seminar will be calculated as one hour per week irrespective of the number of students

- Students should spend considerable time in applying all the concepts studied, into the project. Hence, eight hours each were allotted in Project A, B and three hours for Seminar to the students.

University of Mumbai
Program Structure for B.E. Chemical Engineering (Revised 2016)
S.E. Semester III (w.e.f 2017-2018)

Course code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
CHC301	Applied Mathematics-III	3	-	1	3	-	1	4
CHC302	Engineering Chemistry I	4	-	-	4	-	-	4
CHC303	Fluid Flow Operations (FFO)	4	-	-	4	-	-	4
CHC304	Chemical Engineering Thermodynamics I	3	-	1	3	-	1	4
CHC305	Process Calculations	3	-	1	3	-	1	4
CHC306	Chemical Technology	4	-	-	4	-	-	4
CHL301	Engineering Chemistry-I Lab	-	3	-	-	1.5	-	1.5
CHL302	Chemical Engineering Lab I (FFO)	-	3	-	-	1.5	-	1.5
CHL303	Chemical Engineering Lab II (Synthesis)	-	2	-	-	1	-	1
	Total	21	8	3	21	4	3	28

Course code	Course Name	Examination Scheme								
		Theory					Term Work	Pract /Oral	Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in hrs)				
		Test 1	Test 2	Avg						
CHC301	Applied Mathematics-III	20	20	20	80	3	25	-	-	125
CHC302	Engineering Chemistry I	20	20	20	80	3	-	-	-	100
CHC303	Fluid Flow (FF)	20	20	20	80	3	-	-	-	100
CHC304	Chemical Engineering Thermodynamics I	20	20	20	80	3	25	-	-	125
CHC305	Process Calculations	20	20	20	80	3	25	-	-	125
CHC306	Chemical Technology	20	20	20	80	3	-	-	-	100
CHL301	Engineering Chemistry-I Lab	-	-	-	-	3	-	25	-	25
CHL302	Chemical Engineering Lab I (FFO)	-	-	-	-	3	25	25	-	50
CHL303	Chemical Engineering Lab II (Synthesis)	-	-	-	-	-	25	-	25	50
	Total			120	480	-	125	50	25	800

University of Mumbai
Program Structure for B.E. Chemical Engineering (Revised 2016)
S.E. Semester IV (w.e.f 2017-2018)

Course code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
CHC401	Applied Mathematics-IV	3	-	1	3	-	1	4
CHC402	Engineering Chemistry II	4	-		4	-	-	4
CHC403	Chemical Engineering Thermodynamics II	3	-	1	3	-	1	4
CHC404	Solid Fluid Mechanical Operations (SFMO)	4	-	-	4	-	-	4
CHC405	Mechanical Equipment Design (MED)	4	-	-	4	-	-	4
CHC406	Chemical Engineering Economics	3	-	1	3	-	1	4
CHL401	Engineering Chemistry-II Lab	-	3	-	-	1.5	-	1.5
CHL402	Chemical Engineering Lab III (SFMO)	-	3	-	-	1.5	-	1.5
CHL403	MED Lab	-	2	-	-	1	-	1
	Total	21	8	2	21	4	3	28

Course code	Course Name	Examination Scheme								
		Theory					Term Work	Pract /Oral	Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in hrs)				
		Test 1	Test 2	Avg						
CHC401	Applied Mathematics-IV	20	20	20	80	3	25	-	-	125
CHC402	Engineering Chemistry II	20	20	20	80	3	-	-	-	100
CHC403	Chemical Engineering Thermodynamics II	20	20	20	80	3	25	-	-	125
CHC404	Solid Fluid Mechanical Operations (SFMO)	20	20	20	80	3	-	-	-	100
CHC405	Mechanical Equipment Design (MED)	20	20	20	80	3	-	-	-	100
CHC406	Chemical Engineering Economics	20	20	20	80	3	25	-	-	125
CHL401	Engineering Chemistry-II Lab	-	-	-	-	3	-	25	-	25
CHL402	Chemical Engineering Lab III (SFMO)	-	-	-	-	3	25	25	-	50
CHL403	MED Lab	-	-	-	-	-	25	-	25	50
	Total			120	480	-	125	50	25	800

University of Mumbai
Program Structure for B.E. Chemical Engineering (Revised 2016)
T.E. Semester V (w.e.f 2018-2019)

Course code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
CHC501	Computer programming and Numerical Methods	4	-	-	4	-	-	4
CHC502	Mass transfer Operations-I (MTO- I)	4	-	-	4	-	-	4
CHC503	Heat transfer Operations (HTO)	4	-	-	4	-	-	4
CHC504	Chemical Reaction Engineering-I (CRE I)	4	-	-	4	-	-	4
CHC505	Business Communication & Ethics	2	-	2	-	-	2	2
CHDE501X	Department Elective I	4	-	-	4	-	-	4
CHL501	Computer programming and Numerical Methods lab	-	2	-	-	1	-	1
CHL502	Chemical Engineering Lab IV (MTO-I)	-	3	-	-	1.5	-	1.5
CHL503	Chemical Engineering Lab V (HTO)	-	3	-	-	1.5	-	1.5
CHL504	Chemical Engineering Lab VI (CRE-I)	-	2	-	-	1	-	1
	Total	20	14	-	20	5	2	27

Course code	Course Name	Examination Scheme								
		Theory					Term Work	Pract /Oral	Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in hrs)				
		Test 1	Test 2	Avg						
CHC501	Computer programming and Numerical Methods	20	20	20	80	3	-	-	-	100
CHC502	Mass transfer Operations-I (MTO- I)	20	20	20	80	3		-	-	100
CHC503	Heat transfer Operations (HTO)	20	20	20	80	3		-	-	100
CHC504	Chemical Reaction Engineering-I (CRE I)	20	20	20	80	3		-	-	100
CHC505	Business Communication & Ethics	-	-	-	-	-	50	-	-	50
CHDE501X	Department Elective I	20	20	20	80	3		-	-	100
CHL501	Computer programming and Numerical Methods Lab	-	-	-	-	2	25	25	-	50
CHL502	Chemical Engineering Lab IV (MTO-I)	-	-	-	-	3	25	25	-	50
CHL503	Chemical Engineering Lab V (HTO)	-	-	-	-	3	25	25	-	50
CHL504	Chemical Engineering Lab VI (CRE-I)	-	-	-	-	2	25	25	-	50
	Total			100	400	-	150	100	-	750

Department Elective I (Sem V)		
Engineering Stream (Elective Code)	Advanced Sciences Stream (Elective code)	Technology Stream (Elective Code)
1. Piping Engineering (CHDE5011) 2. Instrumentation (CHDE5014)	1. Colloids and Interfaces (CHDE5012)	1. Advanced Material Sciences (CHDE5013)

University of Mumbai
Program Structure for B.E. Chemical Engineering (Revised 2016)
T.E. Semester VI (w.e.f 2018-2019)

Course code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
CHC601	Environmental Engineering (EE)	4	-	-	4	-	-	4
CHC602	Mass transfer Operations –II (MTO-II)	4	-	-	4	-	-	4
CHC603	Transport Phenomenon	3	-	1	3	-	1	4
CHC604	Chemical Reaction Engineering –II (CRE- II)	4	-	-	4	-	-	4
CHC605	Plant Engineering & Industrial Safety	3	-	1	3	-	1	4
CHDE602X	Department Elective II	4	-	-	4	-	-	4
CHL601	Chemical Engineering Lab VII (EE)	-	3	-	-	1.5	-	1.5
CHL602	Chemical Engineering Lab VIII (MTO-II)	-	3	-	-	1.5	-	1.5
CHL603	Chemical Engineering LabIX CRE-II)	-	2	-	-	1	-	1
	Total	22	8	2	22	4	2	28

Course code	Course Name	Examination Scheme								
		Theory					Term Work	Pract /Oral	Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in hrs)				
		Test 1	Test 2	Avg						
CHC601	Environmental Engineering (EE)	20	20	20	80	3	-	-	-	100
CHC602	Mass transfer Operations –II (MTO-II)	20	20	20	80	3	-	-	-	100
CHC603	Transport Phenomenon	20	20	20	80	3	25	-	-	125
CHC604	Chemical Reaction Engineering –II (CRE- II)	20	20	20	80	3	-	-	-	100
CHC605	Plant Engineering & Industrial Safety	20	20	20	80	3	25	-	-	125
CHDE602X	Department Elective II	20	20	20	80	3	-	-	-	100
CHL601	Chemical Engineering Lab VII (EE)	-	-	-	-	3	25	25		50
CHL602	Chemical Engineering Lab VIII (MTO-II)	-	-	-	-	3	25	25	-	50
CHL603	Chemical Engineering Lab IX CRE-II)	-	-	-	-	2	25	25	-	50
	Total			120	480	-	125	75	--	800

Department Elective II (Sem VI)		
Engineering Stream (Elective Code)	Management Stream (Elective Code)	Technology Stream (Elective Code)
1. Computational Fluid Dynamics (CHDE6021)	1. Operation Research (CHDE6022)	1. Biotechnology (CHDE6023)

University of Mumbai
Program Structure for B.E. Chemical Engineering (Revised 2016)
B.E. Semester VII (w.e.f 2019-2020)

Course code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
CHC701	Process Equipment Design. (PED)	4	-	-	4	-	-	4
CHC702	Process Engineering	3	-	1	3	-	1	4
CHC703	Process Dynamics and Control (PDC)	4	-	-	4	-	-	4
CHDE703X	Department Elective III	4	-	-	4	-	-	4
ILO701X	Institute Elective I	3	-	-	3	-	-	3
CHP701	Project A	-	-	8	-	-	3	3
CHS701	Seminar	-	-	3	-	-	3	3
CHL701	PED Lab	-	3	-	-	1.5	-	1.5
CHL702	Chemical Engineering Lab X (PDC)	-	3	-	-	1.5	-	1.5
	Total	18	6	12	18	3	7	28

Course code	Course Name	Examination Scheme								
		Theory					Term Work	Pract /Oral	Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in hrs)				
		Test 1	Test 2	Avg						
CHC701	Process Equipment Design. (PED)	20	20	20	80	3	-	-	-	100
CHC702	Process Engineering	20	20	20	80	3	25	-	-	125
CHC703	Process Dynamics and Control (PDC)	20	20	20	80	3	-	-	-	100
CHDE703X	Department Elective III	20	20	20	80	3	-	-	-	100
ILO701X	Institute Elective I	20	20	20	80	3	-	-	-	100
CHP701	Project A	-	-	-	-	-	100		25	125
CHS701	Seminar	-	-	-	-	-	50	-	-	50
CHL701	PED Lab	-	-	-	-	-	25	-	25	50
CHL702	Chemical Engineering Lab X (PDC)	-	-	-	-	3	25	25	-	50
	Total			100	400	-	225	25	50	800

Department Elective III (Sem VII)		
Engineering Stream (Elective Code)	Management Stream (Elective Code)	Technology Stream (Elective Code)
1. Corrosion Engineering (CHDE7031)	2. Industrial organization and Management. (CHDE7032)	1.Petroleum Refining Technology(CHDE7033) 3. Food Technology (CHDE7034)

Institute Level Optional Subject I (Sem VII)		
1. Product Lifecycle Management(ILO7011)	4. Design of Experiments(ILO7014)	7. Disaster Management and Mitigation Measures(ILO7017)
2. Reliability Engineering (ILO7012)	5. Operation Research (ILO7015)	8. Energy Audit and Management (ILO7018)
3. Management Information System (ILO7013)	6. Cyber Security and Laws (ILO7016)	9. Development Engineering (ILO7019)

University of Mumbai
Program Structure for B.E. Chemical Engineering (Revised 2016)
B.E. Semester VIII (w.e.f 2019-2020)

Course code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
CHC801	Modeling, Simulation & Optimization (MSO)	4	-	-	4	-	-	4
CHC802	Project Engineering & Entrepreneurship Management	3	-	1	3	-	1	4
CHC803	Energy System Design	3	-	1	3	-	1	4
CHDE804X	Department Elective IV	4	-	-	4	-	-	4
ILO802X	Institute Elective II	3	-	-	3	-	-	3
CHP801	Project B	-	-	8	-	-	6	6
CHL801	Chemical Engineering Lab XI (MSO)	-	2	-	-	1	-	1
	Total	17	2	10	17	1	8	26

Course code	Course Name	Examination Scheme								
		Theory					Term Work	Pract /Oral	Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in hrs)				
		Test 1	Test 2	Avg						
CHC801	Modeling, Simulation & Optimization (MSO)	20	20	20	80	3	-	-	-	100
CHC802	Project Engineering & Entrepreneurship Management	20	20	20	80	3	25	-	-	125
CHC803	Energy System Design	20	20	20	80	3	25	-	-	125
CHDE804X	Department Elective IV	20	20	20	80	3		-	-	100
ILO802X	Institute Elective II	20	20	20	80	3		-	-	100
CHP801	Project B	-	-	-	-	-	100	-	50	150
CHL801	Chemical Engineering Lab XI (MSO)	-	-	-	-	2	25	25	-	50
	Total			100	400	-	175	25	50	750

Department Elective IV (Sem VIII)		
Engineering Stream (Course Code)	Management Stream (Course Code)	Technology Stream (Course Code)
1. Advanced Process Control (CHDE8041)	1. Total Quality Management (CHDE8042)	1. Advanced Separation Technology (CHDE8043) 2. Polymer Technology(CHDE8044)

Institute Level Optional Subject II (Sem VIII)		
1. Project Management (ILO8021)	4. Human Resource Management (ILO8024)	7. IPR and Patenting (ILO8027)
2. Finance Management (ILO8022)	5. Professional Ethics and CSR (ILO8025)	8. Digital Business Management (ILO8028)
3. Entrepreneurship Development and Management (ILO8023)	6. Research Methodology(ILO8026)	9. Environmental Management (ILO8029)

University of Mumbai
Program Structure for B.E. Chemical Engineering (Revised 2016)
S.E. Semester III (w.e.f 2017-2018)

Course code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
CHC301	Applied Mathematics-III	3	-	1	3	-	1	4
CHC302	Engineering Chemistry I	4	-	-	4	-	-	4
CHC303	Fluid Flow Operations (FFO)	4	-	-	4	-	-	4
CHC304	Chemical Engineering Thermodynamics I	3	-	1	3	-	1	4
CHC305	Process Calculations	3	-	1	3	-	1	4
CHC306	Chemical Technology	4	-	-	4	-	-	4
CHL301	Engineering Chemistry-I Lab	-	3	-	-	1.5	-	1.5
CHL302	Chemical Engineering Lab I (FFO)	-	3	-	-	1.5	-	1.5
CHL303	Chemical Engineering Lab II (Synthesis)	-	2	-	-	1	-	1
	Total	21	8	3	21	4	3	28

Course code	Course Name	Examination Scheme								
		Theory					Term Work	Pract /Oral	Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in hrs)				
		Test 1	Test 2	Avg						
CHC301	Applied Mathematics-III	20	20	20	80	3	25	-	-	125
CHC302	Engineering Chemistry I	20	20	20	80	3	-	-	-	100
CHC303	Fluid Flow (FF)	20	20	20	80	3	-	-	-	100
CHC304	Chemical Engineering Thermodynamics I	20	20	20	80	3	25	-	-	125
CHC305	Process Calculations	20	20	20	80	3	25	-	-	125
CHC306	Chemical Technology	20	20	20	80	3	-	-	-	100
CHL301	Engineering Chemistry-I Lab	-	-	-	-	3	-	25	-	25
CHL302	Chemical Engineering Lab I (FFO)	-	-	-	-	3	25	25	-	50
CHL303	Chemical Engineering Lab II (Synthesis)	-	-	-	-	-	25	-	25	50
	Total			120	480	-	125	50	25	800

Course Code	Course/Subject Name	Credits
CHC301	Applied Mathematics III	4

Pre-requisites:

- Basics of Complex numbers, Modulus, Argument, Equation of circle, Roots of unity, Euler's formula, Hyperbolic functions, Matrices, Symmetric, Orthogonal and Unitary matrices, Rank, Normal form, Solution of system of linear equations, L. I. & L. D. vectors, Basics of Probability.

Course Objectives:

- To enable students to solve initial value ODE problems using L-transforms.
- To strengthen the knowledge of students in Linear Algebra.
- To study the basics of statistics and Probability.
- To study the basics of Complex Variable.

Course outcomes:

- The student will be able to apply Laplace Transform techniques for solving initial value problems.
- Identify the Analytic function and Harmonic function and to apply Bilinear Transformation.
- Understanding and apply the concept of Probability distribution and Sampling theory to engineering problems.

Module	Topics	Contact hours
1	**Laplace transform:** 1.1 Introduction, Definition of Laplace transform, Laplace transform of constant, trigonometrical, exponential functions. 1.2 Important properties of Laplace transform: First shifting theorem, Laplace transform of L{ $f(at)$ }, L{ $t^n f(t)$ }, L{ $\frac{f(t)}{t}$ }, L{ $\frac{d^n f(t)}{dt^n}$ }, L{ $\int_0^t f(u)du$ }, without proof. 1.3 Unit step function, Heavi side function, Second shifting theorem, Dirac-delta function, Periodic function and their Laplace transforms without proof. 1.4 Inverse Laplace transform with Partial fraction and Convolution theorem. (without proof) 1.5 Application to solve initial and boundary value problem involving ordinary differential equations with one dependent variable and constant coefficients.	10
2	**Matrices:** 2.1 Eigen values and eigen spaces of 2x2 and 3x3 matrices; existence of a basis and finding the dimension of the eigen space (no proofs); diagonalisable matrices. 2.2 Cayley - Hamilton theorem. (without proof)	08

	2.3 Quadratic forms; orthogonal and congruent reduction of a quadratic form in 2 or 3 variables; rank, index, signature; definite and indefinite forms.	
3	**Probability:** 3.1 Random Variables:- discrete & continuous random variables, expectation, Variance, Probability Density Function & Cumulative Density Function. 3.2 Moments, Moment Generating Function. 3.3 Probability distribution: binomial distribution, Poisson & normal distribution.	**07**
4	**Sampling Theory:** 4.1 Test of Hypothesis, Level of significance, Critical region, One Tailed and two Tailed test, Test of significant for Large Samples:-Means of the samples and test of significant of means of two large samples. 4.2 Test of significant of small samples:- Students t- distribution for dependent and independent samples. 4.3 Chi square test:- Test of goodness of fit and independence of attributes, Contingency table. **Correlation:** 4.4 Karl Pearson's coefficient of correlation, covariance, Spearman's Rank correlation. 4.5 Regression Lines.	**07**
5	**Complex Variable:** 5.1 Functions of a complex variable, Analytic functions, Cauchy-Riemann equations in Cartesian co-ordinates, Polar co-ordinates. (without proof) 5.2 Harmonic functions, Analytic method and Milne Thomson methods to find f(z), Orthogonal trajectories. (without proof) **Mapping** 5.3 Conformal Mapping, Linear, Bilinear transformations, Cross ratio, fixed points and standard transformation such as rotation and magnification, invertion, translation.	**07**

Term work

Term work shall consist of minimum **eight** tutorials from entire syllabus which are to be given at regular intervals Batch wise.

Tutorials: 20 marks
Attendance: 05 marks
Total: 25 marks

Assessment

Internal:

- Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions need to be solved.
- Question No.1 will be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each Module.

Reference Books

1. Higher Engineering Mathematics by Dr. B. S. Grewal 42th edition, Khanna Publication.
2. Advanced Engineering Mathematics by Kreyszig E. 9th edition, John Wiley.
3. A Text Book of Applied Mathematics Vol. II by P.N.Wartilar & J.N.Wartikar, Pune, Vidyarthi Griha Prakashan., Pune.
4. Advanced Engg. Mathematics by C. Ray Wylie & Louis Barrett. TMH International Edition.
5. Mathematical Methods of Science and Engineering by Kanti B. Datta, Cengage Learning.
6. Laplace Transforms by Murry R. Spieget, Schaun'sout line series-McGraw Hill Publication.
7. Theory And Problems of Statistics by Murry R. Spieget, Schaun'sout line series-McGraw Hill Publication.
8. Fundamentals Of Mathematical Statistics by S. C. Gupta, V. K. Kapoor, Sultan Chand & Sons -2003

Course Code	Course/Subject Name	Credits
CHC302	Engineering Chemistry– I	4

Prerequisites:

- Knowledge of Vander-Waal's forces, various bonds, Octet rule, Resonance theory, Hybridization.
- Knowledge of variable valency, ligands.
- Knowledge of properties of transition metals.
- Knowledge of intermediate steps involved in conversion of reactants to products.
- Basic concept of quantum chemistry & wave theory approach.

Course Objectives:

- To understand chemical bonding.
- To study chelation and its advantages.
- To understand structures of different bio-molecules and their chemistry.
- To study importance of iron compounds for life.
- To understand different concepts of organic reactions.
- To study the effect of temperature and time on chemical reactions.
- To become aware of industrially important reactions.
- To understand mechanism of aromatic substitution and elimination reactions.

Course Outcomes:

- Students will understand different theories of chemical bonding, organo metallic chemistry, mechanism and application of Photochemical processes.
- Students will also be capable of defining Stability of Coordination compounds, Kinetics and energy profile diagrams of reactions.
- Students will have knowledge of metal carbonyls and their properties.
- Students will able to express role of metallo proteins in biological processes.
- Students will be able to carry out organic estimations, gravimetric analysis and handle different instruments in the laboratory.

Module	Content	Contact Hours
1	**Basic Concepts of Chemistry and Molecular Structures-** Hydrogen bonding, Valence bond theory (application for H_2 molecule). Molecular orbital theory, Bonding, Non-bonding and anti-bonding orbitals, LCAO method, VSEPR theory .Structure of BrF_3, SF_4, XeF_4, and IF_7. Molecular orbital diagrams of homonuclear and hetero nuclear molecules H_2, Be_2, B_2, C_2, N_2, O_2, F_2,HF CO,NO and NO^+ types etc, metallic bond.	08

2	**Co-ordination chemistry** Definitions- Co-ordination number or ligancy, Ligand, Complex ion, Co-ordination or dative bond. Nomenclature and isomerism (Only Geometrical and Structural) in co-ordination compounds with respect to co-ordination number 4 and 6. Theories of coordination compounds- Werner's Co-ordination theory, Valence bond theory, Crystal field theory (CFT), Ligand field theory. Effective Atomic Number (EAN), Application of CFT to tetrahedral and octahedral complexes, drawbacks of CFT. Measurement of CFSE (10Dq), and Numericals based on EAN and 10Dq measurement.	**08**
3	**Organometallic compounds and Bio-inorganic chemistry** Chemistry of Fe-Carbonyls –Fe $(CO)_5$,$Fe_2(CO)_9$ w.r.t preparation, properties, structure and bonding. Biochemistry of proteins containing Fe and Zn. O_2 atom transfer reactions of bio molecules containing Fe.	**06**
4	**Reaction Mechanism & Reactive Intermediates** Transition state (T.S.), Intermediate, Difference between T.S. & intermediate. Equilibrium (Thermodynamically) controlled & rate (Kinetically) controlled reactions. Explain w.r.t. Nitration of chlorobenzene, methylation of toluene by Friedel-Craft's reaction, sulphonation of naphthalene.	**07**
5	**Reactive intermediates** Definition, carbocation, carbanion, carbon free radicals and carbenes – their formation, structure & stability. Reactive intermediate formation with mechanism and applications- Carbocation – Pinacol - Pinacolone reaction. Carbanion – Michael reaction. Free radical - Wohl-Ziegler bromaination reaction. Carbene - Reimer-Tiemann reaction.	**08**
6	**Photochemistry** Introduction, difference between Photochemical and thermo chemical reaction, laws of Photochemistry i) Grothus Draper Law ii) Stark Einstein Law. Fluorescence and phosphorescence. Jablonskii diagram, Quantum yield, reasons for high quantum yield. **Photochemical reactions of carbonyl compounds**-(i) Norrish type- I cleavage (ii) Norrish type-II cleavage with mechanism.	**08**

Assessment

Internal:

Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.

- Total 4 questions need to be solved.
- Question No.1 should be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each Module

References

1. Principles of Inorganic Chemistry- Puri, Sharma, Kalia – Milestone/Vishal Publishers
2. Advanced Inorganic Chemistry – J. D. Lee
3. Organic Chemistry - I L Finar volume I and II.
4. Advanced Organic Chemistry – Jerry March, John Wiley & Sons (Wiley India)
5. Organic Chemistry – J. Clayden, Greeves, Warren, Wothers. Oxford
6. Organic reaction Mechanisms- V.K. Ahluwalia , Rakesh Parashar, Narosa Publication
7. A textbook of Physical Chemistry - Glasston Samuel, Macmillan India Ltd. (1991)
8. Inorganic Chemistry: Huheey.
9. Principles of Physical Chemistry- B. R. Puri, L. R. Sharma, M.S. Pathania.
10. Photochemistry and Pericyclic Reactions- Jagdamba Singh, Jaya Singh
11. Organic reaction mechanism – Peter sykes
12. Vogel's Textbook of Practical organic chemistry.

Course Code	Course/Subject Name	Credits
CHC303	Fluid Flow Operation	4

Prerequisites:

- Students are assumed to have adequate background in physics, units and dimensions and thermodynamics.

Course Objectives:

- Students should be able to understand the scope of the subject in chemical industry.
- They should be comfortable with measurement of pressure or pressure drop.
- They should be able to calculate pressure drop and flow rates in conduits for incompressible as well as compressible fluids.
- They should be able to determine viscosity using different methods such as Stokes Law, Capillary viscometer.
- They should be able to calculate power requirement in agitation and to be able to select and calculate power requirement for pumps.
- They should be able to select proper valves.

Course Outcomes:

- After studying this subject, students would be able to measure pressure drop, flow rates etc.
- Students will able to understand basic concepts and pressure measurement.
- Students will able to understand kinetics and rheological behavior of fluid flow.
- Students will able to understand flow equations for compressible and incompressible flow.
- Students will able to select pumps and valves and would be able to calculate power requirement for pumping as well as agitation operations.

Module	Contents	Contact Hours
1	**Introduction and Basic Concepts:** Scope and Applications of fluid flow, Properties of fluids such as Density, viscosity, surface tension, capillarity effect, vapour pressure. **Pressure and Fluid Statics:** • Fluid Pressure at a Point, Pascal's Law, Pressure Variation in a fluid at rest. Hydrostatic Equilibrium. • Measurement of Pressure, Manometers – Peizometers, U-Tube, Single Column manometer, U – Tube differential manometer, Inverted Differential U – tube manometer, inclined manometer.	7
2	**Fluid Kinematics:**	2

	• Types of fluid flow namely steady and unsteady, Uniform and non- uniform, laminar and turbulent, compressible and incompressible internal and external, one, two dimensional flow. • Newton's Law of Viscosity, Rheological behavior of fluid, capillary viscometer.	
3	**Basic Equations of Fluid Flow:** • Bernoulli's equation Euler's Equation, Modified Bernoulli's equation. • Major and Minor losses, Equivalent length, flow through pipe in series, parallel, pipe network. **Practical Application of Bernoulli's Equation:** • Venturimeter: Horizontal and inclined, Orificemeter, Pitot tube • Notches and Weirs: Introduction, classification, Derivation for V – notch, Rectangular notch.	**10**
4	**Flow through Pipes:** **A] Incompressible flow:** Shear stress distribution and velocity distribution. Relationship between Skin friction and wall shear, friction factor, Darcy-Weisbach equation. Reynolds experiment and Reynolds no., Formation of Boundary. **Laminar Flow:** Shear stress, velocity distribution, Derivation of local velocity, maximum velocity, average velocity, Kinetic Energy Correction factor, Hagen – Poiseullie equation. **Turbulent Flow:** Velocity distribution equations, Average velocity, local velocity, maximum velocity, kinetic energy correction factor (No Numericals on universal velocity). Von Carman equation and friction factors, Moody diagram. Equivalent diameter for circular and non-circular ducts. Pipes in series and parallel. Frictional Losses in different pipe fittings. **B] Compressible Fluids:** Introduction, Mach no, Sonic, supersonic and subsonic flow, continuity equation and Bernoulli's equation, stagnation properties, Acoustic velocity. Adiabatic Flow. Isothermal Flow. Isentropic Flow.	**12**
5	**Flow past immersed bodies:** Drag forces, Coefficient of drag, Terminal settling velocity, Stoke's law.	**2**
6	**Pumps, Valves and Agitators:** Classification and types, Centrifugal pumps – Construction and working, Power required, Definitions of heads and efficiency, NPSH, Priming, Cavitations, characteristic curves. Specific speed, minimum speed.	**12**

	Reciprocating Pump: Classifications and working. **Power Consumption in Agitation:** Power curves, Power No., types of impellers. **Introduction to Compressors, Fans and Blowers**. **Types of Valves:** Globe valves, Gate valves, butterfly valves and non – Return valves.	

Assessment

Internal:

Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions need to be solved.
- Question No.1 will be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each Module.

References

1. Warren L. Mccabe, Julian C. Smith, Peter Harriott, Unit Operations of Chemical Engineering, McGraw Hill International Edition.
2. Okiishi, Huebsch, Rothmayer Munson, Fluid Mechanics - SI Version, Wiley, 7th edition, 2015.
3. Coulson J. M., Richardson J. F., Backhurst J. R. and J. H. Harker, Chemical Engineering, Vol. 1 and 2.
4. Suresh Ukarande, Fluid Mechanics and Hydraulics, Ane Books, 2012.
5. Robbert W. Fox, Philip J. Pritchard, Alan T. McDonald, Introduction to Fluid Mechanics, 7th edition, WILEY, India Edition.
6. Yunus A. Cengel, John M. Cimbala, Adapted by S. Bhattacharya, Fluid Mechanics Fundamentals and Applications, The McGraw Hill Companies.
7. Dr. R. K. Bansal, Fluid Mechanics and Hydraulic Machines, Laxmi Publications Pvt. Ltd.
8. Fluid Mechanics for Chemical Engineers by Noel de Nevers, McGraw Hill Education

Course Code	Course/Subject Name	Credits
CHC304	Chemical Engineering Thermodynamics I	04

Prerequisites:

- Basic thermodynamic properties, laws and equations.
- Engineering Mathematics: Differential Equations, Linear Algebraic Equations.

Course Objectives:

- To make students understand the Laws of Thermodynamics and Basics of Chemical Engineering Thermodynamics
- To make students learn to apply the concepts of Chemical Engineering Thermodynamics to various Chemical Engineering Processes

Course Outcomes:

- The students will be able to apply thermodynamic laws and equations to various Chemical Engineering processes.

Module	Contents	Contact Hours
01	• First Law of Thermodynamics for flow and non-flow processes • Calculation of heat and work for various types of processes	08
02	• Second Law of Thermodynamics • Concepts of heat engine, heat pump and refrigerator • Carnot Cycle and Carnot Principle • Clausius Inequality • Concept of Entropy and estimation of Entropy change of various processes • Third Law of Thermodynamics	08
03	• Concept of Exergy, Exergy Balance • Steady flow Exergy equation and its application	06
04	• Equations of State for non-ideal gases: Virial equation of state, van der Waals equation of state, Redlich-Kwong, Redlich-Kwong-Soave and Peng-Robinson equation of state	06
05	• Maxwell Equation, Joule Thomson effect • Enthalpy and Entropy departure functions (vander Waals and Redlich Kwong EOS) • Thermodynamic Charts, Diagrams and their applications • Fugacity and fugacity coefficient(vander Waals and Redlich Kwong EOS)	08

Term work

Term work shall consist of minimum **eight** tutorials from entire syllabus which are to be given at regular intervals Batch wise.

Tutorials: 20 marks

Attendance: 05 marks
Total: 25 marks

Assessment

Internal:

- Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions need to be solved.
- Question No.1 will be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each Module.

Reference

1. Introduction to Chemical Engineering Thermodynamic by J.M. Smith, H.C. Van Ness, M.M. Abbott, Latest Edition, McGraw Hill Publishing Company Limited
2. A textbook of Chemical Engineering Thermodynamics by K.V. Narayanan, Latest Edition, Prentice Hall of India Private Limited
3. Chemical Engineering Thermodynamics by Y.V.C. Rao, Latest Edition, University Press
4. Fundamentals of Engineering Thermodynamics by Micheal J Moran , Howard N Shaprio, Latest Edition, Wiley publication.
5. Introduction to Chemical Engineering Thermodynamics by Gopinath Halder, PHI learning Pvt. Ltd

Course Code	Course/Subject Name	Credits
CHC305	Process Calculations	4

Prerequisites:

- Linear algebra.
- Differential equations

Course Objectives:

- Students will learn to write mass balances on various process equipments with and without recycle.
- Students will learn to write energy balances on various process equipments with and without recycle.
- Students will learn to write mass and energy balances for chemical reactions with and without recycle.
- Students will learn to flow sheeting calculations.

Course Outcomes:

- Students will learn to calculate mass and energy flow rates into and out of various process equipments.
- Students will learn to calculate conversion, selectivity etc for various reactions with and without recycle.
- Students will learn to carry out degrees of freedom analysis for various units.

Module	Contents	Contact Hours
1	Introduction. Basic Chemical Calculations .Units And Dimensions Various systems of units, conversion of units. Density, specific volume, specific gravity, Concentration & composition of mixtures and solutions. Ideal Gas law, Dalton's law, Amagat,s law, Raoult's law, Henry's law	06
2	Material Balance without chemical reactions. General material balance equation, degree of freedom analysis for individual units, solving material balance problems for various unit operations using steady state equation, Material Balance for Unsteady Processes. Recycle, Bypass and Purge Calculations.	07
3	Material Balance with chemical reactions. Concept of limiting and excess reactants, conversion and yield, selectivity and degree of completion of reaction, material balance problems related to chemical reactions including recycle, bypass and purge Calculations.	07
4	Energy Balance. Heat capacity, sensible heat, latent heat, calculation of enthalpy changes. General energy balance equation. Energy balances for process involving chemical reaction including adiabatic reactions & combustion processes (Orsat Analysis & Net, Gross Calorific Value determination).	10

5	Combined Material and Energy balance. Material and Energy balance for binary distillation, combustion and evaporation.	**08**

Tutorials

1. Basic chemical calculations.
2. Material balance without chemical reaction.
3. Material balance without chemical reaction for unsteady. Bypass, recycle and purge operations
4. Material balance without chemical reaction for unsteady. Bypass, recycle and purge operations.
5. Energy balance based on heat capacity, enthalpy change.
6. Energy balance based on Hess's law, temperature of reaction.
7. Energy balance based on orsat analysis, NCV and GCV.
8. Combined material and energy balance.

Term work

Term work shall consist of minimum **eight** tutorials from entire syllabus which are to be given at regular intervals Batch wise.

Tutorials: 20 marks
Attendance: 05 marks
Total: 25 marks

Assessment

Internal:

- Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions need to be solved.
- Question No.1 will be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each Module.

Text Books

1. Narayan, K. V. and Lakshmikutty, B. "Stioichiometry and Process Calculations", 1st edition, Prentice Hall of India Pvt. Ltd., New Delhi (2006)
2. Bhatt, B. I. and Thakore, S. B., "Stoichimetry, 5th editionTata McGraw Hill Education Private Limited, New Delhi
3. Ch. Durga Prasad Rao and D. V. S. Murthy, " Process Calculations for Chemical Engineers", McMilan India Ltd. (2010)
4. O. A. Hougen, K. M. Watson, and R. A. Ragatz., "Chemical process principles-part 1, Material and Energy Balances". Second Edition. John Wiley & Sons, Inc., New York (1954). 525 pages.

Reference books

1. Himmelblau, D. M. and Riggs, J. B., "Basic Principles and Calculations in Chemical Engineering, 7th edition, Prentice Hall of India Pvt. Ltd., New Delhi (2009)
2. Stoichiometry and Process calculations by K.V. Narayanan and B. Lakshmikutty, PHI learning Pvt. Ltd

Course Code	Course/Subject Name	Credits

CHC306	Chemical Technology	4

Prerequisites

- Knowledge of Inorganic, Organic and Physical Chemistry, Physics and Mathematics.

Course Objectives

- To give students an insight of different chemical processes.
- To understand the development of a process from its chemistry.
- To understand different engineering problems in process industries.

Course Outcomes

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

- Describe various manufacturing processes used in the chemical process industries.
- Explain industrial processing and overall performance of any chemical process including the major engineering problems encountered in the process.
- Determine the overall process aspects including yield, formation of by-products and generation of waste, etc.
- Draw and illustrate the process flow diagram for a given process.

Module	Contents	Contact Hours
1	**Introduction :** Concept and brief description of the Unit Operations and Unit Processes used in Chemical Industries. **Overview of Industrially Important Products in the Chemical Process Industries:** Soaps and Detergents Dyes and Intermediates Agrochemicals	05
2	**Manufacture of Acids :** Sulphuric Acid (DCDA Process), Nitric Acid, Phosphoric Acid (Wet Process) and Acetic Acid (by reaction of carbon monoxide with methanol). **Manufacture of Fertilizers :** Ammonia, Urea and Superphosphate (SSP and TSP).	12
3	**Natural Product Industries :** Hydrogenation of Vegetable Oils Manufacture of Sugar from Sugarcane, By-products obtained in manufacture of sugar, Inversion of sugar Manufacture of ethanol by fermentation of molasses **Introduction to Biodiesel Processing :** Biodiesel production by base- catalysed transesterification process **Chloro-Alkali Industries :** Manufacture of Caustic Soda	12

	Manufacture of Hydrochloric Acid by combustion of chlorine and hydrogen Manufacture of Soda Ash (Solvay and Dual Processes)	
4	**Synthesis of Important Heavy Organic Chemicals and Intermediates :** Manufacture of Styrene by dehydrogenation of ethylbenzene Manufacture of Cumene from benzene and propylene Manufacture of Phenol from cumene by peroxidation-hydrolysis process Manufacture of Purified Terephthalic Acid (PTA) by oxidation of p-xylene	**05**
5	**Synthesis of Polymers :** Manufacture of Polyethylene : LDPE and HDPE Manufacture of Nylon 66	**03**
6	**Basic Building Blocks of Petrochemical Industry :** Introduction to Petroleum Refining Catalytic Cracking by Fluidized Catalytic Cracking Unit (FCCU) Naphtha Cracking for manufacture of ethylene and propylene Naphtha Reforming Separation of BTX (Benzene-Toluene-Xylene) Isomerization of Xylenes Separation of Xylene isomers	**08**

Assessment

Internal:

- Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions need to be solved.
- Question No.1 will be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each Module.

Reference

1. Austin G.T., Shreve's Chemical Process Industries, 5th Edition, McGraw Hill International Edition.
2. Pandey, G.N., A Textbook of Chemical Technology, Vol.I and II, Vikas Publications, 1984.
3. Rao, G.N. and Sittig M., Dryden's Outlines of Chemical Technology for 21st Century, East West Press, 3rd Edition.
4. B.K. Bhaskara Rao, Modern Petroleum Refining Processes.
5. B.K. Bhaskara Rao, A Textbook of Petrochemicals.
6. Heaton, C.A., An Introduction to Industrial Chemistry, Leonard Hill, 1984.

7. Thomson, R., Modern Inorganic Chemical Industries, Royal Society of Chemistry, 2nd. Edition, 1994.
8. Kirk-Othmer's Encyclopedia of Chemical Technology, John Wiley and Sons, Inc., 4th Edition, 1990.
9. Ullmann's Encyclopedia of Industrial Chemistry, VCH, 1985.
10. McKetta's Encyclopedia of Chemical Processing and Design, Marcel Dekker, 1999.
11. Pletcher D. and Walsh, F.C., Industrial Electrochemistry, Chapman and Hall, 1990.
12. Alok Adholeya and Pradeepkumar Dadhich, Production and Technology of Biodiesel: Seeding a Change, TERI Publication, New Delhi, 2008.
13. NIIR Board of Consultants and Engineers, The complete book on Jatropha (Biodiesel) with Ashwagandha, Stevia, Brahmi and Jatamansi Herbs (Cultivation, Processing and Uses), Asia Pacific Business Press Inc.

Course Code	Course/Subject Name	Credits

CHL301	Engineering Chemistry Lab– I	1.5

List of Experiments Suggested:

Volumetric analysis-[Any 2]
Preparation of standard solutions and to find normality and deviation factor.

Titrimetric analysis- [Any 3]

- Analysis of talcum powder for Mg content by EDTA method
- Analysis of Aspirin as per I.P. or USP
- Determination of Strength of $KMnO_4$
- Determination of fluoride content in the toothpaste spectrophotometrically
- Estimation of CaO in cement
- Estimation of Vitamin C using Ceric ammonium sulphate
- Estimation of Glycine by non aqueous titration using perchloric acid

Organic estimations - [Any 2]

- Estimation of aniline
- Estimation of phenol
- Estimation of Acetamide

Gravimetric estimation - [Any 2]

- Barium as BaCl2
- Tin as SnCl2
- Nickel as Ni D.M.G.
- Zinc as ZnSO4

Preparation.

- Preparation of Methyl Salicylate

Students have to perform any 10 practicals from the above during the semester.

Practical Examination

- Duration for practical examination would be the same as assigned to the respective lab per week.
- A student becomes eligible for practical examination after completing a minimum of eight experiments out of ten experiments.

Course Code	Course/Subject Name	Credits

CHL302	Chemical Engineering Lab (FFO)	1.5

List of Experiments Suggested

Minimum Ten experiments must be performed

- Viscosity by Efflux time
- Reynolds Apparatus
- Bernoulli's apparatus
- Venturimeter
- Orificemeter
- Pitot tube
- V – Notch/ Rectangular notch
- Friction through Circular pipe
- Flow through Annulus.
- Flow through Helical coil
- Pipe Fitting (Minor Losses)
- Pumps
- Power Consumption in agitated vessel
- Viscosity by Stoke's Law

Term work

Term work shall be evaluated based on performance in practical.
Practical Journal: 20 marks
Attendance: 05 marks
Total: 25 marks

Practical Examination

- Duration for practical examination would be the same as assigned to the respective lab per week.
- A student becomes eligible for practical examination after completing a minimum of eight experiments out of ten experiments.

Course Code	Course/Subject Name	Credits
CHL303	Chemical Engineering Lab II (Synthesis)	1

s.n	Preparation	Chemicals required	Apparatus/ glassware required
1	Soap	Sodium hydroxide (20% solution), ethanol saturated solution of sodium chloride ,calcium chloride (5% solution), magnesium chloride (5% solution), ferric chloride (5% solution), cooking oil, phenolphthalein indicator solution.	250-mL beaker, 100- mL beaker; wire gauze; laboratory burner; glass stirring rod; test tubes; filter flask and Buchner funnel; filter paper; graduated cylinder
2	Alum from Aluminum	Aluminum can or aluminum metal, Crushed ice, 9M H2SO4, 1.5M KOH solution, Methanol, NaHCO3 (sodium bicarbonate)	Glass filter funnel, Buchner filter funnel, filter paper, steel wool, two 150 mL and two 150 ml beakers, 500 ml beaker, thermometer, ruler, stirring rod
3	Asprin	2 gm salicylic acid, 5.0 ml of acetic anhydride, ve drops of 85% phosphoric acid, distilled water	burette clamp, burner, stand with iron ring, wire gauze, ice bath,50 ml ask beaker, Buchner funnel aspirator
4	Methyl orange	0.29 g of anhydrous sodium carbonate, 1.0 g of sulfanilic acid monohydrate, 0.375 g of sodium nitrite, 0.7 ml of dimethylaniline and 0.5 mL of glacial acetic acid, 10% aqueous sodium hydroxide, 1.25 ml of concentrated hydrochloric acid	50 ml Erlenmeyer ask, lter,100 ml beaker, test tube
5	Thiokol rubber	Sodium hydroxide solution, 1M Sulfur 1,2-dichloroethane distilled or deionized water	Copper wire, approximately 6 inches long (15 cm); two 10 ml vials with teflon cap liners, two 400 ml beakers ,10 ml graduated cylinder ,glass pipette (dropper), hot plate, chemical resistant gloves
6	RUBBER BALL FROM RUBBER LATEX	15 ml rubber latex, 15 ml vinegar, 15 ml wate	Two paper cups (5 ounce), stir- ring rod (popsicle stick or equiv-

			alent), small bucket or large beaker (1000 ml or larger)
7	p-BROMO-NITROBENEZENE FROM BRO-MOBENEZENE	Conc. H2SO4, conc. HNO3 , bromobenzene, ethyl alcohol, conical ask, funnel, lter paper, water Bath	Conical flask, funnel, filter paper, water bath.
8	DETERGENT	Dodecanol (dodecyl alcohol), sulphuric acid, concentrated sodium hydroxide, 6M phenolphthalein solution, 1% sodium chloride	Erlenmeyer ask, 125 ml beakers, 400 ml, 150 ml, 100 ml graduated cylinders, 10 ml, 25 ml, 125 ml funnel, spatula, stirring rod, Cheese cloth, watch glass, scissors

Term work

Term work shall be evaluated based on performance in practical.

Practical Journal: 20 marks

Attendance: 05 marks

Total: 25 marks

University of Mumbai
Program Structure for B.E. Chemical Engineering (Revised 2016)
S.E. Semester IV (w.e.f 2017-2018)

Course code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
CHC401	Applied Mathematics-IV	3	-	1	3	-	1	4
CHC402	Engineering Chemistry II	4	-		4	-	-	4
CHC403	Chemical Engineering Thermodynamics II	3	-	1	3	-	1	4
CHC404	Solid Fluid Mechanical Operations (SFMO)	4	-	-	4	-	-	4
CHC405	Mechanical Equipment Design (MED)	4	-	-	4	-	-	4
CHC406	Chemical Engineering Economics	3	-	1	3	-	1	4
CHL401	Engineering Chemistry-II Lab	-	3	-	-	1.5	-	1.5
CHL402	Chemical Engineering Lab III (SFMO)	-	3	-	-	1.5	-	1.5
CHL403	MED Lab	-	2	-	-	1	-	1
	Total	21	8	2	21	4	3	28

Course code	Course Name	Examination Scheme								
		Theory					Term Work	Pract /Oral	Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in hrs)				
		Test 1	Test 2	Avg						
CHC401	Applied Mathematics-IV	20	20	20	80	3	25	-	-	125
CHC402	Engineering Chemistry II	20	20	20	80	3	-	-	-	100
CHC403	Chemical Engineering Thermodynamics II	20	20	20	80	3	25	-	-	125
CHC404	Solid Fluid Mechanical Operations (SFMO)	20	20	20	80	3	-	-	-	100
CHC405	Mechanical Equipment Design (MED)	20	20	20	80	3	-	-	-	100
CHC406	Chemical Engineering Economics	20	20	20	80	3	25	-	-	125
CHL401	Engineering Chemistry-II Lab	-	-	-	-	3	-	25	-	25
CHL402	Chemical Engineering Lab III (SFMO)	-	-	-	-	3	25	25	-	50
CHL403	MED Lab	-	-	-	-	-	25	-	25	50
	Total			120	480	-	125	50	25	800

Course Code	Course/Subject Name	Credits
CHC401	Applied Mathematics- IV	4

Prerequisites:

- The concepts of basic Mathematics as well as a few concepts of higher mathematics.
- The concepts of basic chemistry, basic civil engineering, basic mechanical engineering, etc. in order to understand the concepts like, corrosion, corrosion allowance, construction costs, equipment costs, etc.

Course Objectives:

- The Fourier Series, Fourier Transform and Partial Differential Equation
- Module does the Ground work for the techniques required to solve and find the answer for various physiochemical problems.
- To study the basics of Finite Differences.
- To study the basics of Complex Integration.
- To introduce the basics of NLPP.

Course outcomes:

- Demonstrate the ability of using Fourier Series and Fourier Transform in solving PDE.
- Enable the students to solve boundary value Problem using Finite Differences Approximations.
- Identify the applicability of theorems and evaluate the Contour Integral.
- The students will be ready for any further course on Optimization.

Module	Topics	Contact Hours
01	Fourier Series: 1.1 Orthogonal and Ortho-normal functions 1.2 Dirichlet's conditions, Fourier series of periodic functions with period 2π and $2L$. Parsevel's identities (without proof). 1.3 Fourier series for even and odd functions. 1.4 Half range sine and cosine Fourier series, 1.5 Complex form of Fourier series. 1.6 Fourier Integral Representation, sine & cosine Integrals 1.7 Fourier Transform sine & cosine transforms, complex transforms. NO PROOFS REQUIRED.	10
02	Partial Differential Equations: 2.1 Solutions of linear partial differential Equation by method of separation of variables 2.2 Partial differential equations governing transverse vibrations of elastic string its solution using Fourier series. 2.3 Heat equation, steady-state configuration for heat flow. 2.4 Two dimensional Laplace equations.	08

	(ONLY NUMERICAL PROBLEMS. NO PROOFS REQUIRED).	
	Finite Differences and Interpolation 3.1 Forward difference operator Δ, backward difference operator ∇ , shift operator E, properties of operators Δ, ∇ and E, relation between E and D where D = $\frac{d}{dx}$. 3.2Missing terms (equal Intervals),Factorial Notation 3.3 Assumption of interpolation, Gregory Newton's Forward Interpolation formula for equal Intervals, Gregory Newton's Backward Interpolation formula for equal Intervals 3.4 Interpolation with arguments at unequal Intervals-Divided Difference table Newton's Divided Difference Formula , 3.5 Lagrange's Interpolation Formula.	**07**
04	Complex Integration 4.1 Line Integral, Cauchy's Integral theorem for simply connected regions, Cauchy's Integral formula(without proof) 4.2 Taylor's and Laurent's series (without proof) 4.3 Zeros, poles of f(z), Residues, Cauchy's Residue theorem 4.4 Applications of Residue theorem to evaluate Integrals of the type $\int_0^{2\pi} f(sin\theta, cos\theta)d\theta, \int_{-\infty}^{\infty} f(x)dx,$	**07**
05	Optimization (No theory) 5.1Non-linear programming: Lagrange multiplier method for one and two equality constraints for 2 and 3 variables, conditions on the Hessian matrix (no proof); 5.2 Non-linear programming: Kuhn-Tucker conditions with at most 2 constraints with two variables.	**07**

Term work

Term work shall consist of minimum **eight** tutorials from entire syllabus which are to be given at regular intervals Batch wise.

Tutorials: 20 marks
Attendance: 05 marks
Total: 25 marks

Assessment

Internal:

- Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions need to be solved.
- Question No.1 will be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules.

- Weightage of marks should be proportional to number of hours assigned to each Module.

Reference Books

1. Higher Engineering Mathematics by Dr. B. S. Grewal 42th edition, Khanna Publication 2005.
2. Advanced Engineering Mathematics by Kreyszig E. 9th edition, John Wiley.
3. A Text Book of Applied Mathematics Vol. II by P.N.Wartilar & J.N.Wartikar, Pune, Vidyarthi Griha Prakashan., Pune.
4. Advanced Engg. Mathematics by C. Ray Wylie & Louis Barrett.TMH International Edition.
5. Mathematical Methods of Science and Engineering by Kanti B. Datta, Cengage Learning.
6. Lapplace Treansforms by Murry R. Spieget, Schaun'sout line series-McGraw Hill Publication.
7. Operation Research by S. D. Sharma.
8. Operation Research by ER. Prem Kumar Gupta & Dr. D. S. Hira.

Course Code	Course/Subject Name	Credits
CHC402	Engineering Chemistry– II	4

Prerequisites:

- Knowledge of electronic structure of atom and electrolytic properties and their laws.
- Basic concept of quantum chemistry & wave theory approach.
- Knowledge of intermediate steps involved in conversion of reactants to products.
- Knowledge of properties of solutions.

Course Objectives:

- To understand applications of EMF measurement.
- To understand the principles of different instrumental and chromatographic techniques.
- To state and understand Nernst distribution law in extraction.
- To be able to solve numerical on solvent extraction and ion exchange.
- To understand colloidal phenomenon and its applications.
- To be able to predict the significance of active methylene group.
- To state and understand the Huckel's rule of aromaticity and its application to aromatic hydrocarbons and heterocyclic compounds.

Course Outcomes:

- They should be able to understand the role of different conductivity cells and different tirimetric methods and solvent extractions.
- Students will be able to detect the organic and inorganic biological compound by the use of spectrophotometer.
- Students will know the colloidal phenomenon applied in food industry and pesticides.
- Students will be to identify the significance of rearrangement reactions, active methylene group.
- Students will be able to predict and synthesize different products by learning reaction mechanism.
- Students will have deep knowledge of Qualitative (Analysis) and Quantitative (estimations) methods.

Module	Content	Contact Hours
1	**Electrochemistry** Conductance, specific conductance, equivalent conductance, molar conductance. Effect of dilution and temperature on conductance. Transport number (Numerical on moving boundary method). Debye Huckel theory of strong electrolytes. Hydrogen ion concentration by glass electrode/Quinhydrone electrode. Concentration cells with and without transference w.r.t. cations. Weston Standard cells. Application of emf measurement for	08

	determination of solubility product (Ksp) of sparingly soluble salt.	
2	**Instrumental methods of Analysis** Conductometry -Principle and types of titrations - Acid-base and precipitation. Potentiometry- Principle and types of titrations –precipitation only. **Chromatography** Adsorption and partition. Study of Paper Chromatography, Thin Layer Chromatography, High Performance Liquid Chromatography (HPLC), Gas (Liquid and solid) Chromatography –Principle and their applications. **Optical Methods** (Principle, Instrumentation and applications) UV, IR, NMR spectroscopy, flame photometry.	**10**
3	**Ion exchange and solvent extraction techniques** Ion exchange resins, cation and anion exchangers. Desalination by ion exchange and separation of lanthanides. Solvent extraction. Nernst distribution law. Distribution ratio. Batch, continuous and counter current extraction. Numericals based on solvent extraction.	**06**
4	**Colloids and surfactants** Origin of charge on colloidal particles. Concept of electrical double layer-Helmholtz and stern model. Electro-kinetic Phenomenon- Electrophoresis, electro-osmosis, streaming potential and Dorn effect (Sedimentation potential). Colloidal electrolytes, Donnam Membrane equilibrium and its significance. **Catalysis-** Definition. Criteria of catalysis. Types (Homogeneous and Heterogeneous).Catalytic promoters, poisons. Negative catalysis and inhibition. Autocatalysis and Induced catalysis. Activation energy. Intermediate compound formation theory. Adsorption theory. Acid Base catalysis and mechanism. Enzyme catalysis- Characteristics and mechanism.	**10**
5	**Industrially important esters and Aromaticity** Synthesis and properties of malonic ester and acetate acetic ester. Huckel's rule of aromaticity, Aromatic character and reactions of Benzene, Naphthalene, Pyrrole, Furan, Thiophene, Pyridine.	**06**
6	**Name reactions.** Definition, meachanism and application of -Beckman rearangement, Fishcher-Indole synthesis, Favorskii reaction, Reformatsky reaction, Paal-Knorr synthesis of pyrrole, Benzil-Benzilic acid rearrangement.	**05**

Assessment

Internal:

- Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions need to be solved.
- Question No.1 will be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each Module.

References

1. Principles of Physical Chemistry- B. R. Puri, L. R. Sharma, M.S. Pathania.
2. A textbook of Physical Chemistry - Glasston Samuel, Macmillan India Ltd. (1991).
3. Physical chemistry - Castellan G.W. Addison Hesly-Haroda Student Edition(1994).
4. Instrumental methods of Analysis - Willard, Merritt, CBS publishers and Distributor.
5. Instrumental Methods of Chemical Analysis - S.M. Khopkar
6. Principle of instrumental analysis - Douglas A. Skoog
7. Organic Chemistry - I L Finar volume I and II.
8. Advanced Organic Chemistry – Jerry March, John Wiley& Sons(Wiley India)
9. Organic Chemistry – J. Clayden, Greeves, Warren, Wothers. Oxford
10. Organic reaction Mechanisms- V.K. Ahluwalia , Rakesh Parashar, Narosa Publication
11. Spectroscopy – P.S. Kalsi
12. Introduction to Spectroscopy – Pavia, lampman, Kritz.
13. Engineering Chemistry- Jain & Jain Dhanapat Rai publication.
14. Vogels Textbook of Practical organic chemistry.

Course Code	Course/Subject Name	Credits
CHC403	Chemical Engineering Thermodynamics II	04

Prerequisites:

- Engineering Mathematics, Chemical Engineering Thermodynamics-I

Course Objectives:

- To make students understand the concepts of equilibrium in phases and in chemical reactions
- To make students learn to calculate conditions and compositions of ideal and non-ideal vapor liquid equilibrium systems and of various chemical reactions at equilibria.
- To make students understand the concept of refrigerator and learn to calculate COP, power required etc. for a given duty of refrigeration

Course Outcomes

- Students learn the application of First law and second law to the problem of phase equilibrium and reaction equilibrium.
- Students learn to calculate the refrigerant flow rate for a given duty of refrigeration.
- Students learn to calculate the compressor sizes and loads for refrigeration.
- The calculation of phase equilibria and the understanding of it is a fundamental concept to design of mass transfer

Module	Contents	Contact hrs
01	• Properties of ideal mixtures and solutions • Non idealities of solutions and mixtures • Chemical potential • Activity and activity coefficients • Gibbs Duhem equations	04
02	• Partial molar properties • Properties changes of mixing • Excess properties	06
03	• Concept of equilibrium between phases • Review of Raoult's law and Henry's law • Phase diagrams for binary solutions • Vapor liquid equilibria in ideal and non-ideal solutions • Estimation of activity coefficients using van Laar equation, Margules equation, Wilson equation	10
04	• Representation of reaction stoichiometry • Concept of reaction equilibrium in single and multiple reactions • Estimation of standard enthalpy change of a reaction • Heat of reaction in a batch and continuous reactor	10

	• Estimation of standard Gibbs free change and equilibrium constant of a reaction • Estimation of degree of conversion and composition of reactor effluents • Degree of freedom for single and multiple reactions	
05	• Theory of Refrigeration • Vapor compression refrigeration system • Vapor absorption refrigeration system • Refrigeration cycle diagrams (P-V, T-S, H-S, H-X) • Estimation of COP, power of compression, refrigerant flow rate etc.	**06**

Term work

Term work shall consist of minimum **eight** tutorials from entire syllabus which are to be given at regular intervals Batch wise.

Tutorials: 20 marks

Attendance: 05 marks

Total: 25 marks

Assessment

Internal:

- Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions need to be solved.
- Question No.1 will be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each Module.

Reference

1. Introduction to Chemical Engineering Thermodynamic by J.M. Smith, H.C. Van Ness, M.M. Abbott, Latest Edition, McGraw Hill Publishing Company Limited
2. A textbook of Chemical Engineering Thermodynamics by K.V. Narayanan, Latest Edition, Prentice Hall of India Private Limited
3. Chemical Engineering Thermodynamics by Y.V.C. Rao, Latest Edition, University Press
4. Elementary Principle of Chemical Processes by Felder and Rousseau Latest Edition.
5. Introduction to Chemical Engineering Thermodynamics by GopinathHalder, PHI learning Pvt. Ltd

Course Code	Course/Subject Name	Credits
CHC404	Solid Fluid Mechanical Operations	4

Prerequisites:

- Fluid Flow Operations
- Engineering Mechanics
- Differential Equations

Course Objectives:

- understanding basic concept of particle size analysis and size reduction
- Understanding concept of flow through packed bed fluidization and filtration
- Understanding concept of sedimentation & gas solid separation
- Understanding concept of size enlargement, solid mixing and solid storage &conveying.

Course outcomes:

- The students would understand the concept of particle size analysis and size reduction.
- The students would understand the concept of flow through packed bed, fluidization and filtration
- The students would understand the concept of sedimentation and gas- solid separation.
- The students would understand the concept of solid mixing, solid storage & conveying, size enlargement.

Module	Contents	Contact Hours
1	Introduction- scope &application of solid fluid operation • Particle size analysis, particle size measurement and distribution • Sieve analysis • Capacity and effectiveness of screen • Screening Equipment: Vibrating screens; Grizzlier; Trommels • Size reduction of solids • Mechanism of size reduction and method of operation • Energy of size reduction • Size reduction Equipments: Jaw Crusher; Hammer Mill; Ball Mill; Roll Crusher	12
2	• Flow through packed bed • Types of packing • Flow of a single fluid through a packed bed, Ergun's equipment • Fluidization: Conditions for fluidization; Minimum	12

	fluidization velocity; Types of fluidization; Application of Fluidization; Numerical on Fluidization • Filtration: Mechanism of Filtration; Types of Filtration – constant rate & constant pressure; Filtration; Filter aids, washing of filter cake; Flow of filtrate through the cloth & cake combine; Numerical on constant pressure & constant cloth rate & combine cake. • Filters: Rotary drum vacuum filter, Plate & frame filter press	
3	• Economics of production and Growth • Sedimentation: Batch sedimentation; Kynch Theory of sedimentation; Area and Depth of thickener • Particle separation by Flotation and Elutriation • Gas solid separation Equipments: Cyclone separator- theory and derivation for minimum particle separated in cyclone separator. Fabric filter, Electrostatic precipitator	**10**
4	• Size enlargement of particles: Agglomeration & granulation Growth mechanism; Size enlargement processes • Storage of solids: Properties of particulate masses; Pressures in Bins &Silos; Jansen's equation • Conveying of solids: Belt conveyor, bucket conveyer, screw conveyer, pneumatic conveyer • Solid mixing: Introduction to solid mixing, degree of mixing, mixing Index & rate of mixing; Mixing Equipments:1) Mixers for cohesive solids: Muller Mixer; Kneaders . 2) Mixers for free flowing solids: Ribben Blender; Internal Screw mixer	**10**

Assessment

Internal:

- Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions need to be solved.
- Question No.1 will be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each Module.

References

1. Unit operations of Chemical engineering, WC McCabe & J C Smith, McGraw Hill
2. Chemical Engineering, Vol II J M Coulson & J F Richardson, pergamon Press
3. Unit operations by foust
4. Perry's Handbook for chemical Engineers, Robert H. Perry & Don W. Green, 8th edition, McGraw Hill

Course Code	Course/Subject Name	Credits
CHC405	Mechanical Equipment Design (MED)	4

Prerequisites:

- Fundamentals of units
- Elementary theory of engineering mechanics
- Engineering drawing

Course Objectives:

- To understand the basics for design as per the codes & standards for the mechanical design of equipments used in the process industry.
- Selection of material of construction and stress analysis by determining values of stresses arising out of different loading conditions.

Course Outcomes:

- Students will demonstrate ability to design various components of process equipment as heads, shell, flanges and supports and complete design of chemical equipment
- Students will demonstrate understanding of design of storage vessel
- Students will demonstrate general understanding of fabrication techniques and equipment testing as a designer.

Module	Contents	Contact Hours
1	Introduction to Chemical process equipment design. Nature of process equipment, General design procedure. Basic consideration in process equipment design, Standards, codes & their significance, equipment classification & selection. Fundamentals of various stresses due to compression, tension, bending, torsion& thermal stresses. Fundamental of bending moment and shear stress. Concept of moment of inertia. Calculating moment of inertia for I, T, circle and solid bar. Calculation of bending moment of cantilever and simply supported beam and uniform distributed load. Principal stress and theories of failure. Concept of hook's law, material behavior and poison's ratio, material of construction for chemical process equipment, Design pressure, Design temperature, design stress & design loads, Significance of factor of safety and economic considerations.	6
2	Design of Unfired Pressure Vessels Type of pressure vessels, code & standard for pressure vessels (IS: 2825:1969). Material of Construction, Selection of corrosion Allowance & weld joint efficiency. Thin cylinder theory for internal pressure. PART A: Pressure Vessel Subjected to Internal Pressure. Complete design of cylindrical pressure vessel as per IS: 2825: 1969. Study, selection & design of various heads such	10

	as flat, hemispherical, torispherical, elliptical & conical openings/nozzles & manholes etc. Flanged joints. Gasket: Types, selection & design. Bolt design & selection. Flange dimensions & optimization for bolt spacing. PART B: Pressure Vessel Subjected to External Pressure. Design of shell, heads nozzles, flanged joints & stiffening rings as per IS 2825: 1969 equation. Appendix F by use of charts. Analytical approach by elastic bucking & plastic deformation.	
3	Study of Various types of storage vessels and application. Atmospheric vessels, vessels for storing volatile & non-volatile liquids. Storage of gases, Losses in storage vessel. Various types of roofs used for storage vessels. Manholes, Nozzles and mounting. Design of cylindrical storage vessels as per IS: 803 should include base plates, shell plates ,roof plate and wind girders.	**5**
4	Study of various types of agitators & their application. Baffling. Power requirement of agitators & their applications, system which includes design of shaft based on equivalent bending moment and critical speed. Design of blades & Blade assembly, key & key ways. Study of seals. Design of stuffing box and gland.	**6**
5	Introduction, Classification of reaction vessels, Material of Construction, Heating system. Material of Construction, Heating system. Design of vessel. Study & design of various types of jackets like plain and half coil.	**4**
6	Introduction & classification of support. Design of skirt Support considering stresses due to dead weight, wind load, Seismic load & period of vibration. Design of base plates, skirt bearing plate, anchor bolt and bolting chair. Introduction to bracket support. Design of saddle supports.	**5**
7	Fundamentals of pipeline design. Optimum diameter of pipelines. Supporting structure for pipelines. Pipeline design for liquids and gases, steam and thermic fluids. Material of construction for pipelines.	**4**
8	Equipment fabrication and inspection Metal forming techniques (bending, Rolling, Forming). Metal Joining techniques – welding (Gas of Arc & Electric) for various types such as Butt, Lap, fillet, corner. Inspection of vessel by radiography.	**4**

Assessment

Internal:

- Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.

- Total 4 questions need to be solved.
- Question No.1 will be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each Module.

Text Books

1. Process Equipment Design, 4th Edition,V.V.Mahajani, Umarji, Macmillan Publishers
2. Process Design of Equipments, 4th Edition, S.D. Dawande, Central Techno publications
3. Introduction to Chemical Equipment Design, B.C. Bhattacharya, CBS publications
4. Design of machine elements, V.B. Bhandari, McGraw Hill publications
5. Machine Drawing, N.D. Bhatt and V.M. Panchal, Charotar publication
6. Process Equipment Design and Drawing by Kiran Ghadyalji, Nandu publication. Kiran Ghadyalji, Nandu publication

Reference books

1. RC's Chemical Engineering, Fourth edition, R. K. Sinnott, Pergamon Press publications
2. Chemical Engineering Design, Fifth edition, Ray Sinnott and Cavin Towler, Elseveir, Butterworth-Heinemann publications
3. Equipment design handbook for refineries and chemical plants, volume 1 & 2,Evans F.L, Gulf publications
4. Process equipment design-vessel design, Brownell L.E., Edwin Young, John Wiley publications

Course Code	Course/Subject Name	Credits
CHC406	Chemical Engineering Economics	4

Prerequisites:

- The concepts of basic Mathematics as well as a few concepts of higher mathematics.
- The concepts of basic chemistry, basic civil engineering, basic mechanical engineering, etc. in order to understand the concepts like, corrosion, corrosion allowance, construction costs, equipment costs, etc.

Course Objectives:

- To understand various economical terms and economics related activities which can be helpful to them during economical evaluation of any chemical engineering related problem.
- To learn about various basic economic aspects like need, demand, supply, price, cost and market.
- To make familiar to calculate the interest amount on investments as well as loans by different methods
- To understand the concepts of present and future worth of property.
- To understand existing rules and regulations as well as types related to taxes and insurance.
- To understand the methodology of cost estimation including fixed and variable costs by considering the concept of cost indices.
- To have the knowledge about evaluation of depreciation cost as well as salvage value, scrap value, book value of property
- To understand the concept of profitability evaluation of project and select best process alternative based on its economic evaluation.
- To understand the concept of balance sheet, profit and loss accounting and income statement

Course Outcomes:

- Students should will be expose to market And demand driven economics in chemical industry.
- Get an idea on the growth and development of futuristic planning.
- Students will be able to calculate the profitability, rate of return on investments and cost estimation.
- After acquiring the knowledge in this subject, students become familiar with various aspects related to economics and can apply them for economic evaluation of chemical process and decide its economical feasibility.
- The knowledge in this subject will make the students well aware about economic evaluation of dissertation work that they will undertake in final year of their curriculum.
- Students will learn to prepare realistic cost estimation to prepare plan and offer.

Module	Contents	Contact hours
1	**Introduction to Basic Principles of Economics:** • Economics-various definitions • Concept of Need – hierarchy • Market - Concept of Price determination under particular market conditions – perfect competition market & monopoly market, causes • Price Discrimination-concept, types • Concept of Cost-total cost, fixed and variable cost, direct and indirect cost • Cost index – definition, types	**02**
2	**Demand and Supply analysis:** • Law of demand-assumptions and exceptions • Demand schedule and demand curve • Determinants of demand • Changes and variations in demand • Demand elasticity-definition, types, methods of measurement of elasticity, Income elasticity of demand, types. • Law of Supply-assumptions and exceptions • Supply schedule and supply curve • Determinants of supply, changes and variations in supply • Supply elasticity-definition, types, determinants • Methods of measurement of supply	**02**
3	• **Economics of production and Growth:** • Production function-types of production economies • Diseconomies of scale • Features of growth • Growth v/s Development • Determinants of growth (economic and non-economic) • Stages of growth & futuristic planning • Growth strategy- steady state and big – push growth strategy; balanced and unbalanced growth	**02**
4	• **Cost Accounting:** • Outline of Accounting Procedure • Basic Relationship in Accounting • Balance Sheet- types of Asset; Current and Cash Ratio • Income Statement; Debits and Credits; General format of Journal and Ledger • Methods of cost accounting 03 • Accumulation, inventory and cost-of-sales account • Material cost – Different Methods: current average, fifo, lifo	**03**
5	• **Interests and Investment Costs:** • Importance of time value of money- Interest and Interest	**06**

	rate; • Types of Interest – Simple interest (ordinary and exact), Compound interest, Nominal and Effective interest rates, Continuous interest • Present worth and Discount • Annuities, Perpetuities and Capitalized costs • Cash Flow in Chemical Project	
6	• **Taxes and Insurance:** • Concept of taxes and insurance • Types of Taxes - property tax, excise tax, income tax Capital gain tax, surtax, normal tax • Insurance types, Legal responsibilities, Self insurance • Effect of taxes and depreciation on annual income • Depreciation , types of depreciation, Methods of depreciation & Numericals	**03**
7	• **Cost Estimation:** • Cash flow to Industrial operation – Tree diagram; Cumulative Cash position • Factors affecting cost estimation; • Total, fixed, working capital investment • Breakdown of Fixed capital investment- Direct costs; Indirect costs; • Types of Capital Cost Estimates • Grass Root plant; Battery limit; • Estimation of equipment cost by scaling; Components of costs in FCI; • Methods of Cost Estimation • Estimation of Total Product Cost; • Break even Analysis • Cost estimation to prepare offer.	**10**
8	• **Profitability, Alternative Investments & Replacements:** • Introduction; Profitability Standards; • Mathematical methods for profitability evaluation- Rate of Return on investment method , Discounted cash flow method , Net present worth method, Capitalized Cost method , Pay out period method; Advantages & Disadvantages of Different Profitability Analysis Methods and their comparison • Alternative investments • Replacement analysis • Practical factors affecting investment and replacement decisions	**11**

Term work

Term work shall consist of minimum **eight** tutorials from entire syllabus which are to be given at regular intervals Batch wise.

Tutorials: 20 marks
Attendance: 05 marks
Total: 25 marks

Assessment

Internal:

- Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions need to be solved.
- Question No.1 will be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each Module.

References

1. Peters, M. S. and Timmerhaus, K. D. , "Plant design and economics for chemical engineers", latest edition, Mcgraw Hill, New York
2. Pravin Kumar "Fundamentals of Engineering Economics" Wiley India.
3. Kharbanda, O. P. and Stallworthy, E. A. "Capital cost estimating for process industries", Butterworths, Londen
4. K. K Dewett and Adarshchand, " Modern Economic Theory", latest edition, S Chand and Company
5. O. P Khanna, "Industrial Engineering and Management" Dhanpat Rai Publications (P) Ltd.
6. AtulSathe, Shubhada Kanchan, "Chemical Engineering Economics", Vipul Prakashan, Mumbai
7. Indrajit N. Yadav, "Chemical Engineering Economics" Sai- publication, Pune 2nd edition, 2017

Course Code	Course/Subject Name	Credits
CHL401	Engineering Chemistry Lab– II	1.5

List of Experiments Suggested:

- **Organic spotting-** Identification of organic compounds [**at least 05]**.
- **Potentiometric Titrations**
- Titration of strong acid and strong base potentiometrically.
- Determination of solubility and solubility product of AgCl.
- **pH-metry.**
- Determination of dissociation constant of dibasic organic acids such as malonic acid, succinic acid.
- **Conductometric Titrations.**
- Titration of strong acid with strong base.
- Weak acid against strong base.
- Titration of mixture of weak acid and strong acid against strong base.
- **Flame photometry.**
- Determination of Na / K / Ca present in the given sample.
- **Chromatography.**
- Estimation of Sodium by Ion Exchange chromatography.
- Paper Chromatography and TLC [Demonstration of techniques].
- **Organic Estimations.**
- Estimation of Glucose Iodometrically.
- Estimation of Ester by Hydrolysis.
- Volume strength and amount of H_2O_2.
- **Organic preperations**
- Nitration of benzene
- Nitration of Salicylic Acid
- Sulphonation of Benzene

Students have to perform any 10 practicals from the above during the semester.

Practical Examination

- Duration for practical examination would be the same as assigned to the respective lab per week.
- A student becomes eligible for practical examination after completing a minimum of eight experiments out of ten experiments.

Course Code	Course/Subject Name	Credits
CHL402	Chemical Engineering Lab III (SFMO)	1.5

List of Experiments Suggested

Minimum Ten Experiments must be performed

1. Sieve Analysis
2. Effectiveness Of Screen
3. Size reduction by Jaw Crusher
4. Size reduction by Hammer Mill
5. Size reduction by Ball Mill
6. Batch Sedimentation
7. Flow through Packed Bed
8. Flow through Fluidized Bed
9. Filtration
10. Mixing
11. Cyclone Separator
12. Roll Crusher
13. Elutriation
14. Froth Floatation

Term work

Term work shall be evaluated based on performance in practical.

Practical Journal:	20 marks
Attendance:	05 marks
Total:	**25 marks**

Practical Examination

- Duration for practical examination would be the same as assigned to the respective lab per week.
- A student becomes eligible for practical examination after completing a minimum of eight experiments out of ten experiments.

Course Code	Course/Subject Name	Credits
CHL403	MED Lab	1

Drawing sheets based on (Minimum of 8 sheets):

1. Design of Unfired Pressure Vessel with internal pressure.
2. Design of Unfired Pressure Vessel with external pressure.
3. Storage Vessel.
4. Agitator.
5. Reaction Vessel.
6. Vessel Supports.

Term work

Term work shall be evaluated based on performance in Lab.

Drawing Sheets: 20 marks

Attendance: 05 marks

Total: 25 marks

University of Mumbai
Program Structure for B.E. Chemical Engineering (Revised 2016)
T.E. Semester V (w.e.f 2018-2019)

Course code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
CHC501	Computer programming and Numerical Methods	4	-	-	4	-	-	4
CHC502	Mass transfer Operations-I (MTO- I)	4	-	-	4	-	-	4
CHC503	Heat transfer Operations (HTO)	4	-	-	4	-	-	4
CHC504	Chemical Reaction Engineering-I (CRE I)	4	-	-	4	-	-	4
CHC505	Business Communication & Ethics	2	-	2	-	-	2	2
CHDE501X	Department Elective I	4	-	-	4	-	-	4
CHL501	Computer programming and Numerical Methods lab	-	2	-	-	1	-	1
CHL502	Chemical Engineering Lab IV (MTO-I)	-	3	-	-	1.5	-	1.5
CHL503	Chemical Engineering Lab V (HTO)	-	3	-	-	1.5	-	1.5
CHL504	Chemical Engineering Lab VI (CRE-I)	-	2	-	-	1	-	1
	Total	20	14	-	20	5	2	27

Course code	Course Name	Examination Scheme								
		Theory					Term Work	Pract /Oral	Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in hrs)				
		Test 1	Test 2	Avg						
CHC501	Computer programming and Numerical Methods	20	20	20	80	3	-	-	-	100
CHC502	Mass transfer Operations-I (MTO- I)	20	20	20	80	3		-	-	100
CHC503	Heat transfer Operations (HTO)	20	20	20	80	3		-	-	100
CHC504	Chemical Reaction Engineering-I (CRE I)	20	20	20	80	3		-	-	100
CHC505	Business Communication & Ethics	-	-	-	-	-	50	-	-	50
CHDE501X	Department Elective I	20	20	20	80	3		-	-	100
CHL501	Computer programming and Numerical Methods Lab	-	-	-	-	2	25	25	-	50
CHL502	Chemical Engineering Lab IV (MTO-I)	-	-	-	-	3	25	25	-	50
CHL503	Chemical Engineering Lab V (HTO)	-	-	-	-	3	25	25	-	50
CHL504	Chemical Engineering Lab VI (CRE-I)	-	-	-	-	2	25	25	-	50
	Total			100	400	-	150	100	-	750

Department Elective I (Sem V)		
Engineering Stream (Elective Code)	Advanced Sciences Stream (Elective code)	Technology Stream (Elective Code)
1. Piping Engineering (CHDE5011) 2. Instrumentation (CHDE5014)	1.Colloids and Interfaces (CHDE5012)	1. Advanced Material Sciences (CHDE5013)

Course Code	Course/ Subject Name	Credits
CHC501	Computer Programming & Numerical Methods	4

Prerequisites:

- Differential Calculus.
- Integral Calculus.
- Differential Equations.
- Linear Algebraic Equations.

Course Objectives:

- To familiarize students with the use of software in solving numerical problems.
- To develop analytical thinking in designing programs.
- To learn to interpret results of computer programs and debug the same.
- To learn to present results in graphical form.

Course Outcomes:

- The students will be able to solve linear algebraic equations.
- The students will be able to solve non-linear algebraic equations.
- The students will be able to solve differential equations.
- The students will be able to solve partial differential equations.

Module	Contents	Contact Hours
1	• Fundamentals of Python • Variables • Expressions and Arithmetic • Conditional Execution • Functions • Lists and Objects	8
2	• Solution of algebraic and transcendental equations. • Bisection Method • RegulaFalsi Method. • Successive substitution. • Secant Method. • Newtons Method for one and two simultaneous equations • Applications in Chemical Engineering	8
3	• Systems of linear equations. • Gaussian Elimination • Gauss Jordan Method • LU Decomposition • Jacobi Iteration Method • Gauss-Seidel Method. • Applications in Chemical Engineering	8

4	• Ordinary differential equations. • Euler's explicit and implicit methods. • Runge-Kutta second and fourth order methods. • Adams-Bashforth formulas. Predictor and Corrector Formulas • Gear's Method • Applications in Chemical Engineering	**10**
5	• Difference Equations • Linear and Non-linear equations • Applications to Absorption, Adsorption , Extraction etc.	**6**
6	• Partial differential equations. • One-dimensional diffusion equation: Transient and Steady-state problems using explicit and implicit methods. • Two-dimensional diffusion: steady-state problems.	**8**

Assessment
Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

Text Books

1. Numerical Methods for Engineers. By Santosh K. Gupta New Age Publishers, Second Edition, 2010
2. Introduction to Chemical Engineering Computing by Bruce A. Finlayson Wiley-International, 2005.
3. Numerical Methods by Chapra and Canale, 4^{th} Ed.

References

1. Learning Python
   Mark Lutz and David Ascher
2. Numerical Methods
   John Mathews

Course Code	Course/ Subject Name	Credits
CHC502	Mass Transfer Operation I	4

Prerequisites:

- Knowledge of chemistry, physics, physical chemistry, mathematics, process calculations and unit operations.

Course Objectives:

- To give insight of mass transfer basic principle and mass transfer mechanisms.

Course Outcomes:

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

- Demonstrate the knowledge of mass transfer by applying principles of diffusion, mass transfer coefficients, and interphase mass transfer.
- Understand the concept and operation of various types of gas-liquid contacts equipments.
- Determine NTU, HTU, HETP and height of packed bed used for Absorption and Humidification operations.
- Find time required for drying and design of drying equipments.

Module	Contents	Contact Hours
1	**Molecular Diffusion in Gases and Liquid:** Basics of Molecular Diffusion, Fick's First Law of Molecular Diffusion, Various fluxes and relations between them, Molecular Diffusion in binary gas mixtures- Steady state diffusion of one component innon-diffusing second component, Equimolal counter diffusion of two components. Molecular Diffusion in binary liquid solutions- Steady state diffusion of one component in non-diffusing second component, Steady State Equimolal counter diffusion of two components. Diffusivity of gases. Theoretical and experimental determination of diffusivities, Diffusivities of liquids - Theoretical Determination. Diffusion in Solids: Ficks law of diffusion in solids, Types of Solid Diffusion, Diffusion through Polymers, Diffusion through Crystalline Solids, Diffusion in Porous Solids	10
2	**Mass Transfer Coefficients:** Definition of Mass Transfer Coefficient, F-Type and K-Type Mass Transfer Coefficients and relations between them, Mass Transfer Coefficients in Laminar and Turbulent Flow. Heat, Mass and Momentum Transfer Analogies and dimensionless numbers, Interphase Mass Transfer- Individual and Overall Mass Transfer Coefficients and relation between them. Methods of contacting two insoluble phases- Continuous Contact, Stage-wise Contact. Cocurrent, counter current and cross current operations, Equillibrium stage definition and concepts, equilibrium stage	12

	operations: material balance, concepts of operating line and equilibrium line, theoretical stage, point and stage efficiency, overall efficiency. Continuous contacting, concepts of HTU,NTU,HETP etc.	
3	**Equipments for Gas-Liquid Contacting:** Classification of equipments for gas-liquid contacting • Gas dispersed and liquid continuous phase-Sparged Vessels (Bubble Columns), Mechanically Agitated Vessels, Tray Towers. • Liquid dispersed phase and gas continuous phase -Venturi Scrubbers, Wetted Wall Towers, Spray Towers and Spray Chambers, Packed Towers. Comparison of Packed Towers with Tray Towers.	06
4	**Gas Absorption:** Solubility of gases in liquids, Effect of temperature and pressure on solubility, Ideal and Non-ideal solutions, Choice of solvent for gas absorption, Single component gas absorption- Cross Current, Co-current, Countercurrent, Multistage Counter current Operation. Absorption with Chemical Reactions.	07
5	**Drying:** Introduction to drying, Equilibrium, Different types of moisture contents, Rate of Drying and drying curve, Batch Drying and calculation of time of drying, Continuous drying. Equipments for drying.	06
6	**Humidification and Dehumidification:** Introduction, Vapor Pressure Curve, Properties of Vapor-Gas mixtures [Understanding various terms], Theory of wet bulb temperature, Adiabatic Saturation Curves, Humidity Charts, Adiabatic operation : (Air water systems) water coolers, cooling towers	07

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

Text Book

1. Treybal R.E. , Mass transfer operation, 3 Ed., McGraw Hill New York, 1980.
2. McCabe W.L. and Smith J.C., Unit operation in chemical engineering, 5 Ed., McGraw Hill, NewYork,1993.

3. Geankoplis C.J., Transport processes and unit operations, Prentice Hall, New Delhi 1997.

References

1. Coulson J.M. Richardson J.F., Backhurst J.R. and Harker J.H., Coulson and Richardson chemical Engineering, vol 1 & 2, Butterworth Heinman, New Delhi, 2000.
2. Dutta B.K., Mass Transfer and separation processes, Eastern economy edition, PHI learning private ltd, New Delhi, 2009.

CHC 503	Heat Transfer Operations	4

Prerequisites:

- Units and Dimensions, Fluid Flow Principles, Laws of Thermodynamics, Solution Technique of ODEs and PDEs.

Course Objectives:

- Students should be able to calculate heat transfer rates by various modes of heat transfer, for various geometry of equipment and should get introduced to Unsteady Heat Transfer.
- Students should be able to design Double Pipe Heat Exchanger and also be able to do preliminary design of Shell and Tube Heat Exchanger. Should be familiar with Extended Surfaces, Evaporators, and Agitated Vessels etc.

Course Outcomes:

Upon Completion of this course students would be able to

- Analyze Steady and Unsteady State Conduction systems.
- Analyze Convective Heat transfer Systems.
- Analyze Radiative Heat Transfer Systems.
- Analyze Extended Surfaces, Evaporators and Agitated Vessels.
- Basic design of DPHE and STHE.

Module	Contents	Contact Hours
1	**Introduction to Heat Transfer Operations and Heat Transfer by Conduction** Fundamentals of heat transfer, basic modes of heat transfer. Concept of driving force and heat transfer coefficients, rate expressions for three modes i. e. conduction, convection, radiation. **Steady State Conduction:-**Fourier's Law, thermal conductivity, conduction through a flat slab, composite slab, conduction through a cylinder wall, composite cylinder, Conduction through hollow sphere, composite sphere. Thermal resistance network. Critical radius of insulation. **Unsteady state conduction: -**Lumped Parameter Analysis - systems with negligible internal resistance (Heat transfer by convection and radiation). Biot number, Fourier number, Heating a body under conditions of negligible surface resistance, heating a body with finite surface and internal resistance.	10
2	**Heat Transfer by Convection** **Forced and Natural Convection:-**Fundamental considerations in convective heat transfer, significant parameters in convective heat transfer such as momentum diffusivity, thermal diffusivity, Prandtl number, Nusselt number, dimensional analysis of convective heat transfer-Natural and Forced convection, convective heat transfer correlations for internal and external flows, equivalent diameter	8

	for heat transfer, estimation of wall temperature, Reynold's Analogy, Prandtl' Analogy, Coulburn's Analogy. Correlations for heat transfer by natural convection from hot surfaces of different geometries and inclination.	
3	**Boiling and Condensation: -**Introduction, types of condensation, Nusselt's theory of condensation, correlations for vertical and horizontal tube, plate, for stack of tubes etc. Heat transfer to boiling liquids, regimes of pool boiling of saturated liquid, correlations for estimating the boiling heat transfer coefficients.	**6**
4	**Heat Transfer by Radiation** Emissivity, absorptivity, black body, grey body, opaque body, Stephan Boltzmann law, Kirchhoff's law. Calculations for rate of heat transfer by radiation (Steady State) for various cases. Construction and working of various types of Box and Cylindrical types of Furnaces.	**8**
5	**Heat Exchangers** **Extended Surfaces:** -longitudinal, transverse and radial fins, calculations with different boundary conditions, efficiency and effectiveness of fin, calculation of rate of heat transfer.	**5**
6	**DPHE and STHE**: -Overall Heat Transfer Coefficients (U), Resistance form of U, LMTD, and Wilson plot; fouling factors. Process design of Double Pipe Heat Exchanger. Preliminary process design and Kern's method of Design for Shell and Tube Heat Exchanger. Effectiveness-NTU method.	**5**
7	**Heat Transfer to Vessels: -** Jacketed Vessels, Internal Coils and Agitated Vessels- heat transfer correlations and calculations. **Evaporators:**-Types of Tubular Evaporators, Performance Capacity and Economy, Boiling Point Elevation, Mass and Enthalpy Balances For Single Effect Evaporators, Multieffect Evaporators:- Methods of Feeding; Mass and Energy balance.	**6**

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

Text Books

1. B. K. Datta, Heat Transfer: Principles and applications, PHI learning.
2. Yunus A. Cengel and A. J. Ghajar, Heat and Mass Transfer.
3. Welty, Wicks, Wilson and Rorrer, Fundamentals of Momentum, Heat and Mass Transfer,5th Edition, Wiley India.
4. D. Q. Kern, Process Heat Transfer, McGraw hill, 1997.

References

1. MaCabe W. L., Smith J. C., Harriot P., Unit Operations of Chemical Engineering, 5th edition, McGraw Hill,1993.
2. Holman J. P., Heat Transfer, 9th Edition, McGraw Hill, 2008.
3. R. K. Sinnot, Coulson & Richardsons Chemical Engineering Design, Vol 1 & 6, Elsevier Science & Technology Books.

Course Code	Course Name	Credits
CHC504	Chemical Reaction Engineering-I	4

Prerequisites:

- Students should know basic chemistry pertaining to chemical reactions, chemical formula etc. They are required to be aware of chemical process and unit operations used for the manufacturing of chemical products. Simple to complex numerical methods of solving one and two dimensional Mathematical equations.

Course Objectives:

- To understand the different types of reactions and formulation of their reaction rate.
- Development of Kinetic model for homogeneous reactions giving emphasis on various types of reactions.
- Development of design strategy for homogeneous reactions considering different types of reactors.
- To understand the effect of temperature on reactor performance for adiabatic and non adiabatic operation

Course Outcomes:

- Students will be able to identify and analyze different types of homogeneous reactions.
- Students will be able to apply the knowledge they have gained to develop kinetic models for different types of Homogeneous reactions
- Students will be able to find the model equation and use this model to design the reactors used for Homogeneous reactions.
- Students will be able to understand the effect of temperature on reactor performance for adiabatic and non adiabatic operation and develop kinetic model to design the reactors for adiabatic and non-isothermal operations.

Module	Topics	Contact Hours
1	Introduction to Reaction Engineering: Classification of reactions, definitions of reactions rate, variables affecting reaction rate, speed of chemical reactions. Kinetics of homogenous reactions: Simple reactor types, the rate equation, concentration dependent term of rate equation. Molecularity and order of reaction. Rate constant k, representation of an elementary and nonelementary reaction. Kinetic models for non elementary reactions. Testing kinetic models. Temperature dependant term of rate equations from Arrhenius theory and comparison with collision and transition state theory. Activation energy and temperature dependency. Predictability of reaction rate from theory.	10
2	Methods of analysis of experimental data	12

	For constant volume and Variable Volume Batch Reactor- Integral Method of analysis of experimental data. Differential Method of analysis of experimental data. Concept of Half Life/Fractional Life. Overall order of irreversible reaction. Analysis of total pressure data. Reversible and irreversible reaction in parallel and in series. Homogeneous catalyzed reactions, Auto catalytic reactions, Shifting Order reactions.	
3	Design of Reactors: Ideal batch reactor and concept of batch time. Flow reactor and concept of space time / space velocity and holding time/residence time. Ideal Mixed Flow reactor(MFR) and Plug Flow Reactor (PFR). Design for single reactions: Single reactor performance of reversible and irreversible first order, pseudo first order, second order reactions for MFR, PFR. Graphical and analytical techniques. Combination of reactors: PFR in series/ parallel, unequal size MFR in series, performance of the above for the first order and second order reactions. Semi batch reactor and Recycle Reactor. Design for complex reactions: Irreversible and Reversible reactions in series and parallel with same or different order in various combinations.	**12**
4	Heat and pressure effects: Single Reactions: Calculations of heats of reaction and equilibrium constants from thermodynamics, equilibrium conversion, general graphical design procedure. Optimum temperature progression, Energy balances equations in adiabatic and non-adiabatic case. Exothermic reaction in mixed flow, Rules for choice of reactors and optimum operation of reactors.	**10**

Assessment

Internal:

- Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions need to be solved.
- Question No.1 will be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each Module.

References

1. LevenspielO., Chemical Reaction Engineering, John Wiley&Sons,3ed.,1999.
2. Smith J.M., Chemical Reaction Engineering, 3ed.,TataMcGrawHill,1980.
3. Fogler, H.S. Elements of Chemical Reaction Engineering, 4ed.,PHI, 2008

4. Hill C.G., Chemical Reaction Engineering.
5. Walas, Reaction Kinetics for Chemical Engineers, McGraw Hill, 1959.

Course Code	Course/Subject Name	Credits

CHC505	Business Communication and Ethics	2

Prerequisites:

- Students should have basic knowledge of English and general engineering.

Course Objectives

- To inculcate in students professional and ethical attitude, effective communication skills, teamwork, multidisciplinary approach, and an ability to understand Engineers' social responsibilities
- To provide students with an academic environment where they will be aware of the excellence, leadership and lifelong learning needed for a successful professional career
- To inculcate professional ethics and codes of professional practice
- To prepare students for successful careers that meets the global Industrial and Corporate requirement

Course Outcomes:

Students will be able to

- Communicate effectively in both oral and written form and equip to demonstrate knowledge of professional and ethical responsibilities.
- participate and succeed in campus placements and competitive examinations like GATE, TOFEL
- Possess entrepreneurial approach and ability for life-long learning
- Have education necessary for understanding the impact of Engineering solutions on Society, and demonstrate awareness of contemporary issues Detailed Syllabus.
- Design a technical document using precise language, suitable vocabulary and apt style.
- Develop the life skills/ interpersonal skills to progress professionally by building stronger relationships.
- Demonstrate awareness of contemporary issues knowledge of professional and ethical responsibilities.
- Apply the traits of a suitable candidate for a job/higher education, upon being trained in the techniques of holding a group discussion, facing interviews and writing resume/SOP.
- Deliver formal presentations effectively implementing the verbal and non-verbal skills.

Module	Contents	Contact Hours
1	**Report Writing** Objectives of Report Writing Language and Style in a report Types : Informative and Interpretative (Analytical, Survey and Feasibility) and Formats of reports (Memo, Letter, Short and Long Report)	05

2	**Technical Writing** Technical PaperWriting (IEEE Format) Proposal Writing	**03**
3	**Introduction to Interpersonal Skills** Emotional Intelligence Leadership and Motivation Team Building Assertiveness Conflict Resolution and Negotiation Skills Time Management Decision Making	**09**
4	**Meetings and Documentation** Strategies for conducting effective meetings Notice, Agenda and Minutes of a meeting Business meeting etiquettes	**02**
5	**Introduction to Corporate Ethics** Professional and work ethics (responsible use of social media - Facebook, WA, Twitter etc.) Introduction to Intellectual Property Rights Ethical codes of conduct in business and corporate activities(Personal ethics, conflicting values, choosing a moral response and making ethical decisions)	**02**
6	**Employment Skills** Group Discussion Resume Writing Interview Skills Presentation Skills Statement of Purpose	**07**

Term Work

The term work shall be comprised of the neatly written Journal comprising below mentioned assignments.

Assignment 1- Interpersonal Skills (Group activity Role play)

Assignment 2- Interpersonal Skills (Documentation in the form of soft copy or hard copy)

Assignment 3- Cover Letter Resume

Assignment 4- Report Writing

Assignment 5- Technical Proposal (document of the proposal)

Assignment 6- Technical Paper Writing

Assignment7 -Meetings Documentation (Notice, Agenda, Minutes of Mock Meetings)

Assignment 6- Corporate Ethics (Case study, Role play)

Assignment 8- Printout of the PowerPoint presentation

Term-work Marks: 50 Marks

The marks of term-work shall be judiciously awarded depending upon the quality of the term work including that of the report on experiments assignments. The final certification acceptance of Term work warrants the satisfactory the appropriate completion of the assignments, presentation, book report, group discussion and internal oral the minimum passing marks to be obtained by the students. The following weightage of marks shall be given for different components of the term work.

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- Attendance : 05 Marks
- Assignments : 20 Marks
- Internal Oral: 25 Marks. Comprising of:
  Presentation of the Project Report: 10 Marks
  Book Report (one copy per group): 05 Marks
  Group discussion: 10 Marks

References

1. Fred Luthans, *"Organizational Behavior",* McGraw Hill, edition
2. Lesiker and Petit, *"Report Writing for Business",* McGraw Hill, edition
3. Huckin and Olsen, *"Technical Writing and Professional Communication",* McGraw Hill
4. Wallace and Masters, *"Personal Development for Life and Work",* Thomson Learning, 12th edition
5. Heta Murphy, *"Effective Business Communication",* McGraw Hill, edition
6. Sharma R.C. and Krishna Mohan, *"Business Correspondence and Report Writing",*Tata McGraw-Hill Education
7. Ghosh,B. N.,*"Managing Soft Skills for Personality Development",* Tata McGraw Hill. Lehman,
8. Dufrene, Sinha, "BCOM", Cengage Learning, 2nd edition
9. Bell, Smith, "Management Communication" Wiley India Edition,3rd edition.
10. Dr. Alex, K.,"Soft Skills", S Chand and Company
11. Subramaniam,R., "Professional Ethics" Oxford University Press.
12. Robbins Stephens P., "Organizational Behavior", Pearson Education
13. https://grad.ucla.edu/asis/agep/advsopstem.pdf

Course Code	Course Name	Credits
CHDE5011	Department Elective I-Piping Engineering	4.0

Prerequisites:

- Basics of various Chemical Process.

Course Objectives:

- To introduce students to the crucial role of piping engineer in turn key projects
- To make students understand the approval drawings and execute the work adhering to procedures and standards
- To understand the layout and manage the work with adequate safety and reliability

Course Outcomes:

By the end of the course students should be able

- understand the piping fundamentals, codes and standards
- understand pipe fittings, selections, drawings and dimensioning
- understand Pipe Material specifications
- understand pressure design of pipe systems

Module	Content	Contact Hours
1	**Introduction to Piping** 1.1 Introduction to piping 1.2 Piping 1.3 Pipe classification 1.4 General definitions 1.5 Length, area, surface & volume acronyms and abbreviation. Color coding of piping as per types fluid passing through piping (IS 2379:1990) 1.6 Concept of high point vent and low point drain. 1.7 Duties & responsibilities of piping field engineer	06
2	**Materials of Piping** 2.1Selection of material for piping, 2.2 Desirable properties of piping materials 2.3Iron Carbide Diagram 2.4 Materials for various temperature and pressure conditions, 2.5 Materials for corrosion resistance. 2.6 Pipe coating and insulation	08

3	**Piping Components** 3.1 Pipe & tube product 3.2 Pipe sizes & materials, Mitre Joint. 3.3 Pipes joints & bending (Cold & Hot Bending), Welding defect (NDT) 3.4 Valves: Types of valves and selection 3.5 Strainers & traps 3.6 Expansion joints 3.7 Threaded joints 3.8 Types of piping support	**10**
4	**Piping Codes and Standards** 4.1Introduction of ASME codes 4.2 Code cases interpretation 4.3 Introduction of ASME B 31.1, 31.2, 31.3 4.4 Introduction of ANSI 4.5 Introduction of ASTM 4.6 Introduction of API 4.7 Introduction of AWS	**06**
5	**Piping System Design** 5.1 Flows through Pipes. 5.2 Loss of energy / head in pipes Loss of head due to friction. 5.3Minor energy losses, 5.4Water hammer in pipes Unit. 5.5Design Principles and Line Sizing 5.6. Mitre Joint Calculation. 5.7 Various stresses in piping 5.8 Bending stress calculation	**10**
6	**Piping Drawing** 6.1 Piping drawing symbols and abbreviations 6.2 Classification/Types of drawing 6.3 Introduction to simple piping drawings 6.3.1 Plot Plan 6.3.2 G.A.Drawing 6.3.3 Process flow diagram (P.F.D) 6.3.4 Piping and instrumentation diagram (P&ID) / Engineering flow diagram.	**08**

Assessment

Internal

- Assessment consists of average of two tests which should be conducted at proper interval

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions to be solved
- Question no.1 will be compulsory and based on entire syllabus where in sub questions can be asked.

- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each module.

References

1. Handbook of piping design- S.K. Sahu Elsevier Publishers
2. Piping/mechanical hand book- Mohinder L. Nayyar. Peter H. O. Fischer, Manager, Pipeline Operations, Bechtel
3. Piping Design Handbook by John J. Mcketta, by Marcel Dekker, Inc, New York.

Recommended:

i. Arrange visit to a process industry and discuss different features of process piping in use.

ii. Arrange expert lecture by some experienced process piping engineer.

Course Code	Course/Subject Name	Credits
CHDE5012	Department Elective I- Colloids and Interfaces	4

Prerequisites:

- Basic knowledge of Chemical Engineering, basic concept of electron, atom, ions, molecules & molecular rearrangements, Basic knowledge of fluid flow, thermodynamics and heat transfer, Various types of material and metals, Basic knowledge of particle size measurement.

Course Objectives:

- To understand the fundamental knowledge of the Colloids, interfaces and explain their applications
- To understanding of basic nomenclature, concepts and tools of colloid and interface science and engineering; multi-phase nano-systems; mechanics and thermodynamics on small scales.
- To impart the interdisciplinary subject in which chemical engineers, chemists and biotechnologists are involved
- Understand the engineering aspects of fluid-fluid and fluid-solid interfaces and Surface energy.

Course Outcomes:

Upon completion of the course, the student should be able to

- Describe the colloidal state, including colloids and their preparation and properties as well as fundamental concepts in colloid and interface engineering.
- Discuss factors that affect colloidal systems and important factors on solid/liquid interactions as well as apply knowledge in colloid and surface science and analyze and solve problems calculations concerning the practical problems
- Explain experimental techniques used to determine colloidal properties; interfacial phenomena
- To facilitate skills transfer from another relevant area of engineering or science and technology to the study of Interfacial engineering.
- Students should understand, know how to interpret and apply the following topics in colloid and interface engineering to wettability, solubility, surface tension, diffusion, sedimentation, colloid stability and aggregation, adsorption, electrical interfacial layer and surface equilibrium and experimental methods for surface characterization
- Gain knowledge of fabrication methods in nanotechnology and characterization methods in nanotechnology.

Module	Contents	Contact hrs
01	Introduction of Colloids, The colloidal state and classification, Importance of colloids, Properties and application of colloid systems, interaction between particles, colloid stability and aggregation	06
02	Surface tension and interfacial tension surfaces, Experimental	08

	method for measurement of Surface Tension, dynamic surface tension & Contact Angle, Vander Waals forces between colloidal particles	
03	Surfactants: classification, properties, applications Surfactants in solution: micelles, vesicles, Micro emulsions Electrical phenomena at interfaces: Electric double layer, zeta potential, DLVO theory	**08**
04	Surface free energy, films on liquid substrates (mono-molecular films, Langmuir-Blodgett layers), Adsorption-Langmuir and Gibbs adsorption isotherm, Types of Interface (Solid-Gas, Solid-liquid, liquid –gas, liquid-liquid) and its features	**08**
05	Top-down and bottom-up approach for nanostructure Methods: Vacuum Synthesis, Gas Evaporation Tech, Condensed Phase, Synthesis, Sol Gel Processing, Polymer Thin Film	**07**
06	Interaction between Biomolecules & Nanoparticle Surface, Influence of Electrostatic Interactions in the binding of Proteins with Nanoparticles, The Electronic effects of bimolecule - Nanoparticle Interaction, Different Types of Inorganic materials used for the synthesis of Hybrid Nano-bio assemblies, Application.	**07**
07	Particle Size, Surface area, Volume, Equivalent Diameter and Aerodynamic Diameter Measurement Methods – Microscopy, Optical Counter, Electrical Aerosol Analyzer, Bacho Microparticle classifier, Particle Size analyzer Particle mass, Volumetric flow rate and average particle concentration calculation	**08**

Assessment

Internal:

- Assessment consists of an average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions need to be solved.
- Question No.1 will be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules.

Textbook/References Book

1. J. C. Berg, An Introduction to Interfaces and Colloids: The Bridge to Nanoscience, World Scientific, Singapore
2. P. Ghosh, Colloid and Interface Science, PHI Learning, New Delhi
3. R. J. Hunter, Foundations of Colloid Science, Oxford University Press, New York

4. D.J. Shaw, Colloid and Surface Chemistry, 4th Edition, Butterworth-Heinemann, Oxford
5. Myers, D. Surfaces, Interfaces, and Colloids: Principles and Applications. New York
6. Robert J. Stokes, D Fennell Evans, "Fundamentals of Interfacial Engineering", Wiley-VCH
7. P. C. Hiemenz and R. Rajagopalan, Principles of Colloid and Surface Chemistry, Marcel Dekker, New York
8. Louis Theodore, A John, Nanotechnology: Basic Calculations for Engineers and Scientists - Willy & Sons
9. T. Pradeep, Nano-The Essentials, Understanding Nanoscience and Nanotechnology,
10. Kal Ranganathan Sharma, Nanostructuring Operations in NanoScale Science and Engineering, McGraw-Hill

Course Code	Course/ Subject Name	Credits
CHDE5013	Department Elective I- Advanced Material Science	4

Prerequisites

- Mechanical, Electrical, Magnetic and Optical Properties of Materials, Commonly used Materials of Construction and their Selection, Corrosion in Materials.

Course Objectives

- To understand various advanced materials such as conducting polymers, high temperature polymers, stainless steels, composites, ceramics, etc.
- To understand the properties and engineering applications of the above materials.
- To understand the fabrication methods of the above materials.

Course Outcomes

At the end of the course the student will:

- Identify various types of advanced materials such as polymers, ceramics and composites.
- Understand the properties of various advanced polymeric, ceramic and metallic materials and their applications in various fields.
- Have knowledge of different types of composite materials and their properties and applications.
- Understand the fabrication of various composite materials.
- Have knowledge of types of nanotubes and nanosensors and their applications.
- Understand the different thin film coating methods and their applications in various fields.

Module	Contents	Contact Hours
1	**Advanced Metallic Materials:** Stainless Steels: Types, properties of stainless steels, corrosion resistance and selection of stainless steels, failure of stainless steels. High Temperature Alloys: Properties and types. Titanium Alloys and Cobalt-Chromium Alloys: Composition, properties and applications. Nitinol as Shape Memory Alloy and its applications.	08
2	**Advanced Polymeric Materials:** Structure, preparation, and application of various conducting polymers, high temperature polymers and liquid crystal polymers. Biomedical applications of polymers such as hydrogels, polyethylene, polyurethanes, polyamides and silicone rubber.	06
3	**Ceramic Materials:** Properties of ceramic materials, classification of ceramic materials, ceramic crystal structures. Behaviour of ceramic materials: dielectric, semiconductor,	08

	ferroelectric, magnetic, and mechanical behaviour. Preparation and application of ceramic materials: Alumina, Partially Stabilized Zirconia, Sialon, Silicon Nitride, Silicon Carbide. Processing of Ceramics.	
4	**Composite Materials:** Necessity of composite materials, classification of composite materials, types of matrix materials and reinforcements, reinforcement mechanism, choosing material for matrix and reinforcement. **Fiber Reinforced Plastic Processing:** Open Moulding Processes : Filament Winding Process Closed Moulding Processes : Pultrusion and Pulforming, Sheet Moulding Compound Process **Carbon-Carbon Composites :** Fabrication and Properties	**08**
5	**Metal Composites:** Advantage of metal composite over metal, types of reinforcement and matrix fabrication types, various fabrication processes: diffusion bonding process, in-situ process, mechanical behaviour and properties. **Ceramic Composites:** Matrices and reinforcements, mechanical properties, fabrication methods: Slurry infiltration processes, chemical vapour infiltration process.	**08**
6	**Carbon Nanotubes:** Synthesis, properties and applications. **Nanoshells:** Types, properties and applications. **Nanosensors:** Assembly methods, nanosensors based on optical, quantum size, electrochemical and physical properties. **Thin Film Coatings:** Physical and chemical vapour deposition coatings, hard facing, thermal spraying, diffusion process, useful material for appearance, corrosion and wear.	**07**

Assessment

Internal:

- Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions need to be solved.
- Question No. 1 will be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each module.

Text Books and Reference Books

1. B.K. Agrawal, Introduction to Engineering Materials, Tata McGraw Hill Education Pvt. Ltd., 2012.
2. A.K. Bhargava, Engineering Material: Polymers, Ceramics and Composites, PHI Learning Pvt. Ltd., Second Edition 2012.
3. Dr. H.K. Shivanand and B.V. Babu Kiran, Composite Material, Asian Books Private Limited, 2010.
4. T. Pradeep, Nano: The Essentials, Tata McGraw-Hill Education Pvt. Ltd., 2010.
5. William Smith, Structure and Properties of Engineering Alloys, Second Edition, McGraw Hill International Book Co.
6. William Smith, Javed Hasemi, Ravi Prakash, Material Science and Engineering, Tata McGraw Hill Education Company Ltd., 2006.
7. Kenneth G. Budinski, Michael K. Budinski, Engineering Materials Properties and Selection, 8th Edition, Prentice Hall.
8. Bowden M.J. and Tumber S.R., Polymer of High Technology, Electronics and Photonics, ACS Symposium Series, ACS, 1987.
9. Dyson, R.W., Engineering Polymers, Chapman and Hall, First Edition, 1990.
10. Chawala K.K., Composite Materials, Science and Engineering, 3rd Edition.
11. Sujata V. Bhat, Biomaterials, Narosa Publication Pvt. Ltd., Second Edition, 2005.
12. V. Raghavan, PHI Learning Private Ltd, Sixth Edition.

CHDE5014	Department Elective I- Instrumentation	4

Prerequisites

- Process Calculations

Course Objectives

- To understand the primary mechanisms of sensors
- To understand how measured quantities are processed for transmission and control
- To understand how alarms and interlocks are incorporated into over-all instrumentation and control
- To understand basic control configurations of typical process units

Course Outcomes

- The student will be able to calculate the output of various measuring schemes
- The student will be able to select a DAQ card for any given application
- The student will be able to select the appropriate type of instrument for any application
- The student will be able to prepare a basic control scheme for process units
- The student will be able to write programs for a PLC.
-

Module	Contents	Contact Hours
1	Fundamentals of Measuring Instruments: Introduction Standards and Calibration, Elements of Measuring Systems, Classification of Instruments, Performance Characteristics, Errors in Measurement.	**04**
2	Primary Sensing Mechanisms: Introduction, Resistive Sensing Elements, Capacitive Sensing Elements, Inductive Sensing Elements, Thermo-electric Sensing Elements, Piezo-electric Sensing Elements, Elastic Sensing Elements, Pneumatic Sensing Elements, Deferential Pressure Sensing Elements, Expansion Sensing Elements..	**04**
3	Signal Conversion: Signal Conditioning , Wheatstone Bridge, Potentiometer Measurement System, Signal Processing, Mechanical Amplifier, Electronic Amplifier, A/D and D/A conversion, Signal Transmission, Selection of DAQ cards.	**04**
4	Measuring Instruments: Flow Measurement, Temperature Measurement, Level Measurement, Pressure Measurement.	**10**
5	Valves and Drives: Introduction, Control Valve Characteristics, Sizing and Selection of Valves, Variable Drives.	**04**
6	Programmable Logic Controllers:	**04**

	Introduction, Ladder Logic, Applications of PLCs to typical processes.	
7	Introduction to Safety Relief Systems: Introduction, Types of Relieving Devices, Relief Valves, Rupture Discs, Over-pressurization, Emergency Depressurization, Introduction to SIL Classification, LOPA Methods, Basic Process Control Schemes.	**10**

Assessment

Internal:

- Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions need to be solved.
- Question No. 1 will be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each module.

Refrences

1. K. Krishnaswamy and S. Vijayachitra, Industrial Instrumentation, second Edition, New Age International.
2. B. E. Noltingk, Jones Instrument Technology, Vol. 4 and 5, Fourth Edition, Butterworth-Heinemann.
3. W. Bolton, Instrumentation and Control Systems, First Edition, Newnes, Elsevier, 2004.
4. Stephanopoulos, Chemical Process Control, Prentice Hall of India.
5. John P. Bentley, Principles of Measurement Systems, Third edition, Addison Wesley Longman Ltd., UK, 2000.
6. Doebelin E.O, Measurement Systems - Application and Design, Fourth edition, McGraw-Hill International Edition, New York, 1992.
7. Noltingk B.E., Instrumentation Reference Book, 2nd Edition, Butterworth Heinemann, 1995

Course Code	Course/ Subject Name	Credits

CHL501	Computer Programming and Numerical Methods Lab	1

Minimum Ten practicals should be performed from the modules of Theory course of Computer Programming and Numerical Methods (CHC501)

Term work

Term work shall be evaluated based on performance in practical.

Practical Journal: 20 marks
Attendance: 05 marks
Total: 25 marks

Practical Examination

- Duration for practical examination would be the same as assigned to the respective lab per week.
- A student becomes eligible for practical examination after completing a minimum of eight experiments out of ten experiments

Course Code	Course/ Subject Name	Credits

CHL502	Chemical Engineering Lab IV (MTO–I)	1.5

Concept for Experiments

Minimum of ten experiments are to be conducted.

- To determine the diffusivity of given liquid sample.
- To study diffusion through porous solids and determine effective diffusivity.
- To determine Mass Transfer Coefficient in a packed extraction column
- To determine Mass Transfer Coefficient in a packed extraction column
- To determine Mass Transfer Coefficient in a spray extraction column
- To estimate the mass transfer coefficient in flow process system (eg. benzoic acid + water).
- To determine mass transfer co-efficient in gas liquid system by evaporation.
- To study absorption in packed tower.
- To determine the efficiency of cooling and tower study of Humidification and water cooling operations.
- To study the operation of a fluidized bed drier and analyze drying curve.
- To determine rate of absorption and study absorption in spray tower.
- To study batch drying and plot drying curve.
- To study hydrodynamics of packed bed and study variation in pressure drop with velocity.
- Experiments demonstrating determination of mass transfer coefficient/diffusivity/ number of transfer units, HTU, HETP are envisaged.

Term work

Term work shall be evaluated based on performance in practical.

Practical Journal:	20 marks
Attendance:	05 marks
Total:	**25 marks**

Practical Examination

- Duration for practical examination would be the same as assigned to the respective lab per week.
- A student becomes eligible for practical examination after completing a minimum of eight experiments out of ten experiments

Course Code	Course/ Subject Name	Credits
CHL503	Chemical Engineering Lab IV (HTO)	1.5

Concept for Experiments

Minimum of ten experiments are to be conducted.

1. Thermal conductivity of a metal rod.
2. Heat transfer through composite wall.
3. Newtonian heating/cooling.
4. Heat transfer by forced convection.
5. Heat transfer by natural convection.
6. Heat transfer by condensation.
7. Stefan Boltzmann's apparatus
8. Kirchoff's law
9. Double pipe heat exchanger
10. Shell & Tube heat exchanger
11. Finned tube heat exchanger
12. Heat transfer in agitated vessel.

Term work

Term work shall be evaluated based on performance in practical.

Practical Journal:	20 marks
Attendance:	05 marks
Total:	**25 marks**

Practical Examination

- Duration for practical examination would be the same as assigned to the respective lab per week.
- A student becomes eligible for practical examination after completing a minimum of eight experiments out of ten experiments.

Course Code	Course/ Subject Name	Credits
CHL504	Chemical Engineering Lab VI (CRE–I)	1

Concept for Experiments

Minimum 10 experiments need to be performed by the students on following concepts

1. Differential and Integral Analysis (Order of Reaction at Room Temperature)
2. Arrhenius Constants (Verification of Laws)
3. Order and rate constant using Half Life Method
4. Study of Pseudo Order Reaction
5. Acidic Hydrolysis
6. Batch Reactor
7. Plug Flow Reactor (PFR)
8. Continuous Stirred Tank Reactor (CSTR)
9. Continuous Stirred Tank Reactors Series (Three CSTRs In Series)
10. PFR – CSTR In Series Combination

Term work

Term work shall be evaluated based on performance in practical.

Practical Journal: 20 marks
Attendance: 05 marks
Total: 25 marks

Practical Examination

- Duration for practical examination would be the same as assigned to the respective lab per week.
- A student becomes eligible for practical examination after completing a minimum of eight experiments out of ten experiments.

University of Mumbai
Program Structure for B.E. Chemical Engineering (Revised 2016)
T.E. Semester VI (w.e.f 2018-2019)

Course code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
CHC601	Environmental Engineering (EE)	4	-	-	4	-	-	4
CHC602	Mass transfer Operations –II (MTO-II)	4	-	-	4	-	-	4
CHC603	Transport Phenomenon	3	-	1	3	-	1	4
CHC604	Chemical Reaction Engineering –II (CRE- II)	4	-	-	4	-	-	4
CHC605	Plant Engineering & Industrial Safety	3	-	1	3	-	1	4
CHDE602X	Department Elective II	4	-	-	4	-	-	4
CHL601	Chemical Engineering Lab VII (EE)	-	3	-	-	1.5	-	1.5
CHL602	Chemical Engineering Lab VIII (MTO-II)	-	3	-	-	1.5	-	1.5
CHL603	Chemical Engineering Lab IX CRE-II)	-	2	-	-	1	-	1
	Total	22	8	2	22	4	2	28

Course code	Course Name	Examination Scheme								
		Theory					Term Work	Pract /Oral	Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in hrs)				
		Test 1	Test 2	Avg						
CHC601	Environmental Engineering (EE)	20	20	20	80	3	-	-	-	100
CHC602	Mass transfer Operations –II (MTO-II)	20	20	20	80	3	-	-	-	100
CHC603	Transport Phenomenon	20	20	20	80	3	25	-	-	125
CHC604	Chemical Reaction Engineering –II (CRE- II)	20	20	20	80	3	-	-	-	100
CHC605	Plant Engineering & Industrial Safety	20	20	20	80	3	25	-	-	125
CHDE602X	Department Elective II	20	20	20	80	3	-	-	-	100
CHL601	Chemical Engineering Lab VII (EE)	-	-	-	-	3	25	25		50
CHL602	Chemical Engineering Lab VIII (MTO-II)	-	-	-	-	3	25	25	-	50
CHL603	Chemical Engineering Lab IX CRE-II)	-	-	-	-	2	25	25	-	50
	Total			120	480	-	125	75	--	800

Department Elective II (Sem VI)		
Engineering Stream (Elective Code)	Management Stream (Elective Code)	Technology Stream (Elective Code)
1. Computational Fluid Dynamics (CHDE6021)	1. Operation Research (CHDE6022)	1. Biotechnology (CHDE6023)

Course Code	Course/ Subject Name	Credits
CHC601	Environmental Engineering	4

Prerequisites:

- Basic concepts of Fluid Flow Operations, Solid Fluid Mechanical Operations, Mass Transfer Operations and Chemical Reaction Engineering.

Course Objectives:

- Students should be able to understand the scope of subjects in Chemical Industry.
- Students should learn to apply the Environmental Engineering concepts to control management of various types of pollutants.

Course Outcomes:

- To understand Importance of environmental pollution, such as air, water, solid, noise. Various pollutants sources, adverse effects, Environmental Legislation
- To understand meteorological aspects air pollutant dispersion. Sampling and measurement, Control Methods and Equipment:
- To understand Sampling, measurement of various water pollutants.
- To understand and design various Waste Water Treatments,

Module	Contents	Contact Hours
1	Environmental pollution, Importance of environmental pollution control, Concept of ecological balance, Role of environ-mental engineer, Environmental Legislation & Regulations, Industrial pollution emissions &Indian standards, Water (prevention & control of pollution) act, Air (prevention & control of pollution) act.	2
2	**Water Pollution**: Classification of sources and effect of water pollutant on human being and ecology, Sampling, measurement and standards of water quality, Determination of organic matters: DO, BOD, COD, and TOC. **Determination of inorganic substances**: nitrogen, phosphorus, trace elements, alkalinity. **Physical characteristics**: suspended solids, dissolved solids, colour and odour, Bacteriological measurements.	8
3	**Waste Water Treatment:** **Primary treatment**: pre-treatment, settling tanks and their sizing. **Secondary treatment**: micro-organisms growth kinetics, aerobic biological treatment, activated sludge process, evaluation of bio-kinetic parameters, trickling filters, sludge treatment and disposal. **Tertiary treatment**: advanced methods for removal of nutrients, suspended and dissolved solids, Advanced biological systems, Chemical oxidation, Recovery of materials from process effluents.	12
4	**Air Pollution:**	14

	Air pollutants, sources and effect on man and environment, behaviour and fate of air pollutants, photochemical smog, Meteorological aspects of Air pollutants: Temperature lapse rate and stability, inversion, wind velocity and turbulence, Plume behaviour, Dispersion of air pollutants, Gaussian plume model, Estimation of plume rise, Air pollution sampling and measurement, Analysis of air pollutants	
5	**Air Pollution Control Methods and Equipment:** Source correction methods for air pollution control, Cleaning of gaseous effluents, Particulate emission control, Equipment, system and processes for. ----Particulate pollutants: gravity settler, cyclones, filters, ESP, scrubbers etc. ----Gaseous pollutants: scrubbing, absorption, adsorption, catalytic conversion.	**8**
6	**Solid Waste Management:** Solid waste including plastic, nuclear and hazardous waste management, E waste management	**3**
7	**Noise Pollution:** Noise pollution: measurement and control, effect on man and environment.	**1**

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

Text Books

1. Rao, C.S., Environmental Pollution Control Engineering, New Age International (P) Ltd.
2. Peavy, H. S., Rowe, D.R., Tchobanoglous, G., Environmental Engineering, McGraw-Hill Book Company Limited
3. Metcalf et al., Waste Water Treatment, Disposal & Reuse, Tata McGraw Hill Publishing Company Limited.
4. Mahajan, S.P., Pollution Control in Process Industries, Tata McGraw Hill Publishing Company Limited.

References

1. Industrial and Pollution Engineering, Cavaseno, VinCene N.T.

2. Sewage Disposal and Air Pollution Engineering, S.K. Garg
3. Chemistry for Environmental Engineering, C.N. Sawyer
4. Wastewater Engineering, B.C Punmia

Course Code	Course/ Subject Name	Credits
CHC602	Mass Transfer Operations II	4

Prerequisites:

- Knowledge of chemistry, physics, physical chemistry and mathematics.
- Knowledge of process calculations.
- Knowledge of diffusion, mass transfer coefficients, modes of contact of two immiscible phases.

Course Objectives:

- To understand design methods for distillation columns.
- To understand design of extractor and leaching equipments.
- To understand membrane separation.
- To understand crystallisation process and to design crystallization equipments

Course Outcomes

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

- understand equilibrium in all separation process
- design the mass transfer equipments for extraction, leaching and crystallization processes
- design distillation column
- choose the separation operation which will be economical for the process
- optimize the process parameters
- understand membrane separation processes principle and working

Module	Contents	Contact Hours
1	**Distillation:** Introduction to Distillation, Vapor-liquid Equilibrium-At constant Pressure and At constant temperature, Minimum and maximum boiling Azeotropes. Methods of distillation [binary mixtures] – Flash Distillation, Differential distillation, Rectification. Calculations of number of ideal stages in multistage countercurrent rectification. McCabe Thiele Method. Ponchon-Savarit Method, Lewis-Sorel Method, Concepts of [Brief Discussion], Steam Distillation, Azeotropic Distillation, Extractive Distillation, Reactive Distillation, Molecular Distillation, Introduction to Multicomponent Distillation.	12
2	**Liquid-Liquid Extraction:** Introduction to Liquid-Liquid Extraction, Choice of Solvent for Liquid-Liquid Extraction, Triangular coordinate system, Ternary Equilibria [Binodal Solubility Curve with effect of temperature and pressure on it], Single Stage Operation, Multistage Cross Current Operation, Multistage Counter Current Operation[with	10

	and without reflux, Equipments for liquid-liquid extraction.	
3	**Leaching:** Representation of Equilibria, Single stage leaching, Multistage Cross Current Leaching, Multistage Counter Current Leaching, Equipments for Leaching.	06
4	**Adsorption and Ion Exchange:** Introduction to Adsorption, Types of Adsorption, Adsorption Isotherms, Single Stage Adsorption, Multistage Cross Current Adsorption, Multistage Counter Current adsorption, Equipments for Adsorption, Break through curve, Ion Exchange Equilibria, Ion Exchange Equipments	12
5	**Crystallization:** Solubility curve, Super saturation, Method of obtaining super saturation, Effect of heat of size and growth of crystal, Rate of Crystal growth and ΔL law of crystal growth, Material and energy balance for crystallizers, Crystallization equipment-description.	4
6	**Membrane separation Technique:** Need of membrane separation, and its advantages, classification of membrane separation process, Various membrane configurations. Various membrane and their applications, Ultrafiltration, Nanofiltration. Reverse osmosis, Pervaporation, Membrane distillation.	4

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. Treybal R.E. , Mass transfer operation, 3 Ed., McGraw Hill New York, 1980.
2. McCabe W.L. and Smith J.C., Unit operation in chemical engineering, 5 Ed., McGraw Hill New York 1993.
3. Geankoplis C.J., Transport processed and unit operations, Prentice Hall, New Delhi 1997.
4. Coulson J.M. Richardson J.F., Backhurst J.R. and Harker J.H., Coulson and Richardson chemical engineering, vol 1 & 2, Butterworth Heinman, New Delhi, 2000.
5. R.K. Sinnot (Ed) Coulson and Richardson chemical engineering, vol 6, Butterworth Heinman, NewDelhi, 2000.

6. Kiran D. Patil, Principals and Fundamentals of mass transfer operation II, Nirali Prakashan Pune.
7. Dutta B.K., Mass Transfer and separation processes, Eastern economy edition, PHI learning private ltd, New Delhi, 2009.

Course Code	Course/Subject Name	Credits
CHC603	Transport Phenomena	4.0

Prerequisites:

- Continuity equation, equation motion covered in Fluid Mechanics, Diffusion and absorption from Mass Transfer and Conduction, convection and radiation from Heat Transfer.
- Numerical methods to solve ordinary differential equations.

Course Objectives:

- Students will be able to get depth knowledge of momentum, energy and mass transport.
- Applications of fundamental subjects learned, towards chemical engineering problems.
- Ability to analyze industry oriented problems.

Course Outcomes:

- Understanding of transport processes.
- Student will learn to establish and simplify appropriate conservation statements for momentum, energy and mass transfer processes.
- Ability to do momentum, energy and mass transfer analysis.
- To apply conservation principles, along with appropriate boundary conditions for any chemical engineering problem.

Module	Contents	Contact Hours
1	**Introduction:** Importance of transport phenomena, Introduction to analogies between momentum, heat and mass transfer and defining of dimensionless number, Eulerian and Lagrangian approach, introduction of molecular and convective flux, equation of continuity, motion and energy.	06
2	**Momentum Transport:** Introduction of viscosity and mechanism of momentum transport: Newton's law of viscosity, Newtonian & Non-Newtonian fluids, Pressure and temperature dependence of viscosity, theory of viscosity of gases and liquids. Velocity distribution in laminar flow: Shell momentum balances and boundary conditions a) Flow of falling film b) Flow through the circular tube c) Flow through an annulus d) Flow in a narrow slit e) Adjacent flow of two immiscible fluids	10
3	**Energy Transport:** The introduction of thermal conductivity and mechanism of energy transport: Fourier's law of heat conduction, temperature and pressure dependence of thermal conductivity in gases and liquids. Temperature distribution in solids and in laminar flow, shell energy balance and boundary conditions a) Heat conduction with electrical heat source b) Heat conduction with a nuclear heat source c) Heat conduction with a viscous heat	10

	source d) Heat conduction with a chemical heat source e) Heat conduction with variable thermal conductivity f) Heat conduction in composite wall and cylinder g) Heat conduction in a cooling fin	
4	**Mass Transport:** Introduction of diffusivity and mechanism of mass transport: Definitions of concentrations, velocities and mass fluxes, Fick's law of diffusion, temperature and pressure dependence of mass diffusivity. Concentration distribution in solids and in laminar flow, Shell mass balances and boundary conditions a) Diffusion through stagnant gas film b) Diffusion with heterogeneous chemical reaction c) Diffusion with homogeneous chemical reaction d) Diffusion into a falling liquid film (Gas absorption)	**10**

Term Work

Term work shall consist of minimum eight tutorials from entire syllabus which are to be given at regular intervals Batch wise.

Tutorials: 20 Marks

Attendance: 05 Marks

Total: **25 Marks**

Assessment

Internal

- Assessment consists of average of two tests which should be conducted at proper interval

End Semester Theory Examination:

- Question paper will be comprises of six questions, each carrying 20 Marks.
- Total 4 questions need to be solved.
- Question no. 1 will be compulsory and based on entire syllabus wherein sub-questions can be asked.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each module.

References

1. Bird, R.B., W.E. Stewart and E.N. Lightfoot, Transport Phenomena, Wiley, New York, 2nd ed., 2002.
2. Christie J. Geankoplis, Transport Processes and Separation Process Principles, 4th Edition, 2004
3. Slattery, J.C., Advanced Transport Phenomena, Cambridge University Press, Cambridge, 1999.
4. Brodkey, R.S. and H.C. Hershey, 1988, Transport Phenomena: A Unied Approach, McGraw-Hill, New York.
5. Bodh Raj, Introduction to Transport Phenomena (Momentum, Heat and Mas), PHI Learning Pvt. Ltd, Eastern Economy Edition.

Course Code	Course/Subject Name	Credits

CHC604	Chemical Reaction Engineering II	4.0

Prerequisites:

- Students should know basic chemistry pertaining to chemical reactions, chemical formula etc. They are required to be aware of chemical process and unit operations used for the manufacturing of chemical products. Simple to complex numerical methods of solving one and two dimensional Mathematical equations.

Course Objectives:

- To understand the concept of Residence Time Distribution (RTD) in various reactors and obtain the actual design parameters to design Real Reactor.
- To find the model equation and use this model to design the reactors used for heterogeneous non catalytic reactions.
- To apply the knowledge they have gained to develop kinetic model and Design strategy for heterogeneous catalytic reactions.
- To apply the knowledge they have gained to develop kinetic model and use this model to design the reactors used for Fluid-Fluid reactions.

Course Outcomes:

- Students will be able to understand the concept of Residence Time Distribution (RTD) in various reactors and obtain the actual design parameters to design Real Reactor.
- Students will be able to find the model equation and use this model to design the reactors used for heterogeneous non catalytic reactions.
- Students will be able to apply the knowledge they have gained to develop kinetic model and Design strategy for heterogeneous catalytic reactions.
- Students will be able to apply the knowledge they have gained to develop kinetic model and use this model to design the reactors used for Fluid-Fluid reactions.

Module	Content	Contact Hours
1	**Non Ideal flow reactors:** Concept of residence time distribution (RTD), Measurement and characteristics of RTD, RTD in Ideal batch reactors, Plug Flow Reactor and CSTR. Zero Parameter Model – Segregation and Maximum mixedness model. One parameter model–Tanks in series model and Dispersion Model. Effect of dispersion on conversion for general irreversible reaction case, Diagnostic methods of analysis of flow patterns in reactors, Role of micro and macro mixing and segregation in ideal (MFR, PFR) and non ideal reaction cases.	12
2	**Non Catalytic heterogeneous Reactions:** **Kinetics:** General mechanism of reaction. Various models. Specific cases with respect: (a) Film diffusion controlling.	10

	(b) Ash diffusion controlling. (c) Chemical reaction controlling. **Design of reactors for non-catalytic reactions**: Experimental reactors for heterogeneous Reactions, Non-Catalytic Fluid Solid Reactions in Flow Reactor. Application to design of continuous solid flow reactors; various design considerations, Application of fluid bed reactors and their design consideration.	
3	**Kinetics and mechanism** of various Heterogeneous reactions and design consideration of reactors used during different operating conditions. **Catalytic heterogeneous reactions**: Properties of solid catalysts, Physical adsorption and Chemisorption, Surface area and pore size distribution, Langmuir-Hinshelwood model, and General mechanism of solid catalyzed fluid phase reactions. Special cases when (a) Film resistance controls. (b) Surface phenomenon controls. (c) Surface reaction controls (d) Pore diffusion controls. Concept of effectiveness factor of catalyst and its dependence on catalyst properties and kinetic parameters. Numericals based on physical properties of catalyst, Derivations for LHHW model mechanism-various cases, Effectiveness factor. Numericals based on kinetics **Introduction to Catalytic Reactors**: Packed Bed Reactor Fluidized Bed, Trickle Bed and Slurry Reactor. Numericals based on Design of Packed Bed Reactor (Calculation of weight/volume of catalyst).	**12**
4	**Kinetics of fluid-fluid reactions**: Reaction with mass transfer, the rate equation pertaining to fast to very slow reactions. **Applications to design:** Design of gas-liquid, liquid-liquid and gas liquid-solid reactors- Heterogeneous reactors, Bubble heterogeneous reactors, co-current and counter-current flow packed bed reactors.	**10**

Assessment

Internal

- Assessment consists of average of two tests which should be conducted at proper interval

End Semester Theory Examination:

- Question paper will be comprises of six questions, each carrying 20 Marks.
- Total 4 questions need to be solved.
- Question no. 1 will be compulsory and based on entire syllabus wherein sub-questions can be asked.
- Remaining questions will be randomly selected from all the modules.

- Weightage of marks should be proportional to number of hours assigned to each module.

References

1. Levenspiel O., Chemical Reaction Engineering, John Wiley&Sons,3rd ed.,1999.
2. Smith J.M., Chemical Reaction Engineering, 3rd ed., TataMcGrawHill,1980.
3. Fogler, H.S. Elements of Chemical Reaction Engineering, 4th ed.,PHI, 2008
4. HillC. G., Chemical Reaction Engineering.
5. Walas, Reaction Kinetics for Chemical Engineers, McGraw Hill, 1959.

Course Code	Course/Subject Name	Credits

CHC605	Plant Engineering and Industrial Safety	4

Prerequisites:

- Knowledge of Process Calculations, Thermodynamics and Fluidflow.

Course Objectives:

- At the end of the course the students should understand the knowledge of industrial safety, plant utilities.
- They should able to understand industrial accidents and hygiene, hazards and risk analysis.
- They should able to understand various types of steam generators, its performance.
- They should be able to understand various properties of compressed air, air drying methods, study different types of compressors and calculate the power required by compressors.
- They should understand how to select vacuum system.

Course Outcomes

- Students should be able to identify the causative and initiating factors of accidents. They should be able to make quantitative assessment of vapour release and noise impact.
- Students should be able to understand and evaluate situations causing industrial fire and evaluate risk. .
- Students should learn and understand type of boilers and be able to calculate its efficiency.
- Students should be able to calculate work requirements for compressors and draw schematic of instrument air, plant air and venting system.

Module	Contents	Contact Hours
1	Industrial Accidents: Causative and initiating factors of accidents. Identifying the causative and initiating factors of Industrial accidents, case studies.	3
	Industrial Hygiene. Definition and evaluation of toxicity and noise	5
	Ventilation. Local Ventilation, Dilution Ventilation. Problems on Ventilation airflow.	1
2	Fire. Fire triangle, Flammability characteristics of liquids and gases, Limiting oxygen concentration, ignition energy, auto ignition, auto oxidation, adiabatic compression. Ignition sources, spray and mist.	2
	Explosion: Detonation, Deflagration, Confined explosion, unconfined explosion, VCE, BLEVE, Problems on energy of chemical explosion.	5
	Types of relief systems	2
	HAZOP, How to do a HAZOP. HAZOP Checklist.	2
	Risk assessment: Event tree analysis, Fault tree analysis.	2

3	Steam generators: Properties of steam, Use of steam tables, Steam generators, Classification of boilers, Study of high pressure boilers, boiler mountings and accessories. Performance of steam generators. Distribution of steam in plant; Efficient use of steam, steam traps.	**8**
4	Air: Reciprocating compressors, work calculations, PV Diagrams, Two stage compression system with intercooler, problems of work and volumetric efficiency. Instrument Air System, Process Air System, Vacuum producing devices	**6**

Term Work

Term work shall consist of minimum eight tutorials (two from each module) from entire syllabus which are to be given at regular intervals Batch wise.

Tutorials: 20 Marks

Attendance: 05 Marks

Total: **25 Marks**

Assessment

Internal:

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. Crowl, D. A. and Louvar, J. P.; Chemical Process Safety: Fundamentals with Applications; Prentice Hall, Englewood
2. Khurmi, R. S. and Gupta, J. K. A textbook of thermal Engineering, S. Chand.
3. Rajput, R.K .A textbook of Power Plant Engineering. Laxmi Publications (P) Ltd., Navi Mumbai.
4. K. S. N. Raju, Chemical Process Industry Safety, McGraw Hill Education.

Course Code	Course/ Subject Name	Credits
CHDE6021	Department Elective II -Computational Fluid Dynamics	04

Prerequisites:

- Linear Algebra
- Partial Differential Equations
- Scilab or Python

Course Objectives:

- To understand the formulation of CFD problems
- To discretize the problems
- To solve the set of equations in simple cases using Scilab routines.
- To understand and use software in CFD

Course Outcomes:

- The student will be able to obtain flow profiles for some simple applications using Scilab.
- The student will be able to use appropriate software for solving realistic problems.

Module	Contents	Contact Hours
1	Module: Introduction Contents: Advantages of Computational Fluid Dynamics Typical Practical Applications Equation Structure Overview of CFD	02
2	Module: Preliminary Computational Techniques Contents: Discretisation Approximation to Derivatives Accuracy of the Discretisation Process Wave Representation Finite Difference Method	04
3	Module: Theoretical Background Contents: Convergence Consistency Stability Solution Accuracy Computational Efficiency	06
4	Module: Weighted Residual Methods Contents: General Formulation Least Squares, Galerkin and Sub domain Formulations. Weak form of Galerkin Method	08
5	Module: Finite Element Method Contents: Piece-wise Continuous Trial Functions One Dimensional Linear and Quadratic Elements	08

	One Dimensional Heat Transfer Tri-diagonal Matrix Algorithm	
6	Module: Two Dimensional Elements Quadrilateral Elements Steady State Heat Transfer in Two Dimensions Alternating Direction Implicit Method Potential Flow in Two Dimensions	**08**
7	Module: Finite Volume Method One Dimensional Diffusion Two Dimensional Diffusion Diffusion With Convection and The Upwind Scheme	**06**
8	Module: Pressure Velocity Coupling in Steady Flows The Staggered Grid The Momentum Equation The Simple Algorithm	**06**

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

Text Books

1. C.A.J. Fletcher; Computational Techniques for Fluid Dynamics 1; Springer-Verlag Berlin Heidelberg GmbH
2. P. Seshu; Textbook of Finite Element Analysis; PHI Learning Private Limited, New Delhi
3. H.K. Versteeg and W. Malalasekera; An Introduction To Computational Fluid Dynamics; Longman Scientific & Technical

References

1. John D. Anderson; Computational Fluid Dynamics; McGraw Hill Education Private Limited

Course Code	Course/ Subject Name	Credits
CHDE6022	Department Elective II -Operations Research	4

Prerequisites:

- Linear Algebra
- Computer Programming

Course Objectives:

- To understand Linear Programming and its applications to OR models.
- To understand and solve network models in OR.
- To understand Game theory and its applications.
- To study and design Queuing systems.

Course Outcomes:

- The student will be able to solve typical OR models using linear integer and dynamic programming techniques.
- The student will be able to model and solve network flow problems in OR.
- The student will be able to make decisions under various scenarios.
- The student will be able to design Queuing Systems.

Module	Contents	Contact Hours
1	Module: Linear Programming Contents: Introduction Graphical Method of Solution Simplex Method Two-Phase Method Duality Dual Simplex Revised Simplex	10
2	Module: Transportation Models Contents: Examples of Transportation Models The Transportation Algorithm The Assignment Model The Transshipment Model	06
3	Module: Network Models Contents: Scope and Definition of Network Models Minimal Spanning Tree Algorithm Shortest Route Problem Maximal Flow Model	06
4	Module: Integer and Dynamic Programming Contents: Branch and Bound Method Travelling Salesman Problem Introduction to Dynamic Programming Forward and Backward Recursion Selected Applications	06

5	Module: Deterministic Inventory Models Contents: Classic EOQ Model EOQ with Price Breaks Dynamic EOQ Models No-Setup Model Setup Model	**06**
6	Module: Decision Analysis and Game Theory Contents: Decision Making under Certainty Decision Making under Risk Decision Under Uncertainty Game Theory	**06**
7	Module: Queuing Systems Contents: Elements of a Queuing Model Role of Exponential Distribution Pure Birth and Death Models Generalized Poisson Queuing Model Measures of Performance	**08**

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

Text Books

1. Operations Research; Hamdy A. Taha; Eighth Edition; Prentice Hall India

References

1. Hillier and Lieberman; Introduction to Operations Research

Course Code	Course/ Subject Name	Credits

CHDE6023	Department Elective II -Biotechnology	04

Prerequisites

- Knowledge of biology, chemistry, chemical engineering

Course Objectives

- At the end of the course the students should understand the basic concept of biotechnology. They should be able to classify micro-organisms, understand cell structure and basic metabolism.
- They should be able to understand basic knowledge about biological polymers.
- They should be able to understand basic knowledge about enzyme technology.
- They should understand role of biotechnology in medical field and industrial genetics.
- They should know importance of biotechnology in agricultural, food and beverage industries, environment, energy and chemical industries.
- They should understand to how to recover biological products.

Course Outcomes

- Students will demonstrate the knowledge of biotechnology in various fields.
- Students will know cell and metabolism.
- Students will have deep knowledge of biological polymers.
- Students will have deep knowledge of enzymes.
- Students will able to know about other uses of biotechnology in medical/pharmaceutical field and industrial genetics.
- Students will be able to understand how biotechnology helps in agricultural, food and beverage industry, chemical industries, environment and energy sectors.
- Students will be able to understand how biological products are recovered.

Module	Contents	Contact Hours
1	**Introduction:** Traditional and modern applications of biotechnology. Classification of micro-organisms. Structure of cells, types of cells. Basic metabolism of cells. Growth media. Microbial growth kinetics.	7
2	**Biological polymers:** Lipids, Proteins, Amino acids, Nucleic acids, Carbohydrates, Macronutrients and micronutrients.	6
3	**Enzyme Technology:** Nomenclature and classification of enzymes. Enzyme kinetics. Michaels Menten Kinetics, Immobilized enzyme kinetics, Immobilization of enzymes. Industrial applications of enzymes. The technology of enzyme production	7
4	**Biotechnology in health care and genetics:** Pharmaceuticals and bio-pharmaceuticals, antibiotics, vaccines and monoclonal antibodies, gene therapy. Industrial genetics, protoplast and cell fusion technologies, genetic engineering& protein engineering, Introduction to Bio-informatics. Potential lab biohazards of genetic engineering. Bioethics.	10
5	**Applications of biotechnology:** Biotechnology in agriculture, food and beverage industries, chemical industries, environment and energy sectors.	8
6	**Product recovery operations:** Dialysis, Reverse osmosis, ultrafiltration, microfiltration, chromatography, electrophoresis,	10

	elecrodialysis, crystallization and drying.	

Assessment

Internal

- Assessment consists of average of two tests which should be conducted at proper interval

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions to be solved
- Question no.1 will be compulsory and based on entire syllabus where in sub questions can be asked.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each module.

Reference Books

1. Shuller M.L. and F. Kargi. 1992. Bioprocess Engineering, Prentice-Hall, Englewood Cliffs,NJ.
2. Bailey. J.E. and Ollis D.F. 1986, Biochemical Engineering Fundamentals, 2 nd Edition, McGraw Hill, New York.
3. Kumar H.D., Modern Concepts of Biotechnology, Vikas Publishing House Pvt. Ltd.
4. Gupta P.K., Elements of Biotechnology, Rastogi Publications
5. Inamdar, Biochemical Engineering, Prentice Hall of India.

Course Code	Course/ Subject Name	Credits

CHL601	Chemical Engineering Lab VII (EE)	1.5

Concept for Experiments

Students should be able to apply the Environmental Engineering concepts to control and management of various types of pollutants. A minimum of TEN experiments must be performed on following concepts:

- Physical characterization (TDS /turbidity measurement) of waste water.
- Chemical characterization (chloride ion, sulphate ion etc.) of waste water.
- Determination of organic matters (dissolved oxygen) in waste water.
- Sampling measurement and standard of water quality (determination of BOD).
- Sampling measurement and standard of water quality (determination of COD).
- Determination of toxic matters (phenol, chromium etc.) in waste water.
- Determination of inorganic matters (heavy metal) in waste water.
- Measurement of particulate matter in air.
- Measurement of gaseous pollutant (any one) in air.
- Measurement of various types of residues or solids in the given sample.
- Measurement of sound level.

Term work

Term work shall be evaluated based on performance in practical.

Practical Journal:	20 marks
Attendance:	05 marks
Total:	**25 marks**

Practical Examination

- Duration for practical examination would be the same as assigned to the respective lab per week.
- A student becomes eligible for practical examination after completing a minimum of eight out of ten experiments.

CHL602	Chemical Engineering Lab VIII (MTO II)	1.5

Concept for Experiments

A minimum of TEN experiments must be performed on following concepts:

- Verification of Rayleigh Equation.
- To determine the percentage recovery of solute by solid liquid leaching operation (multistage crosscurrent).
- To determine the vapour-liquid equilibrium curve.
- To find out distribution coefficient. [eg. acetic acid between water and toluene]
- To verify Freundlich adsorption isotherm
- To find the yield of crystals in batch crystallizer.
- To prepare the ternary phase diagram of Binodal solubility curve and tie line relationship for ternary system
- To study distillation at total reflux in a packed column.
- To determine the efficiency of steam distillation
- To study the performance of Swenson Walker crystallizer and also to determine the yield.
- To carry out multistage cross current operation in liquid liquid extraction and compare with single stage operation
- To carry out multistage cross current adsorption and compare with single stage operation.

Term work

Term work shall be evaluated based on performance in practical.

Practical Journal:	20 marks
Attendance:	05 marks
Total:	**25 marks**

Practical Examination

- Duration for practical examination would be the same as assigned to the respective lab per week.
- A student becomes eligible for practical examination after completing a minimum of eight out of ten experiments.

CHL603	Chemical Engineering Lab IX (CRE II)	1

Concept for Experiments

Minimum 10 experiments need to be performed by the students on following concepts:

1. Residence Time Distribution (RTD) In Continuous Stirred Tank Reactor (CSTR)-Pulse Input
2. Residence Time Distribution (RTD) In Plug Flow Reactor (PFR) – Pulse Input
3. Residence Time Distribution (RTD) In Packed Bed Reactor (PBR) – Pulse Input
4. Residence Time Distribution (RTD) In Continuous Stirred Tank Reactor (CSTR) – Step Input
5. Residence Time Distribution (RTD) In Plug Flow Reactor (PFR) – Step Input
6. Void volume, Porosity and solid density of catalyst
7. Semibatch reactor
8. Solid fluid heterogeneous non – catalytic reaction
9. Soli fluid Heterogeneous catalytic reaction.
10. Study of adsorption isotherm
11. Adiabatic batch reactor

Term work

Term work shall be evaluated based on performance in practical.

Practical Journal:	20 marks
Attendance:	05 marks
Total:	**25 marks**

Practical Examination

- Duration for practical examination would be the same as assigned to the respective lab per week.
- A student becomes eligible for practical examination after completing a minimum of eight out of ten experiments.

B.E. Semester VII (w.e.f 2019-2020)

Course code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
CHC701	Process Equipment Design. (PED)	4	-	-	4	-	-	4
CHC702	Process Engineering	3	-	1	3	-	1	4
CHC703	Process Dynamics and Control (PDC)	4	-	-	4	-	-	4
CHDE703X	Department Elective III	4	-	-	4	-	-	4
ILO701X	Institute Elective I	3	-	-	3	-	-	3
CHP701	Project A	-	-	8	-	-	3	3
CHS701	Seminar	-	-	3	-	-	3	3
CHL701	PED Lab	-	3	-	-	1.5	-	1.5
CHL702	Chemical Engineering Lab X (PDC)	-	3	-	-	1.5	-	1.5
	Total	18	6	12	18	3	7	28

Course code	Course Name	Examination Scheme								
		Theory					Term Work	Pract /Oral	Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in hrs)				
		Test 1	Test 2	Avg						
CHC701	Process Equipment Design. (PED)	20	20	20	80	3	-	-	-	100
CHC702	Process Engineering	20	20	20	80	3	25	-	-	125
CHC703	Process Dynamics and Control (PDC)	20	20	20	80	3	-	-	-	100
CHDE703X	Department Elective III	20	20	20	80	3	-	-	-	100
ILO701X	Institute Elective I	20	20	20	80	3	-	-	-	100
CHP701	Project A	-	-	-	-	-	100		25	125
CHS701	Seminar	-	-	-	-	-	50	-	-	50
CHL701	PED Lab	-	-	-	-	-	25	-	25	50
CHL702	Chemical Engineering Lab X (PDC)	-	-	-	-	3	25	25	-	50
	Total			100	400	-	225	25	50	800

Department Elective III (Sem VII)		
Engineering Stream (Elective Code)	Management Stream (Elective Code)	Technology Stream (Elective Code)
1.Corrosion Engineering (CHDE7031)	1. Industrial organization and Management. (CHDE7032)	1. Petroleum Refining Technology (CHDE7033) 2. Food Technology (CHDE7034)

Institute Level Optional Subject I (Sem VII)		
1. Product Lifecycle Management (ILO7011)	4. Design of Experiments (ILO7014)	7. Disaster Management and Mitigation Measures (ILO7017)
2. Reliability Engineering (ILO7012)	5. Operation Research (ILO7015)	8. Energy Audit and Management (ILO7018)
3. Management Information System (ILO7013)	6. Cyber Security and Laws (ILO7016)	9. Development Engineering (ILO7019)

Course Code	Course/ Subject Name	Credits
CHC701	Process Equipment Design	4

Prerequisites:

- Fundamentals of units
- Elementary theory of engineering mechanics,
- Engineering drawing.
- Knowledge of heat transfer, mass transfer, mechanical operations and
- Mechanical equipment design.

Course Objectives:

- To understand the basic of design of heat transfer equipments.
- To understand the design of mass transfer equipments.
- To understand the basic of construction and design of high pressure vessels.
- To understand basics of flow diagrams and different equipment inspection methods.

Course Outcomes:

Students would be able to

- Design heat exchanger and evaporator.
- Design distillation and absorption columns.
- Design high pressure vessels.
- Explain different flow sheet presentation and equipment inspection methods.

Module	Contents	Contact Hours
1	**Heat exchangers** Introduction codes and standards for heat exchangers. Material of construction. • Design of shell and tube heat exchanger (U-tube and fixed tube) as per IS: 4503, TEMA standards i.e., shell, tube, tube sheets, channel and channel cover, flanged joints.	8
2	**Evaporators** • Design of standard vertical evaporator with design of calendria and tube, flange evaporator drums and heads.	6
3	**Distillation and Absorption column** Basic features of columns, stresses in column shell. • Shell thickness determination at various heights, elastic stability under compression stresses, allowable deflection. • Column internals, design of supports for trays.	10
4	**High Pressure** Vessels Materials of construction, constructional method of high pressure vessels and stress analysis. • Design of mono block and multi layered high pressure vessels (stress distribution diagram).	8
5	**Flow Diagram** • Symbols of process equipments and their concepts	8

	• Flow sheet representation: 1. Block diagram 2. Process Flow Diagram (PFD) 3. Engineering Line Diagram (ELD or PID) 4. Utility line Diagram (ULD) 5. Plant Layout 6. Tank Farm and Plot plan	
6	**Equipment Inspection** • Methods of Inspection of Equipments 1. Radiography 2. Ultrasound 3. Dye Penetration 4. Fatigue assessment test	**8**

Assessment

Internal

- Assessment consists of average of two tests which should be conducted at proper interval

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions to be solved
- Question no.1 will be compulsory and based on entire syllabus where in sub questions can be asked.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each module.

References

1. Process Equipment Design- Vessel Design by E. Brownell and Edwin, H. Young. John Wiley, New York 1963.
2. Chemical Engineering volume 6- Design by J.M Coulson, J.F. Richardson and P.K. Sinnot, Pregamovr press, International edition 1989.
3. Introduction to Chemical Equipment Design- Mechanical aspects by B.C. Bhattacharya CBS Publications
4. Process Equipment Design by M.V. Joshi Macmillan India.

Course Code	Course/ Subject Name	Credits
CHC 702	**Process Engineering**	**04**

Prerequisites:

- The students should have knowledge of Heat transfer and Mass Transfer to carry out Mass and Energy balance around process.

- They should be aware about basic principles of economics to evaluate cost and profit of process.
- They should be familiar with process and mechanical design of Process equipments.
- They should be familiar with various types of plant utilities.

Course Objectives:

- To provide training to solve problems relevant to the general practice of chemical engineering and design
- To provide experience in the process of original chemical engineering design in the areas of equipment design, process design and plant design through the process of formulating a design solution to a perceived need and then executing the design and evaluating its performance including economic considerations and societal impacts if any, along with other related constraints, and culminating in both written and oral presentation of results.
- To provide students familiarity with professional issues in chemical engineering including ethics, issues related to the global economy and to emerging technologies and fostering of important job related skills such as improved oral and written communications and experience in working in teams at a number of levels.

Course Outcomes:

- The graduates are expected to have ability to apply knowledge of mathematics, science and engineering.
- The graduates are expected to have ability to design a system, a component, or a process to meet the desired needs within realistic constraints such as economic, environmental, social, ethical, health and safety, manufacturability and sustainability.
- The graduates are expected to possess ability to function on multi disciplinary teams.
- The graduates are expected to possess ability to identify, formulate and solve engineering problems.
- The graduates are expected to have an understanding of professional and ethical responsibility.
- The graduates are expected to engage themselves in lifelong learning.
- The graduates are expected to posses' ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Module	Contents	Contact Hours
1	**Introduction to Process Engineering** Chemical Products, Formulation of the Design Problem, Chemical Process Design and Integration, The Hierarchy of Chemical Process, Design and Integration, Continuous and Batch Processes, New Design and Retrofit , Approaches to Chemical Process	06

	Design and Integration, Process Control, Basic concepts regarding PFD, Block diagrams, P and ID Process flow diagram, piping and instrumentation diagram, Importance of safety and environmental aspects.	
2	**Process Design of Piping, Fluid moving Devices and Flow Meters** (with numerical). Process design of piping, process design of fluid moving devices, Centrifugal pump performance for viscous fluids, Revision of formulae for power requirement for fans, blowers, adiabatic compressor, Process Design for orifice and rotameter, Trouble shooting in fluid flow systems	**08**
3	**Process Design of Distillation Column** Selection criteria, equipment selection, distillation column design (multicomponent with numerical), FUG, Lewis Matheson method, Thiele Geddes method, Selection of tray, process design of tray tower, height of packings, Short path distillation, design and working of short path distillation, energy conservation in distillation	**08**
4	**Process Design of Absorbers** Selection criteria, design of absorber including multicomponent (with numerical) using shortcut methods	**08**
5	**Reactors:** Mass and Energy Balance for reactor, Choice of reactors-Reactor Configuration(Temperature Control, Catalyst Degradation, Gas–Liquid and Liquid–Liquid Reactors, Reactor Configuration, Reactor Configuration for Heterogeneous Solid-Catalyzed Reactions, Reactor Configuration from Optimization of a Superstructure	**06**
6	**Sizing/Costing of Equipments in Flow Sheet**: Distillation columns absorbers, pumps, compressors, heat exchangers(with numerical)	**08**
7	**Role and responsibilities:** Role and responsibility of process and chemical engineering profession towards society, environment, ethical aspects, safety concerns.	

Tutorials

- Minimum 8 tutorials should be conducted
- At least one tutorial on each module is expected.
- Tutorial on modules 2 to 6 must include numerical problems.
- One tutorial will be presentation on any process flow sheet demonstrating all the concepts in process engineering.

Term work

Term work should consist of minimum 8 tutorials from entire syllabus which are to be given at regular intervals batch wise.

Tutorial: 20 marks

Attendance: 05 marks
Total: 25 marks

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

Text Books

1. Process Engineering and Design: Shuchen B. Thakore, Bharat I Bhatt, Second Ed., McGraw Hill Education(I) Private Limited,2011-[modules 2,3].
2. Robin Smith, Chemical Process Design and Integration, John Wiley and Sons,[module 1,5]
3. Systematic Methods Of Chemical Process Design, Loren T Biegler, Grossman E.I., West-berg, A.W. Prentice Hall Intl ed., 1997.[module 4,6]
4. Richard M. Felder, Ronald W. Rousseau, Elementary Principles of Chemical Processes, John Wiley &Sons [Module 5].

References

1. Conceptual Design of Chemical Processes, J.M. Douglas, McGraw Hill International Editions, 1988
2. Chemical Process Equipment: selection & design, Walas, S.M., Butterworth, London,1980
3. Strategy of Process Engineering, John D.F. Rudd& C.C. Watson, Wiley & Sons International, 1968
4. Process Design Principles: synthesis analysis & evaluation, Sieder, W.D., Seader J.D. & Lewin D.R., John Wiley & Sons, 1998.
5. Analysis, Synthesis, and Design of Chemical Processes, Richard Turton, Richard C. Bailie, Wallace B. Whiting, Joseph A. Shaeiwitz, PHI Learning Private Limited, New Delhi, 2011.

Course Code	Course/ Subject Name	Credits
CHC703	**Process Dynamics and Control**	**4**

Prerequisites:

- Linear Algebra
- Differential Equations
- Laplace Transforms

Course Objectives:

- To understand dynamic behavior of process systems and equipments.
- To understand frequency response of dynamic systems.
- To understand and analyze stability characteristics of dynamic systems.
- To design controllers**.**

Course Outcomes:

- The student will be able to model dynamical systems
- Will be able to study their responses in Time, Laplace and Frequency domains.
- The student will be able to design stable controllers, for important chemical processes.

Module	Contents	Contact Hours
1	Introduction To Process Control Typical Control Problems A Blending Process Example Control Strategies Hierarchy of Control Activities An Overview of Control System Design	**04**
2	The Rationale for Dynamic Process Models General Modeling Principles Degrees of Freedom Analysis Typical Dynamic Models	**06**
3	Transfer Functions of Typical Systems First and Second Order Systems Properties of Transfer Functions Transfer Functions of Systems in Series Time Delay Processes Linearization of Non-linear Systems	**06**
4	Dynamic Behavior of Processes Standard Process inputs Response of First Order Processes Response of Second Order Processes Response of Integrating Processes	**08**
5	Development of Empirical Models From Process Data Fitting First and Second Order Models Using Step Tests Development of Discrete Time Dynamic Models Identifying Discrete Time Models From Experimental Data	**04**
6	Basic Control Modes Features of PID and On-off Control Response of Feedback Control Systems Digital Versions of PID Controllers	**04**
7	Closed-Loop Transfer Functions Closed-Loop Response	**08**

	Stability of closed loop systems Frequency Response Stability based on Bode criteria. Gain and Phase Margins	
8	Controller Design and Tuning Performance Criteria On-line controller Tuning Guidelines for common control loops	**04**
9	Control Strategies at the process unit level Degrees of Freedom Analysisfor process control Selection of Controlled , Manipulated , and Measured Variables Selection of Instrumentation Typical Applications	**04**

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

Text Books

1. Dale E. Seborg, Thomas F. Edga, Duncan A. Mellichamp Francis J. Doyle; Process Dynamics and ControlIII; Third Edition; John Wiley & Sons (Asia) Pvt. Ltd., New Delhi - 110002

References

1. William L. Luyben; Process Modeling Simulation and Control for Chemical Engineers; 2nd Edition; Mc-Graw Hill Publishing Co.
2. George Stephanopoulos; Chemical Process Control; PHI Learning Pvt. Ltd.
3. Sudheer S Baghade, G.D. Nageshwar, Process Dynamics and Control;, PHI learning Pvt. Ltd.
4. Prabir Kumar Sarkar, Advanced Process Dynamics and Control, PHI Learning Eastern Economy Edition.

Course Code	Name of Subject	Credits
CHDE7031	**Department Elective III- Corrosion Engineering**	**04**

Prerequisites:

- Basic knowledge of Chemical Engineering, Physical Chemistry and Electrochemistry, Basic knowledge of Reaction Mechanism, Thermodynamics, Fluid Flow and Chemical Reaction Engineering, Various types of Material and Metals.

Course Objectives:

- To understand the needs for Corrosion Education, The Functions and Roles of an Engineer to prevent Corrosion.
- Understanding of basic concepts of Corrosion, Corrosion in different materials, Corrosion Electrochemistry, Corrosion Thermodynamics, Kinetics and Applications.
- To impart the interdisciplinary subject in which Chemical Engineering, Materials Engineering, Electrical Engineering, Civil Engineering and Metallurgy Engineering are involved.
- Understand the Methodology, Methods and Materials to prevent the Corrosion.

Course Outcomes:

Upon completion of the course, the student should be able to

- Describe the Chemistry behind the corrosion, process of corrosion, different factors affecting the rate of corrosion.
- Discuss Kinetics and different forms of corrosion and will able to recognize the corrosion occurring in the different materials.
- Explain techniques of corrosion cells, Corrosion avoidance, corrosion failure and the various factors.
- Students shall understand how to prevent the corrosion, selection of materials for corrosion prevention, how to alter the environment for minimal rate of corrosion, different protection techniques and coating to prevent corrosion.
- Gain knowledge of corrosion by water, boilers feed water, cooling tower water and the scaling indices of water used in many processes. They will also learn about atmospheric corrosion, its tests as well as behavior and resistance to such corrosion.

Module	Contents	Contact Hours
01	**The Study of Corrosion-**Needs for Corrosion Education, The Functions and Roles of a Corrosion Engineer, The Corrosion Engineer's Education, Strategic Impact and Cost of Corrosion Damage. **Corrosion Basics-**Why Metals Corrode, Matter Building Blocks, Acidity and Alkalinity (pH), Corrosion as a Chemical Reaction, Corrosion in Acids, Corrosion in Neutral and Alkaline Solutions.	06
02	**Corrosion Electrochemistry-** Electrochemical Reactions, Anodic Processes, Faraday's Law, Cathodic Processes, Surface Area Effect. **Corrosion Thermodynamics-**Free Energy, Standard Electrode Potentials, Nernst Equation, Thermodynamic Calculations, Reference Half-Cells (Electrodes), Measuring the Corrosion Potential, Measuring pH, Potential-pH Diagram.	08
03	**Corrosion Kinetics and Applications of Electrochemistry to Corrosion-**What Is Over potential? Activation Polarization,	06

	Concentration Polarization, Ohmic Drop, Graphical Presentation of Kinetic Data(Evans Diagrams), Examples of Applied Electrochemistry to Corrosion	
04	**Eight Forms of Corrosion-**Recognizing Corrosion, General or Uniform Attack, Galvanic or Two metal Corrosion, Crevice Corrosion, Pitting, Intergranular, Selective Leaching, Erosion Corrosion, Stress Corrosion, Hydrogen Damage.	**08**
05	**Corrosion Failures, Factors, and Cells-** Introduction, Information to Look For, Identifying the Corrosion Factors, Examples of Corrosion Cells, Corrosion Avoidance, Visualizing Corrosion Cells.	**06**
06	**Corrosion Prevention-** Materials Selection, Alteration of Environment, Design, Cathodic and Anodic Protection, Coatings.	**06**
07	**Corrosion by Water**- Importance of Water, Corrosion and Water Quality and Availability, Types of Water, Cooling Water Systems, Steam Generating Systems, Water Treatment, Scaling Indices. **Atmospheric Corrosion-** Introduction, Types of Corrosive Atmospheres, Factors Affecting Atmospheric Corrosion, Measurement of Atmospheric Corrosivity Factors, Atmospheric Corrosivity Classification Schemes, Atmospheric Corrosion Tests, Corrosion Behavior and Resistance.	**08**

Assessment

Internal:

- Assessment consists of an average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions need to be solved.
- Question No.1 will be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules.

Textbook/References Book

1. Pierre R. Roberge, Handbook of Corrosion Engineering, McGraw-Hill Publication
2. Mars G. Fontana, Corrosion Engineering, McGraw-Hill Book Company
3. Pierre R. Roberge, Corrosion Engineering Principles and Practice, McGraw-Hill Pubication
4. Zaki Ahmad, Principles of Corrosion Engineering and Corrosion Control, Butterworth-Heinemann Publication
5. By Branko N. Popov, Corrosion Engineering: Principles and Solved Problems, Elsevier Publication

Course Code	Name of Subject	Credits
CHDE7032	Department Elective III- Industrial Organization and Management	04

Prerequisites

- Communication skills
- Basic Mathematical skills
- Analytical, logical and reasoning skills
- Operations Research

Course Objectives:

- To understand basic concepts business, administration and management
- To understand functions of management such as planning, organizing and decision making
- To understand corporate/company governance structures and laws governing industries
- To understand production and quality management
- To understand basics of marketing and sales management
- To understand financial management of companies

Course Outcomes:

5. Students will be able to use concepts and knowledge of management to excel in their career
6. Students should be able to prepare detailed plans, organization structures and able to use modern tools for decision making
7. Students should be able to use the knowledge of corporate government structures and government law to upgrade their skills
8. Students should be able to use concepts of production and quality management to improve productivity and quality in manufacturing plants
9. Students should be able to use concepts of marketing and sales to improve profitability of business they will work in future
10. Students should be able to use tools of finance and accounting to keep control and improve profitability of industry they are working in.

Module	Contents	Contact Hours
1	**Introduction to business and management** Business: Definition, Characteristics, Divisions, Objectives, Management of business Administration, Organization. Management: Definitions, characteristics, nature, principles, Objectives, difference between policies-goals-objectives role of manager and required managerial skills, Difference of relationship between business, administration and management, types of management, Typical management structure, management structure chart for medium scale industry, difference between management and administration, development of management thought-:Taylor, Fayol, Follet, Gilbreth, Gantt (in brief)	5
2	**Functions of management:** forecasting, planning, organizing, staffing, directing, controlling, coordinating, decision making (brief), **Planning**:- type of plans, steps in planning, management business objectives **(MBO)** **Organization**:Concept,definition,importance,characterization, process,principles of healthy organization, organization planning, organizational structure, design of organization	7

	structure, process of organization, organization chart, types of organizations: military, functional, line and staff, committee, matrix; departmentalization, span of management, delegation of authority, decentralization, organizational conflict **Decision making**: importance, types, theories, techniques, decision making process, scientific approach to decision making, guidelines for effective decision making, quantitative methods in decision making, markov analysis. Numericals based on decision making quantitative methods	
3	**Corporate Management Structures and laws governing industries** Industrial ownership: types of company ownership: single ownership, partnership, joint stock company, cooperative ,government companies; organs of company management and their functions(shareholders, board of directors, CEO, managing director, manager, secretary),state regulation of management, company law board, company meetings and resolutions. Companies act I**ndustries (Development and Regulation) Act, Contract Law, Indian Sale of Goods Act, Foreign Exchange Management Act,** Foreign Exchange Regulation Act , labor laws, factories act, payment of wages act, minimum wages act, workmen's compensation act, industrial disputes act, employees state insurance act, Union and industrial labor relations :trade unions and industrial relations, types of industrial disputes, settlements of industrial disputes, collective bargaining, handling of grievances and disputes	**7**
4	**Production and quality management** Production system, input -output model, application of microeconomics to industries, productivity and measures to increase productivity. Objectives and activities of production planning and production control, major steps in planning and control: routing, scheduling, dispatching, follow-up and expediting, types of production systems, supervision and functions of supervisor. Definition of quality, dimensions of quality, Deming's 14 points for management, Juran's quality trilogy, TQM,ISO 9000,ISO14000 Quality control meaning, objectives, benefits, steps, Inspection, cost of quality ,quality control tools for improvement, Quality circles, statistical quality control	**6**
5	**Marketing and sales management:** Sales management, sales organization, functions of sales department, duties of sales manager, the selling and marketing	**6**

	concept. Marketing: definition, principle and ,marketing management and its functions, marketing research, pricing policies, sales forecasting, marketing mix, advertising, sales promotion, channels of distribution, pricing, product mix and, international marketing	
6	**Financial Management:** Definition, difference between finance and accounts, functions of financial management, objectives of financial management, role and scope of financial management Sources of finance, cash management, capitalization. Definitions of assets, liabilities, book keeping, capital and types of capital, discounts, commission, debtor, creditor, turnover. Mechanics of accounting: cash books, sales book, purchase book, debit/credit note, journal, ledger. Financial accounting, accounting equation, balance sheet, income statements, preparation and analysis of financial statements, analysis and interpretation of financial statements, cash flow statements, ratio analysis **Management information system: MIS** Definition, objectives, functions, Difference between data and information, information as organizational resource, qualities of good information, management information categories, designing information systems, integrated information systems. Numericals	**7**

Assessment

Internal:

- Assessment consists of an average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions need to be solved.
- Question No.1 will be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules.

Textbook/References Book

1. Industrial Engineering and Management-O.P. Khanna, Dhanpat Rai publications (Module 1,2,3,4,5,6)
2. Fundamentals of Business Organization and Management, Y.K. Bhushan, S. Chand (Module 1,2,3)
3. Industrial Organization and Management: Dani, Sabhalok, Parikh, Shahani-Mananprakashan (Module 1,2,3,4)
4. Engineering Management, A.K. Gupta, S.Chand (Module 1,4,5,6)
5. Basic Financial Accounting for Management, Paresh Shah, Oxford press(Module

6)
6. Industrial Organization and Management, Basu S.K ,Prentice Hall India Learning Private Limited (1,2,3,4)
7. NPTEL Course Notes, Managerial Science II(Module 1,2,3,4,5)

Course Code	Course/ Subject Name	Credits
CHDE7033	Department Elective III- Petroleum Refining Technology	4

Prerequisites:

- Knowledge about Formation & Origin of petroleum, Composition & testing methods& Basic treatment techniques.

Course Objectives:

- To understand Petroleum Refining processes & products, its evaluation & treatment techniques

- To understand various cracking processes & its applications in Chemical industries.

Course Outcome:

- Characterize crude petroleum and petroleum refinery
- Fractionate crude petroleum into useful fractions
- Measure important physical properties of petroleum products
- Apply refinery processes to maximize desired petro products
- Use treatment techniques to purify petro products
- Manufacture widely used petrochemicals

Module	Contents	Contact Hours
1	**Introduction -Origin ,Formation & Composition of Petroleum:** Importance, Origin theory, Reserves in India & world. Exploration of Reserves, Types of crude, (Based on constituents, Sulfur contents & Degree API). Indian crude reserves & production scenario, Indian Petroleum Industry Scenario, Agencies engaged in upstream & downstream petroleum industry (Government & Private).	**05**
2	**Crude Oil Assay:** Properties, composition, UOP Characterization factors, Correlation index, Crude distillation curves. Important products test & methods, Gasoline, Kerosene, Diesel.	**06**
3	**Crude Oil Processing & Refining:** Separation of well fluid, Dehydration & desalting of crude, Heating of crude, Overall refinery flow diagram, its processes & Products, Low boiling products –LPG, Gasoline, Kerosene & their Specifications. Multi component fractionation of petroleum including pump around & side stripping, ADU & VDU, Blending of gasoline, Corrosion problem.	**12**
4	**Treatment ,Techniques & Product Specifications:** Treatment of Gasoline, Kerosene, Lubes & Wax.	**08**
5	**Catalytic Cracking & Thermal Processes:** Fluidized bed catalytic cracking, Catalytic reforming, Coking, Hydrogen Processes- Hydro cracking & Hydrodesulphurization, Alkylation Process, Isomerization process, Polymer gasoline.	**10**
6	**Asphalt Technology & Environmental issues:** Source of Asphalt, Air blowing of Bitumen, Brief review of Bio refinery, Environmental issues in Petroleum industry, Alternative energy sources (Bio Diesel, Heavy Oil, Shale Oil).	**07**

Assessment

Internal

- Assessment consists of average of two tests which should be conducted at proper interval

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions to be solved
- Question no.1 will be compulsory and based on entire syllabus where in sub questions can be asked.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each module.

References

1. B.K Bhaskara Rao, Modern Petroleum Refining Process.
2. W.L Nelson, Petroleum Refinery Engineering 4th ed, McGraw Hill.
3. Petroleum Chemistry and Refining Edited by James G. Speight, Taylor and Francies .
4. Chemical Process Industries, Austin, G.T Shreves.
5. Encyclopedia of chemical processing and design by john J. McKhetta; Marcel Deckker, Inc.

Course Code	Course/ Subject Name	Credits
CHDE7034	Department Elective III : Food Technology	04

Prerequisites:

- Knowledge of Microbiology, Biochemistry, chemical engineering

Course Objectives:

- To impart knowledge to the students about food processing and various unit operations involved in it, packaging, storing and preservation, food adulteration, food related hazards and safety.

Course Outcomes:

- Knowledge of food essential nutrients and the various causes of food deterioration.
- Identification of appropriate processing, preservation, and packaging method.
- Students should be able to analyze product quality and effect of processing technique on it.
- They should Identify important species of pathogenic microbes and describe factors that affect their growth in various types of food.
- Analysis of food related hazards and HACCP method

Module	Contents	Contact Hours
1.	**Food Biochemistry and Food Microbiology:** Food Constituents: Carbohydrates, Proteins, Vitamins, Lipids, And Minerals, Flavors, Water, Nutritional & sensory characteristics, Food fortification. Water activity enzymes: Production from microorganisms and application in food processing, Growth of microorganisms and food spoilage, D & Z values, Indian laws regulating Foods and Foods processing	**06**
2	**Ambient Temperature Process**: Raw material preparation, Size reduction of solid fibrous foods and in liquid foods., Emulsification and Homogenization ,Theory and equipment , Mixing and Forming, Extraction and expression , Membrane concentration Fermentation : Theory , Types, Equipment Effect on foods	**08**
3	**Thermal Processing**: Theory, Equipment, Effect on foods, blanching, extrusion, pasteurization, Heat Sterilization, In-container Ultra high temperature (UHT)/aseptic processes, Microbial spoilage, thermal death time curve.	**08**
4	**Freezing and Refrigeration**: Types, Equipments, refrigerants, effects of low temperature on quality, chilling, freezing , freeze drying and freeze concentration	**08**
5	**Food Storage & Packaging**: Modified Atmosphere Storage(MAS) , Hurdle Technology, Modified atmosphere packaging(MAP) **Food Adulteration & Quality Management**: Food Adulteration and food safety. HACCP, GMP, GHP, GLP.	**06**
6	**Food Processing:** Manufacturing and processing of food products: Fruit juice processing, Alcoholic beverages, Milk and Milk Products; Milk powder, cheese, Ice cream, Tea coffee, cocca, Bread , Biscuits , confectionary(hard boiled sweets & chocolates)	**08**

Assessment

Internal

- Assessment consists of average of two tests which should be conducted at proper interval

End Semester Theory Examination

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions to be solved
- Question no.1 will be compulsory and based on entire syllabus where in sub questions can be asked.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each module.

Text Book

1. Fellows, P., Food Processing Technology: Principles and Practice , 2nd ed., Woodhead Publishing Ltd., England , 2000.

Reference Books

1. Toledo, R., Fundamentals of Food Process Engineering, 2nd ed., CBS Publishers &Distributors, New Delhi, 1997.
2. Sharma K., et.al., Food Process Engineering, Theory and Laboratory Experiments, John Wiley and Sons Inc., Canada 2000.
3. Pandey and Srivastava , Chemical Process Technology , Vol.2
4. Singh, R.P. & Heldman , D.R., Introduction to Food Engineering, 3rd ed., Academic press, UK 2001.
5. Lelieveld, H.L.M., et.al. Hygiene in Food Processing, Woodhead Publ. Ltd., England 2003.
6. Subbulakshmi G. & Udipi S.A., Food Processing and Preservation, New Age International Pvt. Ltd., India 2001.
7. Valentas, k.J.et.al., Food Processing Operations and scale up, Marcel Dekker, N.Y 1991.
8. Tamb, I.A. and Singh R.P., Food Storage Stability CRC Press 19981.
9. D. G. Rao, Fundamentals of Food Engineering, PHI Learning Pvt. Ltd.

Course Code	Course Name	Credits
ILO7011	**Institute Level Optional Subject I- 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 Hours
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:**	05

	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.	
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**

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

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
ILO7012	Institute Level Optional Subject I- 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 Hours
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	05

	Interchangeability, Modularization and Accessibility, Repair Vs Replacement. Availability – qualitative aspects.	
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

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

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
ILO7013	Institute Level Optional Subject I- 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 Hours
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

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

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, 10^{th} Ed., Prentice Hall, 2007.
3. D. Boddy, A. Boonstra, Managing Information Systems: Strategy and Organization, Prentice Hall, 2008

Course Code	Course Name	Credits
ILO7014	Institute Level Optional Subject I- 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 Hours
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	07

	4.6 Fractional Factorial Split-Plot Designs	
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**

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

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, Practical Experiment Designs for Engineers and Scientists, 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
ILO7015	Institute Level Optional Subject I- 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 Hours
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	14

	Integer Programming Problem: Introduction, Types of Integer Programming Problems, Gomory's cutting plane Algorithm, Branch and Bound Technique. Introduction to Decomposition algorithms.	
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**

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

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, Kedar Nath Ram Nath-Meerut.
5. Operations Research, Kanti Swarup, P. K. Gupta and Man Mohan, Sultan Chand & Sons.

Course Code	Course Name	Credits
ILO7016	Institute Level Optional Subject I- 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 Hours
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,	8

	The Need for an Indian Cyber Law	
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**

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. Nina Godbole, Sunit Belapure, *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
ILO7017	Institute Level Optional Subject I- 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 Hours
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	06

	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.	
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: 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.	**06**

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

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
ILO7018	Institute Level Optional Subject I- 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 Hours
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**	10

	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.	
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

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

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
ILO7019	Institute Level Optional Subject I- Development Engineering	03

Pre-requisite:

- Interest in societal development.

Course Objective:

- To understand the characteristics of rural Society and the Scope and Nature and Constraints of rural Development.
- To study Implications of 73rd CAA on Planning, Development and Governance of Rural Areas
- The objective of the course is an exploration of human values, which go into making a 'good' human being, a 'good' professional, a 'good' society and a 'good life'. The context is the work life and the personal life of modern Indian professionals.
- To understand the Nature and Type of Human Values relevant to Planning Institutions.

Course Outcome:

- Students will be able to apply knowledge for Rural Development.
- Students will be able to apply knowledge for Management Issues.
- Students will be able to apply knowledge for Initiatives and Strategies
- Students will be able to develop acumen for higher education and research.
- Students will master the art of working in group of different nature.
- Students will develop confidence to take up rural project activities independently.

Module	Contents	Contact Hours
1	Introduction to Rural Development Meaning, nature and scope of development; Nature of rural society in India; Hierarchy of settlements; Social, economic and ecological constraints for rural development.	04
2	Roots of Rural Development in India Rural reconstruction and Sarvodaya programme before independence; Impact of voluntary effort and Sarvodaya Movement on rural development; Constitutional direction, directive principles; Panchayati Raj - beginning of planning and community development; National extension services.	04
3	Post-Independence rural Development BalwantRai Mehta Committee - three tier system of rural local Government; Need and scope for people's participation and Panchayati Raj; Ashok Mehta Committee - linkage between Panchayati Raj, participation and rural development.	04
4	Rural Development Initiatives in Five Year Plans Five Year	06

	Plans and Rural Development; Planning process at National, State, Regional and District levels; Planning, development, implementing and monitoring organizations and agencies; Urban and rural interface - integrated approach and local plans; Development initiatives and their convergence; Special component plan and sub-plan for the weaker section; Micro-eco zones; Data base for local planning; Need for decentralized planning; Sustainable rural development.	
5	Post 73rd Amendment Scenario 73rd Constitution Amendment Act, including - XI schedule, devolution of powers, functions and finance; Panchayati Raj institutions - organizational linkages; Recent changes in rural local planning; Gram Sabha - revitalized Panchayati Raj; Institutionalization; resource mapping, resource mobilization including social mobilization; Information Technology and rural planning; Need for further amendments.	**04**
6	Values and Science and Technology Material development and its values; the challenge of science and technology; Values in planning profession, research and education.	**04**
7	Types of Values Psychological values — integrated personality; mental health; Societal values — the modern search for a good society; justice, democracy, rule of law, values in the Indian constitution; Aesthetic values — perception and enjoyment of beauty; Moral and ethical values; nature of moral judgment; Spiritual values; different concepts; secular spirituality; Relative and absolute values; Human values— humanism and human values; human rights; human values as freedom, creativity, love and wisdom.	**06**
8	Ethics Canons of ethics; ethics of virtue; ethics of duty; ethics of responsibility; Work ethics; Professional ethics; Ethics in planning profession, research and education	**04**

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

Recommendation

Students can take any one or two live projects beneficial to rural population or society at large.

Reference

1. ITPI, Village Planning and Rural Development, ITPI, New Delhi
2. Thooyavan, K.R. Human Settlements: A 2005 MA Publication, Chennai
3. GoI, Constitution (73rdGoI, New Delhi Amendment) Act, GoI, New Delhi
4. Planning Commission, Five Year Plans, Planning Commission
5. Planning Commission, Manual of Integrated District Planning, 2006, Planning Commission New Delhi
6. Planning Guide to Beginners
7. Weaver, R.C., The Urban Complex, Doubleday.
8. Farmer, W.P. et al, Ethics in Planning, American Planning Association, Washington.
9. How, E., Normative Ethics in Planning, Journal of Planning Literature, Vol.5, No.2, pp. 123-150.
10. Watson, V. , Conflicting Rationalities: -- Implications for Planning Theory and Ethics, Planning Theory and Practice, Vol. 4, No.4, pp.395 – 407

Course Code	Course Name	Credits
CHP701	Project-A	03

Guidelines:

- Project groups: Groups can formed with minimum TWO and not more than THREE students per group.
- Students should spend considerable time in applying all the concepts studied, into the Project, hence, eight hours each are allotted in project A and B to the students.
- Students are advised to take up industrial/ experimental/ simulation and/or optimization based topics for their project.
- Students should report their guides with their work on weekly basis.

Exam Guidelines

Term Work - 100 Marks:

- Presentation – 50 Marks
- Report -50 Marks

Oral – 25 Marks

Course Code	Course Name	Credits
CHS701	Seminar	03

Guidelines:

- Each student has to present Seminar on the topic which will be the consensus of the project guide and the student, considering the recent development in the field of Chemical Engineering.
- The load for seminar will be calculated as one hour per week irrespective of the number of students

Exam Guidelines

Term Work - 50 Marks:

- Seminar Presentation – 25 Marks
- Report -25 Marks

Course Code	Course Name	Credits
CHL701	Process Equipment Design Lab	1.5

Concept of Lab

The practical shall include Design and Drawing of:
Minimum TEN practicals should be performed

1. Heat Exchangers
2. Short Tube vertical Evaporator
3. Distillation Column
4. High Pressure vessels

With respect to:

- Symbols
- P & I D
- Plot plan and Tank farm
- Plant Layout

Term work

Term work shall be evaluated based on performance in practical.

Practical Journal: 20 marks
Attendance: 05 marks
Total: 25 marks

Course Code	Course Name	Credits
CHL702	Chemical Engineering Lab X (PDC)	1.5

Minimum of TEN experiments should be performed from the modules of Theory Course Process Dynamics and Control (CHC703)

Term work

Term work shall be evaluated based on performance in practical.

Practical Journal: 20 marks
Attendance: 05 marks
Total: 25 marks

Practical Examination

- Duration for practical examination would be the same as assigned to the respective lab per week.
- A student becomes eligible for practical examination after completing a minimum of eight out of ten experiments.

University of Mumbai
Program Structure for B.E. Chemical Engineering (Revised 2016)
B.E. Semester VIII (w.e.f 2019-2020)

Course code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
CHC801	Modeling, Simulation & Optimization (MSO)	4	-	-	4	-	-	4
CHC802	Project Engineering & Entrepreneurship Management	3	-	1	3	-	1	4
CHC803	Energy System Design	3	-	1	3	-	1	4
CHDE804X	Department Elective IV	4	-	-	4	-	-	4
ILO802X	Institute Elective II	3	-	-	3	-	-	3
CHP801	Project B	-	-	8	-	-	6	6
CHL801	Chemical Engineering Lab XI (MSO)	-	2	-	-	1	-	1
	Total	17	2	10	17	1	8	26

Course code	Course Name	Examination Scheme								
		Theory					Term Work	Pract /Oral	Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in hrs)				
		Test 1	Test 2	Avg						
CHC801	Modeling, Simulation & Optimization (MSO)	20	20	20	80	3	-	-	-	100
CHC802	Project Engineering & Entrepreneurship Management	20	20	20	80	3	25	-	-	125
CHC803	Energy System Design	20	20	20	80	3	25	-	-	125
CHDE804X	Department Elective IV	20	20	20	80	3		-	-	100
ILO802X	Institute Elective II	20	20	20	80	3		-	-	100
CHP801	Project B	-	-	-	-	-	100	-	50	150
CHL801	Chemical Engineering Lab XI (MSO)	-	-	-	-	2	25	25	-	50
	Total			100	400	-	175	25	50	750

Department Elective IV (Sem VIII)		
Engineering Stream (Course Code)	Management Stream (Course Code)	Technology Stream (Course Code)
1. Advanced Process Control (CHDE8041)	1.Total Quality Management (CHDE8042)	1. Advanced Separation Technology (CHDE8043) 2. Polymer Technology (CHDE8044)

Institute Level Optional Subject II (Sem VIII)		
1. Project Management (ILO8021)	4. Human Resource Management (ILO8024)	7. IPR and Patenting (ILO8027)
2. Finance Management (ILO8022)	5. Professional Ethics and CSR (ILO8025)	8. Digital Business Management (ILO8028)
3. Entrepreneurship Development and Management (ILO8023)	6. Research Methodology(ILO8026)	9. Environmental Management (ILO8029)

Course Code	Name of Subject	Credits
CHC801	Modelling Simulation and Optimization	04

Prerequisites:

- Linear Algebra, Process Calculations, Computer Programming

Course Objectives:

- To make students understand writing and solving models of chemical engineering system
- To make students understand writing and solving systems of nonlinear equations for single and multiple units
- To make students understand simulation of complete flowsheets
- To make students understand optimization of single and multiple units

Course Outcomes:

- The students will be able to write and solve models of chemical engineering system.
- The students will be able to carry out sequential and equation oriented simulation of complete flowsheets.
- The student will be able to optimize typical chemical processes.

Module	Contents	Contact hrs
01	Modeling Aspects: 1.1 Definition of process model, physical and mathematical modeling, classification of models, model building, classification of mathematical methods 1.2 Mathematical Models of Chemical Engineering Systems: Introduction, uses of mathematical models, scope of coverage, principles of formulation, fundamental laws, continuity equations, energy equations, equation of motion, transport equation, equation of state, equilibrium, kinetics.	08
02	Examples of Mathematical Models of Chemical Engineering Systems: Introduction, series of isothermal, constant-hold up CSTR, CSTR with variable holds up, two heated tanks, gas-phase, pressurized CSTR, non-isothermal CSTR, single-component vaporizer, batch reactor, reactor with mass transfer, ideal binary distillation column ,batch distillation with holdup. Degree of Freedom analysis Concept of design and rating problem in context of selection variables after DOF analysis.	10
03	Introduction to Simulation, Sequential and Equation oriented Simulation, Flowsheet topology analysis, Recycle, Partitioning and Tearing of flow sheets. Simulation Examples, Williams Otto Flowsheeting	08

04	Numerical Methods for solving sets of nonlinear equations, Newton's method with Armijo Line search, Successive substitution. Solution for models developed in module 2	**08**
05	Introduction to Optimization. Unconstrained single and multi variable non-linear optimization. Numerical methods for single and multivariable optimization. Golden section and Newton's method, for Single variable case, and Gradient and Newton's method for multi-variable cases may be considered. Optimization of specific process units such as Heat exchangers, Reactors, Separation equipment etc. can be considered.	**16**

Assessment

Internal:

- Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions need to be solved.
- Question No.1 will be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each Module.

Reference

1. William Y.Luyben, Process Modelling simulation and control for chemical Engineer, Second edition McGraw Hill
2. Thomas Edger, David M. Himmelbleau, Optimization of chemical processes, 2nd Ed., John Wiley
3. Lorenz T. Beigler, Ignacio E. Grossman, Arthur W. Wesburg, Systematic Methods of Chemical Process Design, Prentice Hall

Course Code	Course/ Subject	Credits
CHC802	Project Engineering and Entrepreneurship Management	04

Prerequisites:

- Communication skills, Mathematical skills, Analytical, logical and reasoning skills

Course Objectives:

- To understand basic concepts project management and application of PM to process industries
- To understand project feasibility reports and learn about various clearances required to start an industry
- To learn various project organizations and basics of contracting
- To learn various tools and techniques used in PM and understand role of entrepreneurship in the society for the economic growth.

Course Outcomes:

Students will be able to use

- concepts and knowledge of project management to manage projects in process industries
- Students should be able to prepare feasibility reports.
- Students should be able to understand various clearances required to start industry
- Students should be able to prepare project organization charts and contracts
- Students should be able to prepare contracts
- Students should be able to use tools of PM to solve problems and will be motivated to become entrepreneurs

Module	Name of module and contents	Contact Hours
1	**Concepts of project management**: Definition of project, project management, project types, project life cycle: purpose, inputs, project manager's role and outputs, Tools and techniques in project management, major knowledge areas of project management , Difference between project management and formal management, Role-responsibilities and skills of project manager, project overruns Project management in process industries: project strategy, project specification, project engineering, detailed design, procurement, construction, commissioning and closure Case studies : swagruha constructions, Advanced recycling sciences, superclean paperboards, Instron manufacturing company, Ind constructions, Goshe Corporation, accorn, govt of India bridge project Delhi, Jharkhand project	10

2	**Feasibility report, licensing and clearances** Feasibility reports: Raw material survey, Market survey and demand study, technical study, location survey, financial survey and types of cost estimates, Estimation of project profitability Industrial license and LOI, Various laws & regulations governing industries, need for clearances and influences on project, List of various clearances. Case studies: Discussion of feasibility report for soap/mustard oil / ready to eat snacks, Decotile corporation, SIRIS pharma Hyderabad, coal fired boilers project, plant on river Yangtze, IC software, temples and towers. Numerical based on cost benefit analysis, profitability, cost estimation	**06**
3	**Project organization and contracting** Project scope, project priorities, development of WBS, Development of process breakdown structure, Development of responsibility matrix, development of project communication plan. The traditional management structure, Project management organizational structure: pure project, matrix, task force, Project team, responsibilities of various members. Contracts types, selection criteria,3R of contracting, types of reimbursements and tendering procedure Case study: Hindustan oil company: Hamad petroleum company, corel production systems, Jones and Shephard Accountants, White manufacturing, Hotel pulkeshi international	**06**
4	**Tools and techniques in project Management and entrepreneurship:** Health-safety and environmental guidelines for chemical plants Quality assurance, Hazard analysis, Risk analysis and management, Change Management. Cost benefit analysis, Project execution plan (PEP), Bar charts/GANTT charts, LOB, Networking techniques (PERT/CPM), Productivity budgeting techniques, Value engineering (VE) , ABC and VED Analysis , Economic Order Quantity (EOQ), CAT vs RAT, Time and cost control tools and techniques. Use of Microsoft projects. Entrepreneurship: Definition, Concept of entrepreneur and entrepreneurship, Characteristics, aspects, factors affecting entrepreneurship, Classification and types of entrepreneurship based on business, technology, motivation, growth and stages of development. Case: Prima industries, Rudra offshore, Bhargava oils case, Acme Corporation. Numerical based on topics mentioned above.	**08**

Term-work Marks: 25 Marks

- Assignments : 20 Marks

- Attendance : 05 Marks

A total of 10 tutorials need to be conducted. At least one tutorial on each module is expected. Six tutorials will be based on case studies and 4 tutorials based on numerical

Assessment

Internal

- Assessment consists of average of two tests which should be conducted at proper interval

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions to be solved
- Question no.1 will be compulsory and based on entire syllabus where in sub questions can be asked.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each module.

References

1. Project Management, Choudhary, S., Tata McGraw Hill(module 1 to 4)
2. Total Project Management, Joy, P. K.,(module 1 and 2)
3. Project Management for process Industries, Gillian Lawson, I chem. E (Module 1 and 4)
4. Project Management Case Studies, Harold Kerzner, Second edition, John Wiley and Sons (for case studies)
5. Project Management Methodology Guidelines, City of Chandler (Module 1)
6. Project Management-The Managerial Process, Clifford Gray, 6th edition, McGraw Hill (module 1, 2, 3)
7. Plant Design and Economics for Chemical Engineers, Klaus D Timmerhaus, 5th edition, McGraw Hill (Module 2 and 4)
8. Theory and problems in financial management, Khan, M.Y.; Jain, P.K.; Second Edition, Tata McGraw Hill (Module 2 and 4)
9. Fundamentals of Financial Management, Vyuptakesh Sharan, Second Edition, Pearson publications(module 2 and 4)
10. Dynamics of entrepreneurial development and management, Vasant Desai (module 4)

Course Code	Course/ Subject Name	Credits
CHC803	Energy System Design	4

Prerequisites:

- The students should have knowledge of Heat transfer to carry out Energy balance.
- They should be aware about basic principles of economics to evaluate cost and profit of energy efficient operations/modifications/techniques.
- They should be familiar with various types of plant utilities.
- They should be familiar with basic Industrial systems/operations like, HVAC, Lighting,
- Steam, Refrigeration, etc.

Course Objectives:

- To provide training to solve problems relevant to the energy conservation.
- To provide students the knowledge in planning conducting energy audit, energy survey, and evaluate energy conservation opportunities.
- To provide knowledge to design and evaluate energy efficient technologies such as heat exchanger networks, multiple effect evaporators, co-generation, etc.

Course Outcomes:

- The graduates should able to design an energy system to meet the desired needs within realistic constraints such as economic, environmental, social, ethical, health and safety, manufacturability and sustainability.
- The graduates should able to function on multidisciplinary teams, identify, formulate and solve engineering problems.
- The graduates are expected to have knowledge of professional and ethical responsibility.
- The graduates should able to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Module	Contents	Contact Hours
1	**Energy Audit:** Energy audit methodology, Types of energy audit, instrumentation used in energy audit, Safety considerations during energy audit, Post audit analysis.	02
2	**Energy Efficient Technologies:** Energy efficient techniques for lighting system, motors, belt and drives system, fans and pumps system, compressed air system; steam system, refrigeration system.	02
3	**Energy Integration in The Process Industries:** Temperature Pinch analysis, concept of minimum number of heat exchangers, Heat Exchanger Network design, Threshold approach temperature difference, targeting for number of shells, Area targets, Optimum approach temperature difference	13

4	**Heat Integration in Process Units:** Heat integration of Multiple effect evaporators (MEE) with background process. Heat integration MEE with and without vapour re-compression: mechanical vapour re-compression, thermal vapour re-compression. Distillation column: heat integration in distillation column – multiple effect distillation, heat pumping, vapour re-compression, Reboiler flashing. Different arrangements of heat integration of columns with background process.	**10**
5	**Co-generation:** Definitions, Brayton cycle, Rankine cycle, topping cycle, bottoming cycle, combined cycle. Steam turbine system, gas turbine system, combined gas steam turbine system, diesel engine system. Heat integration and cogeneration.	**06**
6	**Waste Heat Recovery (WHR):** Waste heat sources, quality and classification of waste heat and its applications. Benefits of WHR. WHR equipments like recuperators, radiation/convective hybrid recuperator, ceramic recuperator, regenerator, heat wheel, heat pipe, waste heat boiler, economizer, heat pumps.	**03**
7	**Global Energy Scenario:** national and international.	Assignment

Term work

Term work should consist of minimum 8 tutorials from entire syllabus which are to be given at regular intervals batch wise.

Tutorial: 20 marks

Attendance: 05 marks

Total: 25 marks

Assessment:

Internal:

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination:

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

Text Books:

1. Robin Smith, Chemical Process Design and Integration, Wiley India, 2005. [Module: 3, 4, 5, 6]

2. Serth, Robert W., Process Heat Transfer Principles and Applications, Elsevier Science & Technology Books, 2007. [Module: 3]
3. Wayne C. Turner, Steve Doty (Ed.), Energy Management Hand Book, John Wiley and Sons, 2000. [Module: 1, 2, 5, 6]

References:

1. Seider W. D., and Seader J. D. and Lewin D. R., Process Design Principles, John Wiley and Sons Inc., 1988.
2. Douglas J. M., Conceptual Design of Chemical Process, McGraw Hill Book Co., 1988.
3. Biegler L. T., Grossman E. I. and Westerberg A. W., .Systematic Methods of Chemical Process Design., Prentice Hall International Ltd., 1997.
4. P K Nag, Power Plant Engineering, The McGraw-Hill Publishing Company Limited.
5. H.M. Robert, J.H. Collins, Handbook of Energy Conservation-Volume 1, CBS Publishers & Distributors.
6. D. P. Kothari, K. C. Singal, Rakesh Ranjan, Renewable Energy Sources and Emerging Technologies, PHI Learning Pvt Ltd, Second Edition.
7. https://www.beeindia.gov.in

Course Code	Course/Subject	Credits
CHDE8041	Department Elective IV: Advanced Process Control	4

Prerequisites:

- Linear Algebra, Differential Equations, Difference Equations, Laplace Transforms.

Course Objectives:

- To understand dynamics of MIMO processes.
- To understand Batch Process Control.
- To understand Model Predictive Control.
- To design digital controllers.

Course Outcomes:

- The student will be able to analyze multi-loop and multi-variable control systems.
- The student will be able to design batch controllers.
- The student will be able to design MIMO controllers.
- The student will be able to design Model Predictive Controllers.

Module	Contents	Contact Hours
1.	Advanced SISO Control Strategies: Cascade Control, Time Delay Compensation, Inferential Control, Selective Control/Override Systems, Nonlinear Control Systems, Adaptive control Systems	**06**
2	Digital Sampling Filtering and Control: Sampling and Signal Reconstruction, Signal Processing and Data Filtering, z-Transform Analysis for Digital Control, Tuning of Digital PID Controllers, Direct Synthesis for Design of Digital Controllers, Minimum Variance Control	**06**
3	Multiloop and Multivariable Control: Process and Control Loop Interactions, Pairing of Control and Manipulated Variables, Singular Value Analysis, Tuning of Multi-loop PID Control Systems, Decoupling and Multivariable Strategies, Strategies for Reducing Control Loop Interactions	**06**
4	Model Predictive Control: Overview of Model Predictive Control, Predictions for SISO Models, Predictions for MIMO Models, Model Predictive Con trol Calculations, Set Point Calculations, Selection of Design and Tuning Parameters, Implementation of MPC	**06**
5	Batch Process Control: Batch Control Systems, Sequential and Logic Control, Control During The Batch, Run-to-Run Control	**06**
6	Introduction To Plantwide Control: Plantwide Control Issues, Hypothetical Plant for Plantwide	**06**

	Control Studies, Internal Feedback of Material and Energy, Interaction of Plant and Control System Design	
7	Plantwide Control System Design: Procedures for the Design of Plant wide Control Systems. A Systematic Procedure for Plantwide Control System Design. Case Study: The Reactor/Flash Unit Plant, Effect of Control Structure on Closed Loop Performance	**06**
8	Optimal Control: Introduction to Optimal Control, Batch Process Optimisation	**06**

Assessment

Internal:

Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions need to be solved.
- Question No. 1 should be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all modules .
- Weightage of marks should be proportional to number of hours assigned to each module.

References

1. Dale E. Seborg, Thomas F. Edgar, Duncan A. Mellichamp, Francis J. Doyle III, Process Dynamics and Control, 3 Ed., John Wiley & Sons (Asia) Pvt. Ltd., New Delhi.
2. William L. Luyben, Process Modeling Simulation and Control For ChemicalEngineers,2 Ed., McGraw Hill Publishing Co.
3. Stephanopoulos, Chemical Process Control, PHI Learning Pvt. Ltd.
4. D Patranabis, Principles of Process Control, McGraw Hill Education
5. Donald R Coughanowr, Stevan E Leblance, Process System Analysis and Control, McGraw Hill Education.

Course Code	Course/Subject	Credits
CHDE8042	Department Elective IV: Total Quality Management	4

Prerequisites:

Course Objectives:

- To acquaint with the significance and features of TQM philosophy.
- To familiarize with various quality tools and their uses in problem solving.
- To appraise on the modern productivity improvement approaches and their interface with TQM
- To familiarize with various quality standards, quality auditing and certification methodology.
- To give and an insight into the ongoing global trends in quality approach and practices with special forms to the customer relationship

Course Outcomes:

Learner will be able to:

- Appreciate the importance of quality and its dimensions in striving for excellence
- Understand the conscious compromise between cost and quality
- Develop competency in the selection in various manufacturing and service functions
- Develop competency in the use of appropriate quality tools in various manufacturing and service functions
- Integrate quality approaches for productivity improvement.
- Acquire knowledge base and develop skills for conducting quality audits

Module	Contents	Contact Hours
01	**Introduction:** Definition of Quality, principles and dimensions of TQM Quality in manufacturing and service segments. Approach in implementation of TQM, barriers in implementation. Cost of quality prevention, appraisal and failure costs, hidden costs, trade-o between quality and cost.	8
02	**Planning for quality and Quality improvement:** Planning for quality: Need for quality policies and objective. Significance of top management commitment, strategic planning for quality. Quality improvement: Management of controllable defects, operator controllable defects, sporadic and chronic problems of operator controllable defects, sporadic and chronic problems of quality, Pareto's principle. Bench marking: Definition and significance, data collection for bench marking and its use.	8
03	**Customer relations:** Customers, user and consumers, product awareness, types of	8

	customers, customer perception and expectations. Quality feedback and redressal. Basic principles of reliability: quality and reliability, Product life cycle, trade-o between maintainability.	
04	**Vendor relations:** Vendor as a partner, vendor selection, vendor evaluation. Push Pull view of supply chain and cycle view of chain management	**8**
05	**SQC Tool:** Histograms, Pie charts, Scatter diagrams, Cause and diagram etc. **Statistical Process Control:** **Process variability:** Variables and process variation, measures of accuracy and centering, precision or spread, normal distribution **Process Control:** Control charts for variables (X-chart, R- chart, -chart) and attributes (np-charts, p-chart, c-charts, U-chart)Process capability: OC curve, acceptance sampling, single and double sampling producer's and consumer's risk.	**8**
06	**Quality System:** **Quality standards:** • ISO 9001:2000 Quality management system. ˆ • ISO 14001:2004 Environmental management system. • ISO 27001:2005 Information security management system. **Quality assurance:** Nature of assurance, reports on quality, measuring performance, internal audit, surveillance audit, quality certification methodology and implications **Productivity improvement Tools/ Approaches/ Techniques:** Principles of Six-Sigma, approaches like JIT, Lean manufacturing zero defect concept, KANBAN, QFD, FMEA, Basics of DOE and Shining concepts of quality. Productivity improvement techniques like 5S, POKAYOKE, SMED, KAIZEN and Concurrent Engineering.	**8**

Note: Seminar/Case study presentation with report by individual or in groups comprising of not more than three students can be considered.

Assessment

Internal:

Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions need to be solved.
- Question No. 1 should be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all modules .

- Weightage of marks should be proportional to number of hours assigned to each module.

References

1. Juran, J. M., Gryana, F. M., Quality planning and analysis, TMH.
2. Bester Fidd, D. H., et.al., Total quality management, Prentice Hall.
3. Erossbly, Pillip b., Quality is free, Mentor/New Americal Library.
4. Ishikawa, K., What is total quality control? The Japanese way, Prentice Hall
5. Fergenbaum, Armand V., Total quality control.
6. Logothetis, N., Managing for total quality, Prentice Hall
7. Aurora, K. C., Total Quality Management, S. K. Kataria and Sons
8. Haldar, U. K., Total Quality Management, Dhanpatrai and Co.

Course Code	Course/ Subject Name	Credits
CHDE8043	Department Elective IV: Advanced Separation Technology	4

Prerequisites:

- Basic knowledge regarding fundamental separation Processes and its application in chemical Industries.

Course Objectives:

The students completing this course are expected to understand:

- The various separation principles like adsorption process, the types and designs.
- The supercritical extraction and modern distillation process.
- Introduction to foam fractionation process and application in waste water treatment.
- Liquid chromatography – types and separation of enzymes using it.
- Types of membranes, membrane characterization, membrane material, membrane modules, membrane applications in biotechnology and other industries.

Course Outcomes:

- The graduates are expected to have ability to apply knowledge of mathematics, science and engineering.
- The graduates are expected to have ability to design a system, a component, or a process to meet the desired needs within realistic constraints such as economic, environmental, social, ethical, health and safety, manufacturability and sustainability.
- The graduates are expected to possess ability to identify, formulate and solve engineering problems.
- The graduates are expected to possess ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Module	Content	Contact Hours
1.	**Adsorption Process:** Absorbent such as activated carbon, molecular sieves of various types, activated alumina. Their characteristics and applications. Regeneration & Activation of absorbents. Thermal & pressure swing process. Fixed bed, moving bed, stimulated moving bed and other processing schemes. Design of adsorption process for separation and purification. Industrial examples and related numericals.	8
2.	**Super critical extraction and advanced distillation techniques:** Working principle, advantages and disadvantages of supercritical solvents over conventional liquid solvents, advantages and disadvantages of supercritical extraction over liquid- liquid extraction. Commercial applications of supercritical extraction. The concept of advanced distillation techniques, advantages and disadvantages and comparison with conventional techniques.	8

3.	**Foam Fractionation Process:** Foam Formation, coalescence, collapse and drainage phenomena Adsorption properties of foams. Principle of froth flotation,. Application of froth flotation in industries and waste water treatment.	**8**
4.	**Liquid Chromatographic Process:** Basic concept of chromatography, phenomena and characterization. Various chromatography options. Typical chromatographic separation systems for preparative chromatography. Applications of chromatography in enzymes and other Industrial separations.	**8**
5.	**Membrane process:** Introduction to the membrane process, definition of membrane, importance, process. **Characterization of membranes:** Characterization of porous membranes, characterization of ionic membranes, characterization of non-ionic membranes. Preparation of synthetic membranes. Preparation of phase inversion membranes. Preparation techniques for immersion precipitation, preparation techniques for composite membranes, influence of various parameters on membrane morphology, preparation of inorganic membranes. Transport process in membrane driving force. Polarization phenomenon and fouling concentration polarization, characteristic flux behavior in pressure driven membrane preparation, various models, membrane fouling, methods to reduce fouling. Modules and process design plate and frame, spiral wound, tubular, capillary, hollow fibre modules and liquid membranes.	**10**
6	**Applications of membranes in industries**: Introduction to various applications in the chemical and allied industries. Basics of design and numericals based on reverse osmosis and dialysis techniques	**6**

Assessment

Internal:

- Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions need to be solved.
- Question No. 1 should be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all modules .
- Weightage of marks should be proportional to number of hours assigned to each module.

References

1. Ruthven, D.M., Principal Adsorption & Adsorption Process, Wiley, 1984.
2. Lemlich, R., Adsorptive Bubble Separation Techniques, Academic Press, 1972.

3. Coulson, Richardson, Chemical Engineering, Vol.3, Pergamon.
4. Terybal, R.E, Mass Transfer Operations, McGraw Hill.
5. Ruthven, Faruqh, Knalbal, Pressure Swing Adsorption, VCH, 1994.
6. Snyder, Kirl, Introduction To Liquid Chromatography, 2 ed., 1979. University of Mumbai Chemical Engineering Rev 2014-15 42
7. Scott RTW, Liquid Chromatography Column Theory, Wiley, 1992.
8. Marcel Mulder, Basic Concepts Of Membrane Technology, Kluwer Academic Publishers (1997).
9. E.J. Hoffman, Membrane Separation Technology, Gulf Professional Publishing.
10. Nath, Membrane Separation Process, Prentice Hall of India.
11. Membrane Handbook - Editors W.S. Winston Ho, K.K. Sirkar, Van Nostrand Reinhold Publication.
12. J. D. Seader and E. J. Henely, Separation Process Principles.
13. C. J. King, Separation Processes.

Course Code	Course/ Subject Name	Credits

CHDE8044	Department Elective IV: Polymer Technology	04

Prerequisites:

- Chemistry, physics, Chemical reaction engineering

Course Objectives:

- To understand thermodynamics of polymer structure.
- To select polymerization reactor for a polymer product.
- To characterize polymers and state polymer additives, blends and composites.

Course Outcomes:

At the end of the course students will be able to

- Understand thermodynamics of polymer structure. .
- Student will identify various types of advance material in polymer, ceramics, & composites. Understand the properties of various polymeric, ceramic and metallic materials and their application in various fields.
- Select polymerization reactor for a polymer product
- Characterize polymers and state polymer additives, blends and composites.
- Student will have knowledge of different types of composite material, their properties and application
- After acquiring the knowledge in this subject, students become familiar with various aspects related to polymerization and can apply them for economic evaluation of chemical process and decide its feasibility

Module	Contents	Contact Hours
1	**Introduction:** Introduction and Classification of Polymers. Thermosets, Factors influencing the polymer properties, Glass Transition Temperature Monomers used for polymer synthesis, Thermoplastics, Linear Branch, Cross Linked Polymers. **Addition and Condensation Polymerisation:** Mechanism, kinetics, synthesis and reactions**.**	**05**
2	**Natural Polymers**: Chemical & Physical structure, properties, source, important chemical modifications, applications of polymers such as cellulose, lignin, starch, rosin, shellac, latexes, vegetable oils and gums, proteins etc. **Polymerization Techniques**: Bulk polymerization, Solution polymerization, Emulsion polymerization and Suspension polymerization, Interfacial Polymerization with their merits Comparison of the various processes Advantages and disadvantages.	**12**
3	**Molecular Weight and Molecular Weight Distribution**: Molecular Weights, Polydispersity Index, Different Methods of determination of Molecular weight, Effect of Molecular weight on	**08**

	Engineering Properties of Polymers. **Co-Polymerization**: Basic concept, Technical significance, steady state assumptions in free radical copolymerization, The copolymer equation, Instantaneous molar composition of copolymer formed; Monomer reactivity ratios; Significance and method of determination, Types of copolymers.	
4	**Polymerization Reactor**: Polymerization reactors types and mode of operation, Polymerization reactor design, control of polymerization, Post polymerization unit operations and unit processes Polymer Degradation.	**06**
5	**Polymer Processing:** High Performance and Specialty Polymers, Polymer additives, compounding. Fillers plastisizers lubricants colourants UV stabilizers, fire retardants, antioxidants, Different moulding methods of polymers. Injection moulding , blow moulding, thermoforming, film blowing etc.	**08**
6	**Manufacturing Processes**: Manufacturing of typical polymers with flow-sheet diagrams properties & application: PE, PP, PS, Polyesters, Nylons, ABS, PC, Teflon, Epoxy, Ureaformaldehyde,a nd poly Urathane. Manufacturing of thermoset polymers such as Phenolic resins	**13**

Assessment

Internal

- Assessment consists of average of two tests which should be conducted at proper interval

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions to be solved
- Question no.1 will be compulsory and based on entire syllabus where in sub questions can be asked.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each module.

References

1. Fried J R, Polymer Science and Technology, Prentice Hall of India Pvt. Ltd., New Delhi, Eastern Economy Edition, 2000.
2. Premamoy Ghosh, Polymer Science and Technology, 3rd Edition, Tata Mc. Graw-Hill Publishing Company, New Delhi, 2010.
3. R. Sinha, Outlines of Polymer Technology: Manufacture of Polymers, Prentice Hall of India Pvt. Ltd., New Delhi, 2002.
4. Gowarikar V.R. et.al., Polymer Science Wiley Eastern 1984.

5. Ghosh P, Polymer Science & Technology of Plastics & Rubbers Tata McGraw Hill, 1990.
6. Encyclopedia of Polymer Science & Engineering., Wiley 1988.
7. Rosen S.L. Fundamental Principles of Polymeric materials, 2nd e.d., John Wiley & Sons Inc, 1993
8. NiranjanKarak, Fundamentals of Polymers, PHI Learning Pvt. Ltd.

Course Code	Course Name	Credits

ILO8021	Institute Level Optional Subject II- 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 Hours
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.	6

	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	
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 (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.	**6**

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

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, 9th Ed.

Course Code	Course Name	Credits

ILO8022	Institute Level Optional Subject II- 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 Hours
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

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

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
ILO8023	Institute Level Optional Subject II- 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 Hours
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

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

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 McGraw Hill 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
ILO8024	Institute Level Optional Subject II- 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 Hours
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	7

	• 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	
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. • Training & Development: Identification of Training Needs, Training Methods	**5**
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**	**10**

	Evolution of IR, IR issues in organizations, Overview of Labor Laws in India; Industrial Disputes Act, Trade Unions Act, Shops and Establishments Act	

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

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
ILO8025	Institute Level Optional Subject II- 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 Hours
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	08

	India, Legal Aspects of Corporate Social Responsibility—Companies Act, 2013.	

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

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 Bidyut Chakrabarty, Routledge, New Delhi.

Course Code	Course Name	Credits
ILO8026	Institute Level Optional Subject II- 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 Hours
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	08

	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	
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 **6.3** Suggestions and Recommendation	**04**

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

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, (2^{nd}ed), Singapore, Pearson Education

Course Code	Course Name	Credits
ILO8027	Institute Level Optional Subject II- IPR and Patenting	03

Objectives:

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

Outcomes:

Learner will be able to…

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

Module	Detailed Contents	Contact Hours
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	08

	convention etc.)	
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

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

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, PritiMathur, AnshulRathi**,** 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
ILO8028	Institute Level Optional Subject II - 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	06

	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	
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 which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

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
ILO8029	Institute Level Optional Subject II- 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 Hours
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

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End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.

- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

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, Majid Hussain, 3rd Ed. Access Publishing.2015

Course Code	Course Name	Credits
CHP801	Project-B	06

Guidelines:

- Project groups: Students can form groups with minimum two and not more than 3 (three).
- Students should spend considerable time in applying all the concepts studied, into the Project, hence, eight hours each are allotted in project A and B to the students.
- Students are advised to take up industrial/ experimental/ simulation and/or optimization based topics for their project
- Students should report their guides weekly with work.

Exam Guidelines

Term Work - 100 Marks:

- Presentation – 50 Marks
- Report -50 Marks

Oral – 50 Marks

Course Code	Course Name	Credits
CHL801	Chemical Engineering Lab XI (MSO)	1

Concept of Experiment:
Students should be able to simulate process models using computer program or mathematical and chemical engineering software such as COCOO/DWSIM/Unisim,/ CWsim, /ChemCAD,/Hysys/ Aspen Plus / or any simulator.
Minimum TEN experiments must be performed.

- Simulation of pipe and pump network flows
- Simulation of linear and non linear systems
- Simulation of mass transfer processes like distillation, Absorption
- Simulation of Heat Transfer Process like Shell and tube heat exchanger
- Simulation of chemical reactor like batch, Semibatch, Continuous reactor
- Simulation of Multicomponent flash calculation for ideal and non ideal system
- Simulation of flowsheet calculation (Any chemical manufacturing process)
- Optimisation of chemical processes.

Term work
Term work shall be evaluated based on performance in practical.
Practical Journal: 20 marks
Attendance: 05 marks
Total: 25 marks

Practical Examination

- Duration for practical examination would be the same as assigned to the respective lab per week.
- A student becomes eligible for practical examination after completing a minimum of eight experiments out of ten experiments.