AC_____
Item No. _____

UNIVERSITY OF MUMBAI

Bachelor of Engineering

in

Chemical Engineering

Second Year with Effect from AY 2020-21

Third Year with Effect from AY 2021-22

Final Year with Effect from AY 2022-23

(REV- 2019 'C' Scheme) from Academic Year 2019 – 20

Under

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2019–2020)

AC_____

Item No. _____

UNIVERSITY OF MUMBAI

Syllabus for Approval

Sr. No.	Heading	Particulars
1	Title of the Course	**Second Year B.E. Chemical Engineering**
2	Eligibility for Admission	**After Passing First Year Engineering as per the Ordinance 0.6242**
3	Passing Marks	**40%**
4	Ordinances / Regulations (if any)	**Ordinance 0.6242**
5	No. of Years / Semesters	**8 semesters**
6	Level	~~P.G.~~ / **U.G.**/ ~~Diploma / Certificate~~ (Strike out which is not applicable)
7	Pattern	~~Yearly~~ / **Semester** (Strike out which is not applicable)
8	Status	**New** / ~~Revised~~ (Strike out which is not applicable)
9	To be implemented from Academic Year	**With effect from Academic Year: 2020-2021**

Date

Dr. S. K. Ukarande
Associate Dean
Faculty of Science and Technology
University of Mumbai

Dr Anuradha Muzumdar
Dean
Faculty of Science and Technology
University of Mumbai

Preamble

To meet the challenge of ensuring excellence in engineering education, the issue of quality needs to be addressed, debated and 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 Science and Technology (in particular Engineering) of University of Mumbai has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development.

Faculty resolved that course objectives and course outcomes are to be clearly defined for each course, so that all faculty members in affiliated institutes understand the depth and approach of course to be taught, which will enhance learner's learning process. 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 and not in teaching. It also focuses on continuous evaluation which will enhance the quality of education. Credit assignment for courses is based on 15 weeks teaching learning process, however content of courses is to be taught in 13 weeks and remaining 2 weeks to be utilized for revision, guest lectures, coverage of content beyond syllabus etc.

There was a concern that the earlier revised curriculum more focused on providing information and knowledge across various domains of the said program, which led to heavily loading of students in terms of direct contact hours. In this regard, faculty of science and technology resolved that to minimize the burden of contact hours, total credits of entire program will be of 170, wherein focus is not only on providing knowledge but also on building skills, attitude and self-learning. Therefore in the present curriculum skill based laboratories and mini projects are made mandatory across all disciplines of engineering in second and third year of programs, which will definitely facilitate self-learning of students. The overall credits and approach of curriculum proposed in the present revision is in line with AICTE model curriculum.

The present curriculum will be implemented for Second Year of Engineering from the academic year 2020-21. Subsequently this will be carried forward for Third Year and Final Year Engineering in the academic years 2021-22, 2022-23, respectively.

Dr. S. K. Ukarande
Associate Dean
Faculty of Science and Technology
University of Mumbai

Dr Anuradha Muzumdar
Dean
Faculty of Science and Technology
University of Mumbai

Incorporation and Implementation of Online Contents from NPTEL/ Swayam Platform

The curriculum revision is mainly focused on knowledge component, skill based activities and project based activities. Self-learning opportunities are provided to learners. In the revision process this time in particular Revised syllabus of ‘C ‘ scheme wherever possible additional resource links of platforms such as NPTEL, Swayam are appropriately provided. In an earlier revision of curriculum in the year 2012 and 2016 in Revised scheme ‘A' and ‘B' respectively, efforts were made to use online contents more appropriately as additional learning materials to enhance learning of students.

In the current revision based on the recommendation of AICTE model curriculum overall credits are reduced to 171, to provide opportunity of self learning to learner. Learners are now getting sufficient time for self-learning either through online courses or additional projects for enhancing their knowledge and skill sets.

The Principals/ HoD’s/ Faculties of all the institute are required to motivate and encourage learners to use additional online resources available on platforms such as NPTEL/ Swayam. Learners can be advised to take up online courses, on successful completion they are required to submit certification for the same. This will definitely help learners to facilitate their enhanced learning based on their interest.

Dr. S. K. Ukarande
Associate Dean
Faculty of Science and Technology
University of Mumbai

Dr Anuradha Muzumdar
Dean
Faculty of Science and Technology
University of Mumbai

Preamble to the Revision of Syllabus in Chemical Engineering

Development in all fields including Chemical Engineering along with use of soft wares for process plant and process engineering, there is demand on academician to upgrade the curriculum in 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 and not in teaching. The Curriculum must integrate knowledge of the basic and advanced sciences with problem solving and creativity abilities.

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. 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, online meeting was organized on 30th May 2020 which was attended by heads of the departments and subject faculty of affiliating Institutes. The program objectives and outcomes were thoroughly discussed in line with AICTE guidelines and the core structure of the syllabus was formulated keeping in mind choice based credit and grading system curriculum along with more emphasis on learning outcomes. Thus Skilled based laboratories and Mini projects are introduced in appropriate 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 online meetings were held by various subjects convenors to finalize the detail syllabus in the month of June 2020.

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 and environmental responsibilities.
4. To prepare the student in achieving excellence which will benefit individually and society at large.

Board of Studies in Chemical Engineering

Dr. Sunil S. Bhagwat - Chairman
Dr. Kalpana S. Deshmukh - Member
Dr. Sunil J. Kulkarni - Member
Dr. Ramesh S. Bhande - Member
Dr. Aparna N. Tamaskar - Member
Dr. Shyamala P. Shingare - Member
Dr. Manisha V. Bagal - Member

University of Mumbai

Program Structure for B.E. Chemical Engineering (Revised 2020-2021)

Semester III

Course code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
CHC301	Engineering Mathematics-III	3	-	1	3	-	1	4
CHC302	Industrial and Engineering Chemistry I	3	-	-	3	-	-	3
CHC303	Fluid Flow Operations	3	-	-	3	-	-	3
CHC304	Chemical Engineering Thermodynamics I	3	-	-	3	-	-	3
CHC305	Process Calculations	3	-	-	3	-	-	3
CHL301	Industrial and Engineering Chemistry I Lab	-	3	-	-	1.5	-	1.5
CHL302	Fluid Flow Operation Lab	-	3	-	-	1.5	-	1.5
CHL303	Basic Chemical Engineering Lab	-	3	-	-	1.5	-	1.5
CHL304	Skilled Based Lab: Chemical Technology Lab	-	2*2	-	-	2	-	2
CHM301	Mini Project 1A	-	3#	-	-	1.5	-	1.5
	Total	15	16	1	15	8	1	24

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	Engineering Mathematics-III	20	20	20	80	3	25	-	-	125
CHC302	Industrial and Engineering Chemistry I	20	20	20	80	3	-	-	-	100
CHC303	Fluid Flow Operations	20	20	20	80	3	-	-	-	100
CHC304	Chemical Engineering Thermodynamics I	20	20	20	80	3	-	-	-	100
CHC305	Process Calculations	20	20	20	80	3	-	-	-	100
CHL301	Industrial and Engineering Chemistry I Lab	-	-	-	-	3	25	25	-	50
CHL302	Fluid Flow Operation Lab	-	-	-	-	3	25	25	-	50
CHL303	Basic Chemical Engineering Lab	-	-	-	-	-	25	-	25	50
CHL304	Skilled Based Lab: Chemical Technology Lab	-	-	-	-	-	25	-	25	50
CHM301	Mini Project 1A	-	-	-	-	-	25	-	25	50
	Total	-	-	100	400	-	150	50	75	775

***Indicates Theory class to be conducted for full class**

 # indicates work load of Learner (Not Faculty), for Mini Project;
faculty load : 1 hour per week per four groups, for Mini Project

Semester III

Course Code	Course Name	Credits
CHC301	Engineering Mathematics III	04

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	01	03	-	01	04

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hours	25	-	-	125

Prerequisites

Engineering Mathematics-I, Engineering Mathematics-II,

Course Objectives

1. To familiarize with the Laplace Transform, Inverse Laplace Transform of various functions, its applications.
2. To acquaint with the concept of Fourier Series, its complex form and enhance the problem solving skills.
3. To familiarize with the concept of complex variables, C-R equations with applications.
4. To study the application of the knowledge of matrices and numerical methods in complex engineering problems.

Detailed Syllabus

Module No.	Course Contents	No. of Hours.
01	**Module: Laplace Transform** 1.1 Definition of Laplace transform, Condition of Existence of Laplace transform, 1.2 Laplace Transform (L) of Standard Functions like e^{at}, $sin(at)$, $cos(at)$, $sinh(at)$, $cosh(at)$ and t^n , $where\ n \geq 0$. 1.3 Properties of Laplace Transform: Linearity, First Shifting theorem, Second Shifting Theorem, change of scale Property, multiplication by *t*, Division by *t*, Laplace Transform of derivatives and integrals (Properties without proof). 1.4 Evaluation of integrals by using Laplace Transformation. **Self-learning topics:** Heaviside's Unit Step function, Laplace Transform. of Periodic functions, Dirac Delta Function.	07

02	**Module: Inverse Laplace Transform** 2.1 Inverse Laplace Transform, Linearity property, use of standard formulae to find inverse Laplace Transform, finding Inverse Laplace transform using derivative. 2.2 Partial fractions method & first shift property to find inverse Laplace transform. 2.3 Inverse Laplace transform using Convolution theorem (without proof) **Self-learning Topics:** Applications to solve initial and boundary value problems involving ordinary differential equations.	06
03	**Module: Fourier Series:** 3.1 Dirichlet's conditions, Definition of Fourier series and Parseval's Identity (without proof) 3.2 Fourier series of periodic function with period 2π and $2l$, 3.3 Fourier series of even and odd functions 3.4 Half range Sine and Cosine Series. **Self-learning Topics:** Complex form of Fourier Series, orthogonal and orthonormal set of functions, Fourier Transform.	07
04	**Module: Complex Variables:** 4.1 Function $f(z)$ of complex variable, limit, continuity and differentiability of $f(z)$, Analytic function, necessary and sufficient conditions for $f(z)$ to be analytic (without proof), 4.2 Cauchy-Riemann equations in cartesian coordinates (without proof) 4.3 Milne-Thomson method to determine analytic function $f(z)$ when real part (u) or Imaginary part (v) or its combination (u+v or u-v) is given. 4.4 Harmonic function, Harmonic conjugate and orthogonal trajectories **Self-learning Topics:** Conformal mapping, linear, bilinear mapping, cross ratio, fixed points and standard transformations	07
05	**Module: Matrices:** 5.1 Characteristic equation, Eigen values and Eigen vectors, Properties of Eigen values and Eigen vectors. (**No theorems/ proof**) 5.2 Cayley-Hamilton theorem (without proof): Application to find the inverse of the given square matrix and to determine the given higher degree polynomial matrix. 5.3 Functions of square matrix 5.4 Similarity of matrices, Diagonalization of matrices **Self-learning Topics:** Verification of Cayley Hamilton theorem, Minimal polynomial and Derogatory matrix & Quadratic Forms (Congruent transformation & Orthogonal Reduction)	06
06	**Module: Numerical methods for PDE** 6.1 Introduction of Partial Differential equations, method of separation of variables, Vibrations of string, Analytical method for one dimensional heat and wave equations. (only problems) 6.2 Crank Nicholson method 6.3 Bender Schmidt method	06

	Self-learning Topics: Analytical methods of solving two and three dimensional problems.	

Course Outcomes

On successful completion of course learner/student will:

1. Apply the concept of Laplace transform to solve the real integrals in engineering problems.
2. Apply the concept of inverse Laplace transform of various functions in engineering problems.
3. Expand the periodic function by using Fourier series for real life problems and complex engineering problems.
4. Find orthogonal trajectories and analytic function by using basic concepts of complex variable theory.
5. Apply Matrix algebra to solve the engineering problems.
6. Solve Partial differential equations by applying numerical solution and analytical methods for one dimensional heat and wave equations

Term Work

General Instructions:

1. Batch wise tutorials are to be conducted. The number of student's per batch should be as per University pattern for practical's.
2. Students must be encouraged to write at least 6 class tutorials on entire syllabus.
3. A group of 4-6 students should be assigned a self-learning topic. Students should prepare a presentation/problem solving of 10-15 minutes. This should be considered as mini project in Engineering Mathematics. This project should be graded for 10 marks depending on the performance of the students.

The distribution of Term Work marks will be as follows –

1.	Attendance (Theory and Tutorial)	05 marks
2.	Class Tutorials on entire syllabus	10 marks
3.	Mini project	10 marks

Assessment

Internal Assessment Test:

Assessment consists of two class tests of 20 marks each. The first class test (Internal Assessment I) is to be conducted when approx. 40% syllabus is completed and second class test (Internal Assessment II) when additional 35% syllabus is completed. Duration of each test shall be one hour.

End Semester Theory Examination:

1. Question paper will comprise of total 06 questions, each carrying 20 marks.
2. Total 04 questions need to be solved.
3. Question No: 01 will be compulsory and based on entire syllabus wherein 4 sub-questions of 5 marks each will be asked.

4. Remaining questions will be randomly selected from all the modules.
5. Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

References

1. Engineering Mathematics, Dr. B. S. Grewal, Khanna Publication
2. Advanced Engineering Mathematics, Erwin Kreyszig, Wiley Eastern Limited,
3. Advanced Engineering Mathematics, R. K. Jain and S.R.K. Iyengar, Narosa publication
4. Advanced Engineering Mathematics, H.K. Das, S. Chand Publication
5. Higher Engineering Mathematics B.V. Ramana, McGraw Hill Education
6. Complex Variables and Applications, Brown and Churchill, McGraw-Hill education,
7. Text book of Matrices, Shanti Narayan and P K Mittal, S. ChandPublication
8. Laplace transforms, Murray R. Spiegel, Schaum's Outline Series.

Semester III

Course Code	Course Name	Credits
CHC302	Industrial and Engineering Chemistry – I	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hours	-	-	-	100

Prerequisites

1. Basic knowledge of Vander-Waal's forces, various bonds, octet rule, resonance theory, and hybridization.
2. Knowledge of periodic table, properties of transition metals, non-metals, oxidation state, variable valency, basic functional groups etc.
3. XII class chemistry

Course Objectives

1. To study nomenclature, shapes, stability of coordination compounds and its applications.
2. To understand structures of different bio-molecules and stereochemistry of organic molecules.
3. To study structure and bonding of organometallic compounds and its industrial applications.
4. To study applications of electrochemistry conductometrically and potentiometrically and solvent extraction technique.
5. To study the effect of temperature on stability of reactive intermediate and their reaction mechanism.
6. To understand importance of dyes, fertilizers and their effects.

Detailed Syllabus

Module No.	Course Content	No of Hours
01	**Applications of Electrochemistry-** Conductance, specific conductance, equivalent conductance, molar conductance. Effect of dilution and temperature on conductance. Transport number, moving boundary method and numericals. Conductometry: Principle and types of titrations - Acid-base and Potentiometric precipitation titrations	04

02	**Co-ordination chemistry & Organometallic compounds** Definitions: Co-ordination number/ligancy, Complex ion, Co-ordination/dative bond. Nomenclature and isomerism (only geometrical and structural) in co-ordination compounds w.r.t co-ordination number 4 and 6. MOT, Effective Atomic Number (EAN) and numericals. Crystal field theory (CFT), Application of CFT to octahedral complexes and its drawbacks. Measurement of CFSE (10Dq) and numericals. Applications of coordination compounds**.** **Organometallic compounds:** Definition, metal clusters. Chemistry of Fe-carbonyls [Fe $(CO)_5$] and [$Fe_2(CO)_9$] w.r.t preparation, properties, structure and bonding.	08
03	**Stereochemistry & Bio-Inorganic chemistry** **Stereochemistry:** Definition, geometrical isomers and optical isomers, Asymmetric carbon, Enantiomers and Diastereomers, different configurations – R, S, E, Z. Conformational analysis of n-Butane and Cyclohexane. **Bio-Inorganic chemistry:** Biochemistry of proteins containing Fe and Zn, oxygen atom transfer reactions of biomolecules containing Fe. Cytochrome	06
04	**Reactive Intermediates & Name reactions** Definition, Carbocation, Carbanion, Carbene and Free radicals-formation, structure & stability. **Name reactions with mechanism**: Carbocation – Pinacol Pinacolone rearrangement reaction, Carbanion – Michael addition reaction, Carbene - Reimer-Tiemann reaction, Free radical- Norrish type- I, Norrish type-II. **Reaction pathways.** Difference between Transition state & intermediate. Equilibrium (Thermodynamically) and Rate (Kinetically) controlled reactions-explain w.r.t. sulphonation of naphthalene, Nitration of Chlorobenzene, Friedel-Craft's reaction.	08
05	**Dyes and Fertilizers** **Dyes**: Nomenclature, methods of application, color and chemical constitution (chromophore-auxochrome), classification of dyes on the basis of chemical structure, diazotization and coupling for azo dye, synthesis of congo red, alizarin, methyl orange, **Fertilizers**: Definition, nutrient functions in plant growth: Nitrogen, Phosphorous, Potassium, Calcium, Magnesium, Sulphur, Iron, Zinc, Chlorine, Role of these nutrients as: Functions, Excess supply and deficiency. Qualities of ideal fertilizers, types of fertilizers, manufacture of fertilizers- Ammonium sulphate, Superphosphate, Triple superphosphate, Pollution caused by fertilizers.	08
06	**Ion Exchange and solvent extraction techniques** Ion exchange resins, cation and anion exchangers. Desalination by ion exchange and separation of lanthanides. Liquid-Liquid solvent extraction, Nernst distribution law, distribution ratio. Batch, continuous and counter current extraction. Numericals based on solvent extraction.	05

❖ **One guest lecture from industry expert.**

Course Outcomes

On completion of the course the **students will:**

1. Understand the different theories of chemical bonding, organometallic chemistry and reactive intermediate.
2. Apply knowledge of dyes, fertilizers, analytical techniques of separation, identification and quality of fertilizers.
3. Describe the reaction mechanisms, states of molecules, various types of dyes and reaction pathway in biological process.
4. Justify stability of coordination compounds, kinetics and energy of reactions and importance of organometallic compounds in biological process.
5. Express role of biomolecules, elemental constituents in fertilizers, and exchangers in industries.
6. Apply concepts of electrochemistry and its applications quantitatively.

Assessment

Internal Assessment (20 Marks):

Consisting **Two Compulsory Class Tests.** First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I).

End Semester Examination (80 marks):

1. Weightage of each module in end semester examination will be proportional to number of respective lectures.
2. Question paper will comprise of total **six questions, each carrying 20 marks**
3. **Question 1** will be compulsory and should cover **maximum contents of the curriculum.**
4. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module3)
5. Only **Four questions need to be solved.**

Recommended Books

1. Engineering Chemistry- Jain& Jain Dhanpat Rai & Co. (P) Ltd
2. Engineering Chemistry- Satyaprakash & Manisha Agrawal, Khanna Book Publishing
3. Organic reaction Mechanisms- V.K. Ahluwalia , Rakesh Parashar, Narosa Publication
4. Industrial Chemistry – B K Sharma, Goel Publishing House

Reference Books

1. Principles of Physical Chemistry- B. R. Puri, L. R. Sharma, M.S. Pathania.
2. Principles of Inorganic Chemistry- Puri, Sharma, Kalia ,Milestone Publishers
3. Advanced Inorganic Chemistry – J. D. Lee
4. Organic Chemistry - I L Finar volume I and II.
5. Organic Chemistry – J. Clayden, Greeves, Warren, Wothers. Oxford university press
6. Principles Of Bioinorganic Chemistry- S.J. Lippard & J.M. Berg
7. Stereochemistry: Conformation and Mechanism by Kalsi, P.S, New Age International. Delhi
8. Stereochemistry of carbon compounds- Ernest Eliel, Tata McGraw Hill.
9. A textbook of Physical Chemistry - Glasston Samuel, Macmillan India Ltd. (1991)
10. Technology of Textile Processing Vol. 2: Chemistry of Dyes and Principles of Dyeing- Prof. V. A. Shena

Semester III

Course Code	Course Name	Credits
CHC303	Fluid Flow Operations	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hours	--	--	--	100

Prerequisites

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

Course Objectives

1. Students should be able to understand the scope of the subject in chemical industry and pressure drop- flow rate relationship.
2. They should be able to understand the boundary layer conditions and types of flow.
3. They should be able to understand the Bernoulli's equation and its applications in transportation of fluids.
4. They should be able understand the relationship between pressure drop and flow rates in conduits for incompressible fluids.
5. They should be able understand the types of velocities and stagnation properties for compressible flow and viscosity using Stokes law.
6. They should be able understand the purpose and need of power requirement in agitation and selection and importance of pumps and valves.

Detailed Syllabus

Module no.	Course Contents	No. of Hours
1	**Introduction and Basic Concepts:** Scope and applications of fluid flow, Properties of fluids, Types of Fluids, 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 – Piezometers, U- tube, Single column manometer, U – tube differential manometer, Inverted differential U – tube manometer, Inclined manometer.	7

2	**Fluid Flow Phenomena:** Newton's law of viscosity, Kinematic viscosity, Rheological behavior of fluid, Reynold's experiment and Reynold 's number, Laminar and turbulent flow in boundary layer, Boundary layer formation in straight tube, Transition length for laminar and turbulent flow.	4
3	**Basic Equations of Fluid Flow:** Bernoulli's equation, Euler's equation, Modified Bernoulli's equation. **Practical Application of Bernoulli's Equation:** Venturi meter: Horizontal and inclined, Orifice meter, Pitot tube**.**	6
4	**Flow of Incompressible fluids: Laminar/Turbulent-** Shear stress distribution and velocity distribution, Relationship between skin friction and wall shear, Friction factor, Darcy- Weisbach equation, Local velocity, Maximum velocity, Average velocity, Kinetic energy correction factor, Hagen – Poiseullie equation, Moody diagram, Equivalent diameter for circular and non-circular ducts. Major and minor losses, Equivalent length, Flow through pipe in Series and Parallel. Frictional losses in different pipe fittings.	8
5	**Flow of Compressible Fluids:** Introduction, Mach number, Sonic, Supersonic and Subsonic flow, Continuity equation and Bernoulli's equation, Stagnation properties, Acoustic velocity. Adiabatic flow, Isothermal flow. Isentropic flow. **Flow past immersed bodies:** Drag Forces, Coefficient of Drag, One dimensional motion of particle through fluid, Terminal Settling Velocity, Stoke's law, Stagnation Point.	6
6	**Pumps, Valves and Agitators:** Classification and types, **Centrifugal Pumps** – Construction and Working, Power Requirement, Definitions of Heads and Efficiency, Specific Speed, Minimum Speed, Characteristic Curves,Cavitation, NPSH, NPSHA, NPSHR, Priming. **Reciprocating Pump:** Classifications and Working. **Power Consumption in Agitation:** Purpose of Agitation, Types of Impellers, Prevention of Swirling, Power Curves, Power Number **Introduction to Compressors, Fans and Blowers**. **Types of Valves:** Globe valve, Gate valve, Butterfly valve and Non – Return valve.	8

Course Outcomes

On completion of the course the students will:

1. Acquire basic concepts and pressure measurement methods.
2. Learn kinematics of flow, rheological behavior of fluid and boundary layer conditions.
3. Learn Bernoulli's equation and apply it in practical applications of various problems in Chemical Engineering.
4. Learn flow equations and evaluate the losses in incompressible flow.
5. Learn the behavior of compressible fluids and Stokes Law and also able to apply these concepts for estimation of stagnation properties.
6. Gain the knowledge of various pumps, choice of pumps, valves and agitators and would be able to calculate power requirement for pumps as well as for agitators.

Assessment

Internal Assessment (20 Marks):

Consisting **Two Compulsory Class Tests.** First test based on approximately 40% of contents and second test based on remaining contents (approximately) 40% but excluding contents covered in Test 1).

End Semester Examination (80 marks):

1. Weightage of each module in end semester examination will be proportional to number of respective lecture.
2. Question paper will comprise of total **six questions, each carrying 20marks.**
3. **Question 1** will be compulsory and should cover **maximum contents of the Curriculum.**
4. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from Module 3 then part (b) will be from any module other than module3).
5. Only **Four Questions need to be solved.**

Recommended Books

1.Warren L. Mccabe, Julian C. Smith, Peter Harriott, Unit Operations of Chemical Engineering, McGraw Hill International Edition.

2. Coulson J. M., Richardson J. F., Backhurst J. R. and J. H. Harker, Chemical Engineering, Vol. 1 and2.

3. Dr. R. K. Bansal, Fluid Mechanics and Hydraulic Machines, Laxmi Publications Pvt.Ltd.

Reference Books

1. Cengel, Y. A. (2006). Fluid mechanics: fundamentals and applications. New Delhi, India: Tata McGraw-Hill Publishing.

2. Darby, R. (2001). Chemical Engineering Fluid Mechanics (2nd ed., rev.). New York: Marcel Dekker.

3. Douglas, J. F. (2001). Fluid mechanics (5th ed.). New Delhi, India: Pearson Education

4. Batchelor, G. K. (1999). Introduction to Fluid Dynamics. New Delhi, India: Cambridge University Press.

5. Rajput, R. K. (1998). A Textbook of Fluid Mechanics. New Delhi, India: S Chand and co

6. Mohanty, A. K. (2009). Fluid Mechanics (2nd ed.). New Delhi, India: PHI Learning.

Semester III

Course Code	Course Name	Credits
CHC304	Chemical Engineering Thermodynamics I	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	--	--	100

Prerequisites

1. Basic thermodynamic properties, laws and equations.
2.Engineering Mathematics : Differential and Integral Calculus, Linear Algebraic Equations.
3. Engineering Physics and Engineering Chemistry.

Course Objectives

1. To apply the first law of thermodynamics to chemical engineering systems.
2. To apply the second law of thermodynamics to chemical engineering systems.
3. To predict the P-V-T behavior of ideal gases and real gases.
4. To explain various thermodynamic concepts such as Entropy, Exergy and Fugacity.
5. To perform calculations involving the applications of the laws of thermodynamics to flow processes.
6. To demonstrate the use of thermodynamic charts and diagrams.

Detailed Syllabus

Module No	Course Contents	No. of Hours
1	1.1 First Law of Thermodynamics for flow and non-flow processes 1.2 Calculation of heat and work for various types of processes	08
2	2.1 Second Law of Thermodynamics 2.2 Concepts of heat engine, heat pump and refrigerator 2.3 Carnot Cycle and Carnot Principle 2.4 Clausius Inequality	05
3	3.1 Concept of Entropy and estimation of entropy change of various processes 3.2 Concept of Exergy, Applications of Exergy	05

4	4.1 Applications of Thermodynamics to Flow Processes : Flow in Pipes, Flow through Nozzles, Ejectors, Turbines (Expanders) and Compressors.	05
5	1.1 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 equations of state	08
6	6.1 Maxwell's Equations, Joule-Thomson Effect 6.2 Enthalpy and Entropy departure functions (van der Waals and Redlich-Kwong EOS) 6.3 Thermodynamic Charts, Diagrams and their applications 6.4 Fugacity and fugacity coefficient (van der Waals and Redlich-Kwong EOS)	08

Course Outcomes

On completion of the course the students will:

1. Apply the First Law of Thermodynamics to flow and non-flow Chemical Engineering processes.
2. Compute the thermal efficiencies of various engines and machines using Second Law of Thermodynamics and Entropy concepts.
3. Apply the concept of Exergy to engineering applications and utilize the laws of thermodynamics to analyze flow processes.
4. Compute the properties of real fluids using different equations of state.
5. Compute property changes of non-ideal gas systems using departure functions.
6. Use thermodynamic charts and diagrams for estimation of various thermodynamic properties.

Assessment

Internal Assessment (20 Marks):

Consisting **Two Compulsory Class Tests.** First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I).

End Semester Examination (80 marks):

1. Weightage of each module in end semester examination will be proportional to number of respective lectures.
2. Question paper will comprise of total **six questions, each carrying 20 marks.**
3. **Question 1** will be compulsory and should cover **maximum contents of the curriculum.**
4. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
5. Only **Four questions need to be solved.**

Recommended Books

1. J.M. Smith, H.C. Van Ness, M.M. Abbot, M.T. Swihart, Introduction to Chemical Engineering Thermodynamics, 8th Edition, McGraw-Hill Education, 2017.

2. K.V. Narayanan, A Textbook of Chemical Engineering Thermodynamics, 2nd Edition, Prentice Hall of India Pvt. Ltd., 2013.
3. Y.V.C. Rao, Chemical Engineering Thermodynamics, Universities Press, 1997.

Reference Books

1. M.J. Moran, H.N. Shapiro, D.D. Boettner, M.B. Bailey, Fundamentals of Engineering Thermodynamics, 9th Edition, Wiley, 2018.
2. Gopinath Halder, Introduction to Chemical Engineering Thermodynamics, 2nd Edition, Prentice Hall of India Pvt. Ltd., 2014.
3. M.D. Koretsky, Engineering and Chemical Thermodynamics, John Wiley and Sons, 2009.
4. J. Richard Elliot and Carl T. Lira, Introductory Chemical Engineering Thermodynamics, 2nd Edition, Prentice Hall, 2012.

Semester III

Course Code	Course Name	Credits
CHC305	Process Calculations	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 hours	--	--	--	100

Prerequisites

1. Linear algebra
2. Differential equations

Objectives

1 Familiarize various systems of units and conversion.
2 Learn about material balance of various unit operations for both steady and unsteady state operations.
3 Understand the material balance of various unit processes.
4 To have the knowledge of recycle, bypass and purge operations.
5 Understand the energy balance calculations over various processes with and without chemical reactions.
6 Development of the material balance and energy load of a binary distillation column.

Detailed Syllabus

Module No.	Course Contents	No. of 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 and Raoult's law.	07
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 under steady and unsteady state conditions.	08
3	**Material Balance with Chemical Reactions:** Concept of limiting and excess reactants, conversion and yield, selectivity and degree of completion of reaction.	08

4	**Recycle, Bypass and Purge Operations:** Material Balance calculations for both with and without chemical reactions.	06
5	**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.	08
6	**Combined Material and Energy Balance:** Material and energy balance for binary distillation.	02

Course Outcome

On completion of the course the students will:

1 Identify the various systems of units and conversion and apply principles of basic chemical calculations.
2 Apply the material balance for various unit operations for both steady and unsteady state operations.
3 Compute the material balance of various unit processes.
4 Evaluate recycle, bypass and purge operations and its streams.
5 Perform energy balance calculations over various processes with and without chemical reactions.
6 Assess the material balance and energy load of a binary distillation column.

Assessment

Internal Assessment (20 Marks):

Consisting **Two Compulsory Class Tests.** First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in TestI).

End Semester Examination (80 marks):

1. Weightage of each module in end semester examination will be proportional to number of respective lecture.
2. Question paper will comprise of total **six questions, each carrying 20marks.**
3. **Question 1** will be compulsory and should cover **maximum contents of the curriculum.**
4. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module3).
5. Only **Four questions need to be solved.**

Recommended 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 edition, Tata McGraw Hill Education Private Limited, New Delhi
3. Ch. Durga Prasad Rao and D. V. S. Murthy, "Process Calculations for Chemical Engineers", McMillan 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).

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)

Semester III

Course Code	Course Name	Credits
CHL301	Industrial and Engineering Chemistry Lab-I	1.5

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	03	-	-	1.5	-	1.5

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR/OR	OR	
Test-I	Test-II	Average						
-	-	-	-	-	25	25	--	50

Prerequisites

1. Basic knowledge of quantitative terms, Mole fractions, Normality, Morality etc.
2. Basic identification of salts, acids, bases, indicators etc.
3. Basic introduction of lab safety and handling of glass wares.

Lab Objectives

1. To enable students to prepare the standard solutions, carry out volumetric analysis to check their accuracy and present the outcome of the experiment in statistical format to calculate standard deviation.
2. To provide students an insight of titrimetry to determine contents of solution quantitatively.
3. To enable students to apply knowledge of instrumental analysis to carry out acid-base titrations without indicators, to calculate solubility product etc.
4. To make students learn the estimation of organic compound from given solution quantitatively.
5. To make students understand the concept and importance of gravimetric analysis in determination of amount of element in given solution.
6. To enable students carry out synthesis of chemicals by laboratory methods

Lab Outcomes

On completion of the course the **students will:**

1. Prepare standard solutions, check their accuracy and present results in statistical format to calculate standard deviation.
2. Perform titrations and determine contents of solution quantitatively.
3. Apply knowledge of instrumental analysis like Conductometry and Potentiometry.
4. Learn methods of estimation of organic compounds quantitatively.
5. Carry out gravimetric analysis systematically with proper understanding.
6. Carry out synthesis of chemicals in laboratory.

List of Experiments (Minimum Eight)

Experiment no.	Details of Experiment	Lab Hours
1	**Volumetric analysis:** Preparation of standard solutions and to find normality and deviation factor.[Any two]	3
2	**Titrimetric analysis:** Analysis of talcum powder for Mg content by EDTA method	3
3	Analysis of Aspirin as per I.P. or USP	3
4	Estimation of Glycine by non aqueous titration using perchloricacid	3
5	**Conductometric Titrations.** Titration of strong acid with strong base.	3
6	Weak acid against strong base.	3
7	Titration of mixture of weak acid and strong acid against strong base	3
8	**Potentiometric Titrations** Titration of strong acid and strong base potentiometrically.	3
9	Determination of solubility and solubility product of AgCl.	3
10	**Organic estimations** Estimation of aniline	3
11	Estimation of phenol	3
12	Estimation of Acetamide	
13	**Gravimetric estimation of** Barium as $BaCl_2$	3
14	Tin as $SnCl_2$	3
15	Nickel as Ni D.M.G.	3
16	**Preparation.** Preparation of Methyl Salicylate	3
17	Preparation of Azo dye (benzene diazonium salt and 2- naphthol from aniline/ nitroaniline)	3
18	Estimation of sodium by Ion Exchange chromatography.	3
19	Determination of Partition coefficient of iodine in water and carbon tetra chloride.	3

Assessment

Term Work (25 marks):

Distribution of marks will be as follows:

Laboratory work: 15 marks

Assignments: 05

Attendance: 05

End Semester Practical Examination/orals (25 marks):

Practical Examination will be on experiments performed in the laboratory

Reference Books

1. Vogel's Quantitative Chemical Analysis- David J. Barnes J. Mendham, R.C. Denney, M.J.K Thomas Pearson Education; 6 edition

2. Laboratory Manual Engg. Chemistry- Anupma Rajput, Dhanpat Rai & Co.
3. Vogel's Textbook of Practical organic chemistry.

Semester III

Course Code	Course Name	Credits
CHL302	Fluid Flow Operations Lab	1.5

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	03	-	-	1.5	-	1.5

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR/OR	OR	
Test-I	Test-II	Average						
-	-	-	-	-	25	25	-	50

Prerequisites

1. Knowledge of physical sciences and units and dimensions.
2. Knowledge of properties of fluids, law of conservation of mass and law of momentum.
3. Knowledge of flow and pressure measurement devices.
4. Knowledge of different flow patterns and pumps.

Lab Objectives

Students should be able to:
1. Understand the basic properties and concepts of the fluid behavior in chemical industry.
2. Understand various flow patterns and boundary layer conditions.
3. Understand applications of flow and pressure measuring devices.
4. Understand various pipe fittings, valves and its applications.
5. Understand working and operations of various pumps.
6. Understand Working and application of agitated vessel and use of different impellers in process industries.

Lab Outcome

On completion of the course the students will:
1. Determine viscosity by stokes law.
2. Distinguish different flow patterns and calculations involving Reynolds number.
3. Find coefficient of discharge for various flow measuring devices.
4. Evaluate minor losses and frictional losses for various pipe fittings and network.
5. Calculate power required and efficiency for various pumps.
6. Find power requirement for various impellers in agitated vessel.

List of Experiments (Minimum Eight)

Experiment No.	Details of Experiment	Lab Hours

1	Determination of flow behavior by Reynolds Apparatus	3
2	Verification of Bernoulli's theorem by Bernoulli's Apparatus	3
3	Venturimeter	3
4	Orifice meter	3
5	Pitot Tube	3
6	Flow through Helical Coil	3
7	Flow through Annulus	3
8	Flow through Circular Pipe	3
9	Losses in Pipe Fittings (Minor Losses)	3
10	Flow through Pipes (Major Losses)	3
11	To Study the operating characteristics of Pump	3
12	Power Consumption in Agitated Vessel	3
13	Viscosity by Stokes Law	3
14	Experiments using Virtual Labs	3

Assessment

Term Work (25 marks):

Distribution of marks will be as follows:
Laboratory work: 15 marks
Assignments: 05
Attendance: 05

End Semester Practical Examination/Orals (25 marks):

Practical Examination will be based on experiments performed in the laboratory.

Reference Books

1. Warren L. Mccabe, Julian C. Smith, Peter Harriott, Unit Operations of Chemical Engineering, McGraw Hill International Edition.
2. Coulson J. M., Richardson J. F., Backhurst J. R. and J. H. Harker, Chemical Engineering, Vol. 1 and 2.
3. Batchelor, G. K. (1999). Introduction to fluid dynamics. New Delhi, India: Cambridge University Press.
4. Darby, R. (2001). Chemical engineering fluid mechanics (2nd ed., rev.). New York: Marcel Dekker.

Semester III

Course Code	Course Name	Credits
CHL303	Basic Chemical Engineering Lab	1.5

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	03	-	-	1.5	-	1.5

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR/OR	OR	
Test-I	Test-II	Average						
-	-	-	-	-	25		25	50

Prerequisites

1. Knowledge of Inorganic, Organic and Physical Chemistry
2. Knowledge of Physics and
3. Knowledge of Mathematics

Lab Objectives

1. To understand basic chemical engineering concepts such as vapor pressure, surface tension, heat of reaction, solubility, colligative properties etc.
2. To apply knowledge of chemistry to do experimental set up and carry out experiment
3. To understand different errors, sampling methods and sample size in laboratory experiments.
4. To collect data after experiments
5. To study applications of experimental methods in practical situations
6. To become aware of industrially important reactions and operations

Lab Outcomes

On completion of the course the students will:

1. Apply basic principles of chemistry and chemical engineering to solve and analyze complex industrial problems
2. Apply mathematical skills to perform calculations on data obtained and use required formulas to do the same
3. Evaluate sampling methods, required sampling size and reduce measurement errors for accurate experimental design
4. Evaluate experimental data by different data analysis methods on PC using MS Excelfor investigating complex problems
5. Analyze and interpret the results obtained from experiments
6. Design new laboratory experiments to study industrial problems which will benefit society and environment by following strict ethical standards

List of Experiments (minimum eight)		
Experiment no.	**Details of Experiment**	**Lab Hours**
1	Method of carrying out lab experiments, Types of measurement errors in scientific experiments and methods of reducing them	3
2	Heat of reaction and Hess's law of heat summation	3
3	Measurement of Dew Point Temperature	3
4	Demonstration of vapor pressure	3
5	Contact Angle measurement	3
6	Size distribution of bubbles-Analysis with PC	3
7	Freezing point depression	3
8	Boiling point elevation	3
9	Solubility diagram of two partially miscible liquids	3
10	Partial Molar Volume	3
11	Material and energy balance over evaporation	3
12	Limiting reactant and excess reactant for chemical reaction	3

Assessment

Term Work (25 marks):

Distribution of marks will be as follows:

Laboratory work: 20 marks

Attendance: 05

End Semester orals (25 marks):

Orals will be on experiments performed in the laboratory

Semester III

Course Code	Course Name	Credits
CHL304	Skilled based lab: Chemical Technology Lab	02

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
02	02	-	01	01	-	02

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR/OR	OR	
Test-I	Test-II	Average						
-	-	-	-	-	25	-	25	50

Prerequisites

1. Knowledge of Inorganic Chemistry.
2. Knowledge of Organic Chemistry.
3. Knowledge of Physical Chemistry.
4. Knowledge of Physics and Mathematics.

Course Objectives

1.To provide students an insight of different chemical processes and their engineering problems.
2. To enable the students to understand the development of a process from its chemistry.
3. To equip students to draw and illustrate process flow diagrams.
4. To develop laboratory procedures for the preparation of industrially important chemicals and products.
5. To enable students to be skilled in the practical aspects of synthesis of chemicals.
6. To present the outcomes of laboratory experiments in the form of reports.

Course Outcomes

On completion of the course the students will:

1. Describe various manufacturing processes used in the chemical process industries.
2. Explain industrial processing and overall performance of any chemical process including the major engineering problems encountered in the process.
3. Draw and illustrate the process flow diagram for a given process.
4. Outline laboratory procedures for the preparation of industrially important chemicals and products.
5. Plan and perform synthesis of important chemicals in the laboratory.
6. Demonstrate the ability to present scientific and technical information resulting from laboratory experimentation and draw conclusions from the results of the experiments.

Detailed Syllabus (theory 02 hours per week)

Module No.	Course Contents	No. of 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	04
2	**Natural Product Industries and Biodiesel Processing :** Manufacture of ethanol by fermentation of molasses Biodiesel production by base-catalysed transesterification process	03
3	**Manufacture of Acids :** Sulphuric Acid (DCDA Process), Nitric Acid **Manufacture of Fertilizers :** Ammonia, Urea	05
4	**Chloro-Alkali Industries :** Manufacture of Caustic Soda Manufacture of Soda Ash (Solvay and Dual Processes)	04
5	**Basic Building Blocks of Petrochemical Industry :** Introduction to Petroleum Refining Catalytic Cracking by Fluidised Catalytic Cracking Unit (FCCU) Naphtha Cracking for manufacture of ethylene and propylene Naphtha Reforming and recovery of BTX (Benzene-Toluene-Xylene) Isomerization of Xylenes	05
6	**Synthesis of Important Heavy Organic Chemicals and Intermediates :** Manufacture of Cumene from benzene and propylene Manufacture of Phenol from cumene by peroxidation-hydrolysis process **Synthesis of Polymers :** Manufacture of Polyethylene : LDPE and HDPE Manufacture of Nylon 66	05

List of Experiments (minimum six)

Experiment no.	Details of Experiment	Lab Hours
1	Preparation of Soap	2
2	Preparation of Alum from Aluminum	2
3	Preparation of Aspirin	2
4	Preparation of Methyl Orange	2
5	Preparation of Thiokol Rubber	2
6	Preparation of Rubber Ball from Rubber Latex	2
7	Preparation of p-Bromonitrobenzene from Bromobenzene	2

8	Preparation of Detergent	2
9	Preparation of Biodiesel	2
10	Preparation of Adhesive	2
11	Preparation of Food Product	2
12	Preparation of Toothpaste	2
13	Preparation of Hand Sanitizer	2
14	Extraction of Essential Oils	2

Assessment

Term Work (25 marks):

Distribution of marks will be as follows:

Laboratory work: 20 marks

Attendance (of theory and practical): 05 marks

End Semester Orals (25 marks):

Orals on topics covered in theory and experiments performed in the laboratory

Recommended Books

1.Rao, G.N. and Sittig M., Dryden's Outlines of Chemical Technology for 21st Century, East West Press, 3rd Edition, 1997.

2.Austin G.T., Shreve's Chemical Process Industries, 5th Edition, McGraw Hill International Edition, 1984.

3. Pandey, G.N., A Textbook of Chemical Technology, Vol. I and II, Vikas Publications, 1984.

4. B.K. Bhaskara Rao, Modern Petroleum Refining Processes, 6th Edition, Oxford and IBH Publishing, 2020.

5.B.K. Bhaskara Rao, A Textbook of Petrochemicals, Khanna Publishers, 2004.

Reference Books

1.Kirk-Othmer's Encyclopedia of Chemical Technology, John Wiley and Sons, Inc., 5th Edition, 2007.

2.Ullmann's Encyclopedia of Industrial Chemistry, Wiley-VCH, 7th Edition, 2011.

3.Alok Adholeya and Pradeep kumar Dadhich, Production and Technology of Biodiesel : Seeding a Change, TERI Publication, New Delhi, 2008.

4. 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.

Semester III

Course Code	Course Name	Credits
CHM301	Mini Project 1A	1.5

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	03	-	-	1.5	-	1.5

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR/OR	OR	
Test-I	Test-II	Average						
-	-	-	-	-	25	-	25	50

Objectives

1. To acquaint with the process of identifying the needs and converting it into the problem.
2. To familiarize the process of solving the problem in a group.
3. To acquaint with the process of applying basic engineering fundamentals to attempt solutions to the problems.
4. To inculcate the process of self-learning and research.

Outcome: Learner will…

1. Identify problems based on societal /research needs.
2. Apply Knowledge and skill to solve societal problems in a group.
3. Develop interpersonal skills to work as member of a group or leader.
4. Draw the proper inferences from available results through theoretical/ experimental/simulations.
5. Analyse the impact of solutions in societal and environmental context for sustainable evelopment.
6. Use standard norms of engineering practices
7. Excel in written and oral communication.
8. Demonstrate capabilities of self-learning in a group, which leads to life long learning.
9. Demonstrate project management principles during project work.

Guidelines for Mini Project

- Students shall form a group of 3 to 4 students, while forming a group shall not be allowed less than three or more than four students, as it is a group activity.
- Students should do survey and identify needs, which shall be converted into problem statement for mini project in consultation with faculty supervisor/head of department/internal committee of faculties.
- Students hall submit implementation plan in the form of Gantt/PERT/CPM chart, which will cover weekly activity of mini project.
- A log book to be prepared by each group, wherein group can record weekly work progress, guide/supervisor can verify and record notes/comments.
- Faculty supervisor may give inputs to students during mini project activity; however, focus shall be on self-learning.

- Students in a group shall understand problem effectively, propose multiple solution and select best possible solution in consultation with guide/ supervisor.
- Students shall convert the best solution into working model using various components of their domain areas and demonstrate.
- The solution to be validated with proper justification and report to be compiled in standard format of University of Mumbai.
- With the focus on the self-learning, innovation, addressing societal problems and entrepreneurship quality development within the students through the Mini Projects, it is preferable that a single project of appropriate level and quality to be carried out in two semesters by all the groups of the students. i.e. Mini Project 1 in semester III and IV. Similarly, Mini Project 2 in semesters V and VI.
- However, based on the individual students or group capability, with the mentor's recommendations, if the proposed Mini Project adhering to the qualitative aspects mentioned above gets completed in odd semester, then that group can be allowed to work on the extension of the Mini Project with suitable improvements/modifications or a completely new project idea in even semester. This policy can be adopted on case by case basis.

Guidelines for Assessment of Mini Project:

Term Work

- The review/ progress monitoring committee shall be constituted by head of departments of each institute. The progress of mini project to be evaluated on continuous basis, minimum two reviews in each semester.
- In continuous assessment focus shall also be on each individual student, assessment based on individual's contribution in group activity, their understanding and response to questions.
- Distribution of Term work marks for both semesters shall be as below;
  - Marks awarded by guide/supervisor based on log book : 10
  - Marks awarded by review committee : 10
  - Quality of Project report : 05

Review/progress monitoring committee may consider following points for assessment based on either one year or half year project as mentioned in general guidelines.

One-year project:

- In first semester entire theoretical solution shall be ready, including components/system selection and cost analysis. Two reviews will be conducted based on presentation given by students group.
  - First shall be for finalisation of problem
  - Second shall be on finalisation of proposed solution of problem.
- In second semester expected work shall be procurement of component's/systems, building of working prototype, testing and validation of results based on work completed in an earlier semester.
  - First review is based on readiness of building working prototype to be conducted.
  - Second review shall be based on poster presentation cum demonstration of working model in last month of the said semester.

Half-year project:

- In this case in one semester students' group shall complete project in all aspects including,

- Identification of need/problem
- Proposed final solution
- Procurement of components/systems
- Building prototype and testing

- Two reviews will be conducted for continuous assessment,
  - First shall be for finalisation of problem and proposed solution
  - Second shall be for implementation and testing of solution.

Assessment criteria of Mini Project.

Mini Project shall be assessed based on following criteria;

1. Quality of survey/ need identification
2. Clarity of Problem definition based on need.
3. Innovativeness in solutions
4. Feasibility of proposed problem solutions and selection of best solution
5. Cost effectiveness
6. Societal impact
7. Innovativeness
8. Cost effectiveness and Societal impact
9. Full functioning of working model as per stated requirements
10. Effective use of skill sets
11. Effective use of standard engineering norms
12. Contribution of an individual's as member or leader
13. Clarity in written and oral communication

- In **one year, project**, first semester evaluation may be based on first six criteria's and remaining may be used for second semester evaluation of performance of students in mini project.
- In case of **half year project** all criteria's in generic may be considered for evaluation of performance of students in mini project.

Guidelines for Assessment of Mini Project Practical/Oral Examination:

- Report should be prepared as per the guidelines issued by the University of Mumbai.
- Mini Project shall be assessed through a presentation and demonstration of working model by the student project group to a panel of Internal and External Examiners preferably from industry or research organisations having experience of more than five years approved by head of Institution.
- Students shall be motivated to publish a paper based on the work in Conferences/students competitions.

Mini Project shall be assessed based on following points;

1. Quality of problem and Clarity
2. Innovativeness in solutions
3. Cost effectiveness and Societal impact
4. Full functioning of working model as per stated requirements
5. Effective use of skill sets
6. Effective use of standard engineering norms
7. Contribution of an individual's as member or leader
8. Clarity in written and oral communication

University of Mumbai

Program Structure for B.E. Chemical Engineering (Revised 2020-2021)

Semester IV

Course code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
CHC401	Engineering Mathematics-IV	3	-	1	3	-	1	4
CHC402	Industrial and Engineering Chemistry II	3	-		3	-	-	3
CHC403	Numerical Method in Chemical Engineering	3	-	-	3	-	-	3
CHC404	Solid Fluid Mechanical Operations	3	-	-	3	-	-	3
CHC405	Chemical Engineering Thermodynamics II	3	-	-	3	-	-	3
CHL401	Industrial and Engineering Chemistry II Lab	-	3	-	-	1.5	-	1.5
CHL402	Numerical Method in Chemical Engineering Lab	-	3	-	-	1.5	-	1.5
CHL403	Solid Fluid Mechanical Operation Lab	-	3	-	-	1.5	-	1.5
CHL404	Skilled based lab: Design Calculation of Auxiliary Plant Equipment	-	3	-	-	1.5	-	1.5
CHM401	Mini Project 1B	-	2#	--	-	1		1
	Total	15	14	1	15	7	1	23

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	Engineering Mathematics-IV	20	20	20	80	3	25	-	-	125
CHC402	Industrial and Engineering Chemistry II	20	20	20	80	3	-	-	-	100
CHC403	Numerical Method in Chemical Engineering	20	20	20	80	3	-	-	-	100
CHC404	Solid Fluid Mechanical Operations	20	20	20	80	3	-	-	-	100
CHC405	Chemical Engineering Thermodynamics II	20	20	20	80	3	-	-	-	100
CHL401	Industrial and Engineering Chemistry II Lab	-	-	-	-	3	25	25	-	50
CHL402	Numerical Method in Chemical Engineering Lab	-	-	-	-	-	25	-	25	50
CHL403	Solid Fluid Mechanical Operation Lab	-	-	-	-	3	25	25	-	50
CHL404	Skilled based lab: Design Calculation of Auxiliary Plant Equipment	-	-	-	-	-	25	-	25	50
CHM401	Mini Project 1B	-	-	-	-	-	25	-	25	50
	Total	-	-	100	400	-	150	50	75	775

 # indicates work load of Learner (Not Faculty), for Mini Project
faculty load : 1 hour per week per four groups, for Mini Project

Semester IV

Course Code	Course Name	Credits
CHC401	Engineering Mathematics IV	04

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	01	03	-	01	04

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR/OR	OR	
Test-I	Test-II	Average						
20	20	20	80	3 Hours	25	-	-	125

Prerequisites

1. Engineering Mathematics-I
2. Engineering Mathematics-II
3. Engineering Mathematics-III.

Course Objectives

1. To study the concept of Vector calculus & its applications in engineering.
2. To study Line and Contour integrals and expansion of complex valued function in a power series.
3. To familiarize with the concepts of statistics for data analysis.
4. To acquaint with the concepts of probability, random variables with their distributions and expectations.
5. To familiarize with the concepts of probability distributions and sampling theory with its applications.

Detailed Syllabus

Module No.	Course Contents	No. Of Hours.
01	**Module : Vector Calculus** 1.1 Solenoidal and irrotational (conservative) vector fields. 1.2 Line integrals – definition and problems. 1.3 Green's theorem (without proof) in a plane, Stokes' theorem (without Proof), Gauss' Divergence theorem (without proof) and problems (only evaluation). **Self Learning Topics**: Identities connecting Gradient, Divergence and Curl, Angle between surfaces. Verifications of Green's theorem, Stoke's theorem & Gauss-Divergence theorem, related identities & deductions.	07

02	**Module: Complex Integration** 2.1 Line Integral, Cauchy's Integral theorem for simple connected and multiply connected regions (without proof), Cauchy's Integral formula (without proof). 2.2 Taylor's and Laurent's series (without proof). 2.3 Definition of Singularity, Zeroes, poles of *f(z)*, Residues, Cauchy's Residue Theorem (without proof) **Self-learning Topics:** Application of Residue Theorem to evaluate real integrations.	07
03	**Module: Statistical Techniques** 3.1 Karl Pearson's Coefficient of correlation (r) and related concepts with problems 3.2 Spearman's Rank correlation coefficient (R) (Repeated & non repeated ranks problems) 3.3 Lines of regression 3.4 Fitting of first and second degree curves. **Self-learning Topics:** Covariance, fitting of exponential curve.	06
04	**Module: Probability Theory:** 4.1 Conditional probability, Total Probability and Baye's Theorem. 4.2 Discrete and Continuous random variables, Probability mass and density function, Probability distribution for random variables, 4.3 Expectation, Variance, Co-variance, moments, Moment generating functions, (Four moments about the origin &about the mean). **Self- learning Topics:** Properties variance and covariance.	06
05	**Module: Probability Distribution and Sampling Theory-I** 5.1 Probability Distribution: Poisson and Normal distribution 5.2 Sampling distribution, Test of Hypothesis, Level of Significance, Critical region, One-tailed, and two-tailed test, Degree of freedom. 5.3 Students' t-distribution (Small sample). Test the significance of single sample mean and two independent sample means and paired t- test) **Self -learning Topics:** Test of significance of large samples, Proportion test, Survey based project.	07
06	**Module: Sampling theory-II** 6.1 Chi-square test: Test of goodness of fit and independence of attributes (Contingency table) including Yate's Correction. 6.2 Analysis of variance: F-test (significant difference between variances of two samples) **Self- learning Topics:** ANOVA**:** One way classification, Two-way classification (short-cut method).	06

Course Outcomes

Learner will ….

1. Apply the concept of Vector calculus to evaluate line integrals, surface integrals using Green's theorem, Stoke's theorem & Gauss Divergence theorem.
2. Use the concepts of Complex Integration for evaluating integrals, computing residues & evaluate various contour integrals.
3. Apply the concept of Correlation, Regression and curve fitting to the engineering problems in data science.
4. Illustrate understanding of the concepts of probability and expectation for getting the spread of the data and distribution of probabilities.
5. Apply the concept of probability distribution to engineering problems & Testing hypothesis of small samples using sampling theory
6. Apply the concepts of parametric and nonparametric tests for analyzing practical problems.

Term Work:

General Instructions:

1. Batch wise tutorials are to be conducted. The number of students per batch should be as per University pattern for practical.
2. Students must be encouraged to write at least 6 class tutorials on entire syllabus.
3. A group of 4-6 students should be assigned a self-learning topic. Students should prepare a presentation/problem solving of 10-15 minutes. This should be considered as mini project in Engineering mathematics. This project should be graded for 10 marks depending on the performance of the students.

The distribution of Term Work marks will be as follows –

1.	Attendance (Theory and Tutorial)	05 marks
2.	Class Tutorials on entire syllabus	10 marks
3.	Mini project	10 marks

Assessment

Internal Assessment Test:

Assessment consists of two class tests of 20 marks each. The first class test (Internal Assessment I) is to be conducted when approx. 40% syllabus is completed and second class test (Internal Assessment II) when additional 35% syllabus is completed. Duration of each test shall be one hour.

End Semester Examination:

1. Question paper will comprise of total 06 questions, each carrying 20 marks.
2. Total 04 questions need to be solved.
3. Question No: 01 will be compulsory and based on entire syllabus wherein 4sub-questions of 5 marks each will be asked.
4. Remaining questions will be randomly selected from all the modules.
5. Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

References

1. Higher Engineering Mathematics, Dr. B. S. Grewal, Khanna Publication
2. Advanced Engineering Mathematics, Erwin Kreyszig, Wiley Eastern Limited,
3. Advanced Engineering Mathematics, R. K. Jain and S. R. K. Iyengar, Narosa publication,
4. Vector Analysis, Murray R. Spiegel, Schaum Series
5. Complex Variables and Applications, Brown and Churchill, McGraw-Hill education
6. Probability Statistics and Random Processes, T. Veerarajan, Mc. GrawHill education.

Semester IV

Course Code	Course Name	Credits
CHC402	Industrial and Engineering Chemistry II	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR/OR	OR	
Test-I	Test-II	Average						
20	20	20	80	3 Hours	-	-	-	100

Prerequisites

1. Basic knowledge of wave theory, properties of solution, organic reaction mechanism.
2. Basic knowledge of solute, solvent, states of matter and quantum mechanics.
3. XII class chemistry.

Course Objectives

1. To study aqueous solutions, non aqueous solution and their reactions.
2. To study various Spectroscopic, Thermal techniques.
3. To study different analytical and separation processes.
4. To study reactions of active methylene group of esters, their synthesis and organic reactions with its mechanism.
5. To study applications of colloids and surfactants in industry.
6. To study various types and theories of catalytic reactions.

Detailed Syllabus

Module No	Course Content	No of Hours
01	**Non- Aqueous Solvents** Introduction, Dipole moment, Dielectric constants of ionizing solvents, Leveling effect of solvents, Classification and properties of solvents. Study of liquid ammonia and liquid sulphur dioxide w.r.t (a) Acid Base reaction (b) Redox reactions (c) Complex formation (d) Solvolysis (e) Precipitation reactions.	06
02	**Spectroscopy and Optical Methods** Ultraviolet, Infrared, Nuclear Magnetic Resonance (H^1) w.r.t Principle, Instrumentation and applications.	07

	Thermal methods – TGA, DTA w.r.t Principle, Instrumentation and applications.	
03	**Analytical Techniques: Chromatography** Adsorption and partition based, Paper Chromatography, Thin Layer Chromatography, Column Chromatography, High Performance Liquid Chromatography, GC-MS, Gas (liquid and solid) Chromatography –Principle and their applications.	06
04	**Colloids and Surfactants** Introduction, 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, Donnan membrane equilibrium and its significance. Emulsions O/W and W/O types, emulsifying agents, surfactants. Applications of surfactants in detergents, pesticide formulations and food industry.	07
05	**Important industrial Esters and reaction mechanism** Preparation, properties and synthetic applications of malonic ester and AAE. **Name Reactions-** Beckman rearrangement, Favorskii reaction, Reformatsky reaction, Benzil-Benzilic acid reaction- mechanism and its applications. **Aromatic character of:** Furan, Pyridine, Naphthalene and Anthracene.	08
06	**Catalysis-** Definition, criteria of catalysis. Types (Homogeneous and Heterogeneous), catalytic promoters, catalytic poisoning, negative catalysis and catalytic inhibitors. Auto catalysis and induced catalysis. Activation energy, intermediate compound formation theory, adsorption theory. Acid base catalysis and mechanism. Enzyme catalysis-characteristics and mechanism.	05

❖ **Industry visit/ Instrumentation laboratory visit can be arranged for the students.**

Course Outcomes

On completion of the course the **students will:**

1. Understand the theories of aqueous, non aqueous solutions, surfactants, and colloids.
2. Differentiate between aromatic and non-aromatic compounds.
3. Apply different spectroscopic methods and thermal methods for the detection of compounds.
4. Analyze interpretation of spectral data and analytical techniques.
5. Understand the reaction mechanism, its applications and synthesis of organic molecules.
6. Express catalytic reactions and its applications in industry.

Assessment

Internal Assessment (20 Marks):

Consisting **Two Compulsory Class Tests.** First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I).

End Semester Examination (80 marks):

1. Weightage of each module in end semester examination will be proportional to number of respective lecture
2. Question paper will comprise of total **six questions, each carrying 20 marks**
3. **Question 1** will be compulsory and should cover **maximum contents of the curriculum.**
4. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module3)
5. Only **Four questions need to be solved.**

Recommended Books

1. Engineering Chemistry- Jain& Jain Dhanpat Rai & Co. (P) Ltd
2. Engineering Chemistry- Satyaprakash & Manisha Agrawal, Khanna Book Publishing.
3. Organic reaction Mechanisms- V.K. Ahluwalia , Rakesh Parashar, Narosa Publication.
4. Basic Concepts of Analytical Chemistry- S. M. Khopkar, New Age International.

Reference Books

1. Principles of Physical Chemistry- B. R. Puri, L. R. Sharma, M.S. Pathania.
2. Introduction to Spectroscopy – Pavia, Lampman, Kriz , CENGAGE Learning.
3. Industrial Chemistry – B K Sharma, Goel Publishing House.
4. Organic Chemistry – J. Clayden, Greeves, Warren, Oxford University Press.
5. Principle of instrumental analysis - Douglas A. Skoog.
6. Essentials of Physical Chemistry, Bahl & Tuli, S.Chand Publishing.
7. A Text Book of Engg. Chemistry, Shashi Chawla, Dhanpat Rai & Co. (P) Ltd.
8. Textbook of Engineering Chemistry- S.S. Dara, S. Chand publication..

Semester IV

Course Code	Course Name	Credits
CHC403	Numerical Method in Chemical Engineering	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	--	--	100

Prerequisites

1. Differential Calculus.
2. Integral Calculus.
3. Differential Equations.
4. Linear Algebraic Equations.

Objectives

1. To study numerical analysis methods
2. To understand the application of numerical analysis in solving Chemical Engineering problems
3. To solve Chemical Engineering problems with numerical analysis techniques
4. To understand fitting of experimental data using appropriate method
5. To analyze and evaluate the accuracy of numerical methods
6. To apply appropriate numerical method to obtain approximate solution of Chemical Engineering problems

Detailed Syllabus

Module No.	Course Contents	No. of Hours
1	**Approximations and Errors:** Types of Errors, Significant figures, Accuracy of Numbers, Precision, Truncation error and Taylor series, Error Propagation **Solution of Algebraic and Transcendental equations:** Roots of equations and Engineering Practice, Bracketing methods: (Bisection, RegulaFalsi Method/false position) Open methods: (Successive substitution/simple fixed point iteration, Secant Method, Newton Raphson Method) **(Numericals based on application in Chemical Engineering)**	9

2	**Solution of linear Algebraic equations**. Gauss Elimination, LU decomposition, Gauss-Seidel Method, Gauss-Jordan Method. **(Numericals based on application in Chemical Engineering)**	7
3	**Curve Fitting** Method of Least Squares, Fitting a Straight Line and a Polynomial, Fitting a Non-linear Function **(Numericals based on application in Chemical Engineering)**	5
4	**Numerical Differentiation & Integration:** Differentiation Formula based on Tabulator at Equal and Unequal Intervals, Trapezoidal Rule and Simpson's 1/3 and 3/8 Rule **(Numericals based on application in Chemical Engineering)**	4
5	**Ordinary Differential Equations :**Euler's Method, Modifications and Improvements in Euler's Method, Runge-Kutta 2nd Order & 4th Order Methods. **(Numericals based on application in chemical engineering)**	8
6	**Partial Differential equations:** Finite difference: Elliptic Equations (Laplace Equations) Finite difference: Parabolic Equations (Heat Conduction Equation) Crank-Nicolson method, Bender Schmidt Method	6

Course Outcome

On completion of the course the students will:

1. Solve linear algebraic equations.
2. Solve nonlinear algebraic equations.
3. Solve using Curve fitting
4. solve Ordinary Differential equations
5. Solve Partial Differential equations
6. Solve Chemical engineering problems with numerical analysis techniques.

Assessment

Internal Assessment (20 Marks):

Consisting **Two Compulsory Class Tests.** First test based on approximately 40% of contents and second test based on remaining contents (approximately40% but excluding contents covered in TestI).

End Semester Examination (80 marks):

1. Weightage of each module in end semester examination will be proportional to number of respective lectures
2. Question paper will comprise of total **six questions, each carrying 20marks**
3. **Question 1** will be compulsory and should cover **maximum contents of the curriculum.**
4. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module3)
5. Only **Four questions need to be solved.**

Recommended Books

1. Numerical Methods for Engineers **Author** : S C Chapra and R P Canale **Publisher** : McGraw Hill International Edition

2. Introductory Methods of Numerical Analysis **Author** : S S Shastry **Publisher** : Prentice Hall of India
3. Numerical Methods in Engineering & Science **Author** : B S Grewal **Publisher** : Khanna Publishers
4. Numerical methods in chemical engineering **Author** : Pradeep Ahuja **Publisher** : PHI learning
5. Numerical Methods for Scientific and Engineering Computation **Author** : M K Jain, S R K Iyengar and R K Jain **Publisher** : Wiley Eastern
6. Numerical Methods **Author** :P. Kandasamy, K. Thilagavathy, K. Gunavathi **Publisher** : S. Chand

Reference Books

1. Numerical Methods for Computer Science, Engineering and Mathematics **Author** : John H. Mathews **Publisher** : Prentice-Hall International
2. Numerical Methods for Chemical Engineering: Applications in MATLAB **Author :** Kenneth J. Beers **Publisher:** Cambridge university press
3. Applied Numerical Methods with MATLAB: for Engineers & Scientists **Author** : S C Chapra **Publisher**: McGraw-Hill Education

Semester IV

Course Code	Course/Subject Name	Credits
CHC404	Solid Fluid Mechanical Operations	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hours	--	--	--	100

Prerequisites

1. Fluid Flow Operations
2. Engineering Mechanics
3. Differential Equations

Course Objectives

1. Familiarize particle size distribution.
2. Learn size reduction principles
3. Understand fluidization and filtration
4. To have the knowledge of solid-fluid separation
5. Understand storage and handling of solids
6. Understand solid fluid mixing

Detailed Syllabus

Module No.	Course Contents	No. of Hours
1	**Particle Size :** Introduction: scope and application of solid fluid operation. Particle size measurement and distribution using sieve analysis. Capacity and effectiveness of screen (numerical on the topic). Screening equipment: Vibrating screens, Grizzlies and Trommels	05
2	**Size reduction:** Size reduction of solids. Mechanism of size reduction and method of operation. Energy requirement for size reduction (numerical on the topic). Size reduction equipment: Jaw Crusher, Hammer Mill, Ball Mill and Roll Crusher.	07

3	**Fluidization and Filtration :** Flow through packed bed. Types of packing. Flow of a single fluid through a packed bed, Ergun's equation. Fluidization: Conditions for fluidization. Minimum fluidization velocity. Types of fluidization; Application of fluidization (numerical on the topic). Filtration: Mechanism of filtration. Types of filtration: constant rate and constant pressure filtration. Filter aids, washing of filter cake, flow of filtrate through the cloth and cake combined; Numerical on constant pressure, constant rate and specific case of cloth & cake combine. Filters: Rotary drum vacuum filter, plate & frame filter press.	10
4	**Solid-Fluid separation:** Sedimentation: Batch sedimentation. Kynch theory of sedimentation. Derivation of area and depth of thickener (numerical on the topic). Particle separation by flotation and elutriation. Gas solid separation equipment: Cyclone separator (theory and derivation for minimum particle separated in cyclone separator), fabric filter and electrostatic precipitator	08
5	**Storage and handling of solids :** Storage of solids: Properties of particulate masses; Pressures in bins &silos; Jansen's equation. Conveying of solids: Belt conveyor, bucket conveyer, screw conveyer and pneumatic conveyer.	04
6	**Mixing :** Solid mixing: Introduction to solid mixing, degree of mixing, mixing Index & rate of mixing (numerical on the topic). Mixing equipment for cohesive and free flowing solids. Mixers for cohesive solids: Muller mixer and kneaders. Mixers for free flowing solids: Ribbon blender and internal screw mixer	05

Course Outcomes

On completion of the course the students will:

1. Apply the concept of particle size distribution and identify the equipment
2. Explain size reduction principles
3. Compute the fluidization and filtration parameters
4. Design solid-fluid separation equipment
5. Discuss the techniques for storage and handling of solids
6. Explain solid fluid mixing

Assessment

Internal Assessment (20 Marks):

Consisting **Two Compulsory Class Tests.** First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in TestI).

End Semester Examination (80 marks):

1. Weightage of each module in end semester examination will be proportional to

number of respective lecture.

2. Question paper will comprise of total **six questions, each carrying 20marks.**
3. **Question 1** will be compulsory and should cover **maximum contents of the curriculum.**
4. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module3)
5. Only **Four questions need to be solved.**

Recommended Books

1. W. McCabe, J.C. Smith and P. Harriot, Unit operations of chemical engineering, 7th edition, McGraw Hill, 2004.
2. J .M Coulson and J. F Richardson, Chemical Engineering, vol 2, Pergamon Press, 1974.
3. A.S. Foust and L.A. Wenzel, Principles of unit operation, 2nd edition, Wiley, 1980.

Reference

1. Perry's Chemical Engineers' Handbook , Robert H. Perry & Don W. Green, 8thedition, McGraw Hill

Semester IV

Course Code	Course Name	Credits
CHC405	Chemical Engineering Thermodynamics II	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hours	--	--	--	100

Prerequisites

1. Chemical Engineering Thermodynamics I.
2. Engineering Mathematics.
3. Engineering Physics and Engineering Chemistry

Course Objectives

1. To compute the thermodynamic properties of ideal and non-ideal solutions and mixtures.
2. To explain thermodynamic concepts such as activity, chemical potential and excess property for solutions.
3. To perform calculations and analyze problems related to phase equilibria.
4. To predict and analyze vapour-liquid equilibrium data for various systems.
5. To perform calculations and analyze problems related to chemical reaction equilibria.
6. To outline various types of refrigeration cycles and predict their performance.

Detailed Syllabus

Module No.	Course Contents	No. of Hours
1	1.1 Properties of ideal mixtures and solutions 1.2 Non-idealities of solutions and mixtures 1.3 Partial molar properties 1.4 Chemical potential	04
2	2.1 Activity and activity coefficients 2.2 Gibbs-Duhem equation 2.3 Property changes of mixing 2.4 Excess properties	06
3	3.1 Concept of equilibrium between phases 3.2 Review of Raoult's law and Henry's law 3.3 Phase diagrams for binary solutions	04

4	4.1 Vapour-liquid equilibria in ideal and non-ideal solutions 4.2 Estimation of activity coefficients using Margules equations, van Laar equation and Wilson equation 4.3 Introduction to UNIQUAC equation and UNIFAC method 4.4 Consistency tests for VLE data	08
5	5.1 Representation of reaction stoichiometry 5.2 Concept of reaction equilibrium in single and multiple reactions 5.3 Estimation of standard heat of reaction 5.4 Estimation of standard Gibbs free energy change and equilibrium constant of a reaction 5.5 Estimation of degree of conversion and composition of reactor effluents for single and multiple reactions 5.6 Degrees of freedom for single and multiple reactions	10
6	6.1 Theory of Refrigeration 6.2 Vapour compression refrigeration system 6.3 Vapour absorption refrigeration system 6.4 Refrigeration cycle diagrams (P-V, T-S, H-S, P-H) 6.5 Estimation of COP, refrigerant flow rate and power consumption	07

Course Outcomes

On completion of the course the students will:

1. Evaluate the thermodynamic properties of ideal and non-ideal solutions and mixtures.
2. Perform calculations related to solution thermodynamics.
3. Analyze and solve the problems of phase equilibria and vapour-liquid equilibria.
4. Apply various methods for estimation of thermodynamic properties.
5. Analyze and solve the problems of chemical reaction equilibria.
6. Describe various types of refrigeration cycles and evaluate their performance.

Assessment

Internal Assessment (20 Marks):

Consisting **Two Compulsory Class Tests.** First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I).

End Semester Examination (80 marks):

1. Weightage of each module in end semester examination will be proportional to number of respective lectures.
2. Question paper will comprise of total **six questions, each carrying 20 marks.**
3. **Question 1** will be compulsory and should cover **maximum contents of the curriculum.**
4. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
5. Only **Four questions need to be solved.**

Recommended Books

1. J.M. Smith, H.C. Van Ness, M.M. Abbot, M.T. Swihart, Introduction to Chemical Engineering Thermodynamics, 8th Edition, McGraw-Hill Education, 2017.

2. K.V. Narayanan, A Textbook of Chemical Engineering Thermodynamics, 2nd Edition, Prentice Hall of India Pvt. Ltd., 2013.
3. Y.V.C. Rao, Chemical Engineering Thermodynamics, Universities Press, 1997.

Reference Books

1. M.J. Moran, H.N. Shapiro, D.D. Boettner, M.B. Bailey, Fundamentals of Engineering Thermodynamics, 9th Edition, Wiley, 2018.
2. Gopinath Halder, Introduction to Chemical Engineering Thermodynamics, 2nd Edition, Prentice Hall of India Pvt. Ltd., 2014.
3. S. Sandler, Chemical, Biochemical and Engineering Thermodynamics, 5th Edition, John Wiley and Sons, 2017.
4. J. Richard Elliot and Carl T. Lira, Introductory Chemical Engineering Thermodynamics, 2nd Edition, Prentice Hall, 2012.

Semester IV

Course Code	Course Name	Credits
CHL401	Industrial and Engineering Chemistry Lab II	1.5

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	03	-	-	1.5	-	1.5

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR/OR	OR	
Test-I	Test-II	Average						
-	-	-	-	-	25	25	-	50

Prerequisites

1. Basic knowledge of qualitative & quantitative terms, mole fractions, normality, morality etc.
2. Basic idea of salts, acids, bases, phenol, neutral compounds and indicators etc.
3. Basic introduction of lab safety and handling of glass wares.

Lab Objectives

1. To use pH meter for different applications.
2. To give insight of inorganic titrimetric analysis.
3. Use of instrumental methods such as Spectrophotometer for the detection of alkali metal ions.
4. Use of different chromatographic techniques for the separation and estimation ions.
5. Estimation and preparation of organic compounds.
6. To enable students to identify organic compounds by systematic analysis.

Lab Outcomes

On completion of the course the **students will:**

1. Determine dissociation constant of dibasic acid, strength of solution and quantity of solute pH metrically.
2. Perform the titration and find the content in terms of quantity.
3. Detect alkali metal ions spectrophtometrically.
4. Identify, separate and detect ions present in solvent chromatographically.
5. Identify the compound by interpreting the spectral data received from optical method.
6. Synthesize chemical compounds in laboratory.

List of Experiments (Minimum Eight)

Experiment no.	Details of Experiment	Lab Hours
1	**Organic spotting:** Identification of organic compounds (**05**).	3

2	**pH-metry:** Determination of dissociation constant of dibasic organic acids such as malonic acid, succinic acid	3
3	**Titrimetric analysis:** Estimation of CaO in cement	3
4	Estiimation of Vitamin C using ceric ammonium sulphate	3
5	Determine strength of $CuSO_4$ with help of hypo solution	3
6	**Flame photometry.** Determination of Na / K / Ca present in the given sample.	3
7	**Chromatography.** Paper chromatography and TLC [Demonstration of techniques].	3
8	Gravimetric Estimation of Zn	3
9	**Spectro-photometry.** Estimation of Fe^{3+} ions by Spectrophotometry.	3
10	Determination of fluoride content in the toothpaste spectrophotometrically	3
11	**Organic Estimations:** Estimation of Glucose Iodometrically.	3
12	Estimation of Ester by Hydrolysis.	
13	Volume strength and amount of H_2O_2.	3
14	**Organic Preparation** Nitration of Salicylic acid	3
15	Sulphonation of Benzene	3
16	**Spectroscopy Interpretation** Problem solving and spectral interpretation	3

Assessment

Term Work (25 marks):

Distribution of marks will be as follows:

Laboratory work: 15 marks
Assignments: 05
Attendance: 05

End Semester Practical Examination/orals (25 marks):

Practical Examination will be on experiments performed in the laboratory

Reference Books

1.Vogel's Quantitative Chemical Analysis-David J. Barnes J. Mendham, R.C. Denney, M.J.K Thomas Pearson Education; 6 edition
2. Laboratory Manual Engg. Chemistry- Anupma Rajput, Dhanpat Rai & Co.
3. Vogel's Textbook of Practical organic chemistry.

Semester IV

Course Code	Course Name	Credits
CHL402	Numerical Methods in Chemical Engineering lab	1.5

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	03	-	-	1.5	-	1.5

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR/OR	OR	
Test-I	Test-II	Average						
-	-	-	-	-	25	-	25	50

Prerequisites

1. Basic computer skills is essential.
2. Knowledge of programming language
3. Differential Calculus.
4. Integral Calculus.
5. Differential Equations.
6. Linear Algebraic Equations

Lab Objectives

1. To study numerical analysis methods
2. To understand the application of numerical analysis in solving Chemical Engineering problems
3. To learn mathematical computing tools like Matlab, Scilab, Python etc
4. To solve Chemical Engineering problems with numerical analysis techniques using Matlab, Scilab, Python etc
5. To understand fitting of experimental data using appropriate method
6. To analyze and evaluate the accuracy of numerical methods

Lab Outcomes

On completion of the course the students will:

1. Solve linear algebraic equations.
2. Solve nonlinear algebraic equations.
3. Solve using Curve fitting
4. Solve Ordinary Differential equations
5. Solve Partial Differential equations
6. Solve Chemical engineering problems with numerical analysis techniques.

List of Experiments (minimum eight)

Experiment no.	Details of Experiment	Lab Hours
1	Find the root of given Equation using Bisection method	3
2	Find the root of given equation using Regula Falsi/False position method	3
3	Find the root of given equation using Secant method	3
4	Find the root of given equation using Newton Raphson Method	3
5	Solve linear algebraic equations using Gauss Elimination method (or LU Decomposition method)	3
6	Regression analysis	3
7	Numerical integration	3
8	Solving ordinary differential equation using Eulers method	3
9	Solving ordinary differential equation using Runge Kutta 2^{nd} order method	3
10	Solving ordinary differential equation using Runge Kutta 4^{th} order method	3
11	Solve non-linear equations based on applications in Chemical Engineering	3
12	Solve linear equations based on applications in Chemical Engineering	3
13	Solve ordinary differential equations based on applications in Chemical Engineering	3

Note: Practicals can be performed using Python, Scilab, Matlab or any other programming language

Assessment

Term Work (25 marks):

Distribution of marks will be as follows:

Laboratory work: 20 marks

Attendance: 05 marks

End Semester Orals (25 marks):

Orals on experiments done in the laboratory

Recommended Books

1. Numerical Methods for Engineers **Author** : S C Chapra and R P Canale **Publisher** : McGraw Hill International Edition
2. Introductory Methods of Numerical Analysis **Author** : S S Shastry **Publisher** : Prentice Hall of India
3. Numerical methods in chemical engineering **Author** : Pradeep Ahuja **Publisher** : PHI learning
4. Numerical Methods for Scientific and Engineering Computation **Author** : M K Jain, S R K Iyengar and R K Jain **Publisher** : Wiley Eastern
5. Numerical Methods **Author** :P. Kandasamy, K. Thilagavathy, K. Gunavathi **Publisher** : S. Chand

Reference Books

1. Numerical Methods for Computer Science, Engineering and Mathematics **Author** : John H. Mathews **Publisher** : Prentice-Hall International
2. Numerical Methods for Chemical Engineering: Applications in MATLAB **Author :** Kenneth J. Beers **Publisher:** Cambridge university press
3. Applied Numerical Methods with MATLAB: for Engineers & Scientists **Author** : S C Chapra **Publisher**: McGraw-Hill Education

Semester IV

Course Code	Course Name	Credits
CHL403	Solid Fluid Mechanical Operation Lab	1.5

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	03	-	-	1.5	-	1.5

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR/OR	OR	
Test-I	Test-II	Average						
-	-	-	-	-	25	25	-	50

Prerequisites

1. Fluid Flow Operations
2. Basic knowledge on mechanical operations
3. Differential Equations

Lab Objectives

1. Understand the importance of various mechanical operations used in process industry
2. Apply principles of basic sciences and chemical engineering for designing various size reduction and separation equipment.
3. Understand particulate solid characterization, storage and transportation of solids
4. Familiarize primary and secondary crushers.
5. Acquire knowledge of mixing operation.
6. Understand filtration and sedimentation operation.

Lab Outcomes

On completion of the laboratory course the students will:

1. Understand the operation of various equipment used in chemical and allied process industry.
2. Acquire analytical skills for determination of particle size of solid mixture.
3. Determine the effectiveness of vibrating screen.
4. Apply the laws of crushing.
5. Design a thickener.
6. Determine filtration parameters

List of Experiments (minimum eight)

Experiment no.	Details of Experiment	Lab Hours
1	Sieve Analysis	3
2	Effectiveness of screen	3

3	Size reduction by jaw crusher	3
4	Size reduction by hammer mill	3
5	Size reduction by ball mill	3
6	Batch sedimentation	3
7	Flow through fluidized bed	3
8	Flow through packed bed	3
9	Filtration	3
10	Mixing	3
11	Cyclone separator	3
12	Roll crusher	3
13	Elutriation	3
14	Froth floatation	3
15	Experiments using virtual labs	3

Assessment

Term Work (25 marks):

Distribution of marks will be as follows:
Laboratory work: 15 marks
Assignments: 05
Attendance: 05

End Semester Practical Examination/orals (25 marks):

Practical Examination will be on experiments performed in the laboratory

Recommended Books

1. W. McCabe, J.C. Smith and P. Harriot, Unit operations of chemical engineering, 7th edition, McGraw Hill, 2004.
2. J .M Coulson and J. F Richardson, Chemical Engineering, vol 2, Pergamon Press, 1974.
3. A.S. Foust and L.A. Wenzel, Principles of unit operation, 2nd edition, Wiley, 1980.

Reference

1. Perry's Chemical Engineers' Handbook, Robert H. Perry & Don W. Green, 8thedition, McGraw Hill.

Semester IV

Course Code	Course Name	Credits
CHL404	Skilled based lab: Design Calculation of Auxiliary Plant Equipment	1.5

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	03	-	-	1.5	-	1.5

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR/OR	OR	
Test-I	Test-II	Average						
-	-	-	-	-	25	-	25	50

Prerequisites

1. Basic computer skills including MS EXCEL is essential.
2. Various basic units with their inter conversion.
3. Laws from thermodynamics and Ideal gas law.
4. Laws of Mechanics.
5. Basic mathematical skills in Algebra and Geometry.
6. Basic knowledge of Fluid Flow Operations.

Lab Objectives

1. Students should be able to understand the various units and their conversion factors.
2. They should be able to calculate basic properties of various substances.
3. They should be able to do calculations for designing the pressure vessels subjected to internal and external pressure and properties related to storage tanks of various geometries.
4. They should be able to do calculations to determine sizing of the pipelines and valves.
5. They should be able to calculate power requirement in agitation.
6. They should be able to perform various calculations from basic principles of chemical engineering.

Lab Outcome

On completion of the course:

1. Students will perform unit conversion and apply to chemical engineering problems.
2. Students will understand basic function and design of steam trap.
3. Students will understand the pressure vessels and its design.
4. Students will understand various characteristics and power requirement of pumps.
5. Students will understand use of Psychrometric chart for properties of water and steam.
6. Students will understand the theoretical concepts from process calculation

List of Experiments (Minimum eight)		
Experiment no.	**Details of Experiment**	**Lab Hours**
1	Preparation of conversion table for universal gas constant, dynamic and kinematic viscosity and pressure.	3
2	Calculation of molar volume from Van der Waals equation of state.	3
3	Calculation of vapour pressure of liquid mixture from Antoine Equation.	3
4	Calculation of dew point temperature of acidic gases.	3
5	Estimation of properties of Water and Steam from Psychrometric Chart.	3
6	Excess air calculation in hydrocarbon fuel oil fired furnace	3
7	To study the characteristics and power requirement of pump.	3
8	Calculation of depth of water in an open channel with semicircular bottom.	3
9	Sizing and selection of steam traps.	3
10	Solving Raoult's law for binary systems.	3
11	Calculation of natural gas viscosity and compressibility factor.	3
12	Material balance calculation over an entire process in EXCEL.	3
13	Calculation of Cooling tower.	3
14	Calculation for refrigeration and air conditioning load.	3
15	Calculation of temperature rise and power consumed in compressing a gas mixture from an Inlet Pressure to Desired Outlet pressure for reciprocating compressor.	3
16	Calculating boiler and process thermal heater efficiency by input- output and heat loss method.	3

Note: All the Experiments (Minimum eight) should be performed using MS EXCEL **or** any open source software **or** any paid software if available in institute.

Assessment

Term Work (25 marks):

Distribution of marks will be as follows:
Laboratory work: 20 marks
Attendance: 05 marks

End Semester Orals (25 marks):

Orals on experiments carried out in the laboratory.

Recommended Books

1. Chemical Engineering Thermodynamics by Y.V.C. Rao, Latest Edition, University Press
2. Narayan, K. V. and Lakshmikutty, B. "Stioichiometry and Process Calculations", 1st edition, Prentice Hall of India Pvt. Ltd., New Delhi (2006)
3. Bhatt, B. I. and Thakore, S. B., "Stoichimetry, 5th edition Tata McGraw Hill Education Private Limited, New Delhi
4. Warren L. Mccabe, Julian C. Smith, Peter Harriott, Unit Operations of Chemical Engineering, McGraw Hill International Edition.

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. Ch. Durga Prasad Rao and D. V. S. Murthy, " Process Calculations for Chemical Engineers", McMilan India Ltd. (2010)
3. A textbook of Chemical Engineering Thermodynamics by K.V. Narayanan, Latest Edition, Prentice Hall of India Private Limited
4. Introduction to Chemical Engineering Thermodynamics by Gopinath Halder, PHI learning Pvt. Ltd
5. Coulson J. M., Richardson J. F., Backhurst J. R. and J. H. Harker, Chemical Engineering, Vol. 1 and 2.
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.

Semester IV

Course Code	Course Name	Credits
CHM401	Mini Project 1B	1.0

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	02	-	-	1.0	-	1.0

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR/OR	OR	
Test-I	Test-II	Average						
-	-	-	-	-	25	-	25	50

Objectives

1. To acquaint with the process of identifying the needs and converting it into the problem.
2. To familiarize the process of solving the problem in a group.
3. To acquaint with the process of applying basic engineering fundamentals to attempt solutions to the problems.
4. To inculcate the process of self-learning and research.

Outcome: Learner will…

1. Identify problems based on societal /research needs.
2. Apply Knowledge and skill to solve societal problems in a group.
3. Develop interpersonal skills to work as member of a group or leader.
4. Draw the proper inferences from available results through theoretical/ experimental/simulations.
5. Analyse the impact of solutions in societal and environmental context for sustainable development.
6. Use standard norms of engineering practices
7. Excel in written and oral communication.
8. Demonstrate capabilities of self-learning in a group, which leads to life long learning.
9. Demonstrate project management principles during project work.

Guidelines for Mini Project

- Students shall form a group of 3 to 4 students, while forming a group shall not be allowed less than three or more than four students, as it is a group activity.
- Students should do survey and identify needs, which shall be converted into problem statement for mini project in consultation with faculty supervisor/head of department/internal committee of faculties.
- Students hall submit implementation plan in the form of Gantt/PERT/CPM chart, which will cover weekly activity of mini project.
- A log book to be prepared by each group, wherein group can record weekly work progress, guide/supervisor can verify and record notes/comments.

- Faculty supervisor may give inputs to students during mini project activity; however, focus shall be on self-learning.
- Students in a group shall understand problem effectively, propose multiple solution and select best possible solution in consultation with guide/ supervisor.
- Students shall convert the best solution into working model using various components of their domain areas and demonstrate.
- The solution to be validated with proper justification and report to be compiled in standard format of University of Mumbai.
- With the focus on the self-learning, innovation, addressing societal problems and entrepreneurship quality development within the students through the Mini Projects, it is preferable that a single project of appropriate level and quality to be carried out in two semesters by all the groups of the students. i.e. Mini Project 1 in semester III and IV. Similarly, Mini Project 2 in semesters V and VI.
- However, based on the individual students or group capability, with the mentor's recommendations, if the proposed Mini Project adhering to the qualitative aspects mentioned above gets completed in odd semester, then that group can be allowed to work on the extension of the Mini Project with suitable improvements/modifications or a completely new project idea in even semester. This policy can be adopted on case by case basis.

Guidelines for Assessment of Mini Project:

Term Work

- The review/ progress monitoring committee shall be constituted by head of departments of each institute. The progress of mini project to be evaluated on continuous basis, minimum two reviews in each semester.
- In continuous assessment focus shall also be on each individual student, assessment based on individual's contribution in group activity, their understanding and response to questions.
- Distribution of Term work marks for both semesters shall be as below;
  - Marks awarded by guide/supervisor based on log book : 10
  - Marks awarded by review committee : 10
  - Quality of Project report : 05

Review/progress monitoring committee may consider following points for assessment based on either one year or half year project as mentioned in general guidelines.

One-year project:

- In first semester entire theoretical solution shall be ready, including components/system selection and cost analysis. Two reviews will be conducted based on presentation given by students group.
  - First shall be for finalisation of problem
  - Second shall be on finalisation of proposed solution of problem.
- In second semester expected work shall be procurement of component's/systems, building of working prototype, testing and validation of results based on work completed in an earlier semester.
  - First review is based on readiness of building working prototype to be conducted.
  - Second review shall be based on poster presentation cum demonstration of working model in last month of the said semester.

Half-year project:

- In this case in one semester students' group shall complete project in all aspects including,
  - Identification of need/problem
  - Proposed final solution
  - Procurement of components/systems
  - Building prototype and testing
- Two reviews will be conducted for continuous assessment,
  - First shall be for finalisation of problem and proposed solution
  - Second shall be for implementation and testing of solution.

Assessment criteria of Mini Project.

Mini Project shall be assessed based on following criteria;

1. Quality of survey/ need identification
2. Clarity of Problem definition based on need.
3. Innovativeness in solutions
4. Feasibility of proposed problem solutions and selection of best solution
5. Cost effectiveness
6. Societal impact
7. Innovativeness
8. Cost effectiveness and Societal impact
9. Full functioning of working model as per stated requirements
10. Effective use of skill sets
11. Effective use of standard engineering norms
12. Contribution of an individual's as member or leader
13. Clarity in written and oral communication

- In **one year, project**, first semester evaluation may be based on first six criteria's and remaining may be used for second semester evaluation of performance of students in mini project.
- In case of **half year project** all criteria's in generic may be considered for evaluation of performance of students in mini project.

Guidelines for Assessment of Mini Project Practical/Oral Examination:

- Report should be prepared as per the guidelines issued by the University of Mumbai.
- Mini Project shall be assessed through a presentation and demonstration of working model by the student project group to a panel of Internal and External Examiners preferably from industry or research organisations having experience of more than five years approved by head of Institution.
- Students shall be motivated to publish a paper based on the work in Conferences/students competitions.

Mini Project shall be assessed based on following points;

1. Quality of problem and Clarity
2. Innovativeness in solutions
3. Cost effectiveness and Societal impact
4. Full functioning of working model as per stated requirements
5. Effective use of skill sets
6. Effective use of standard engineering norms

7. Contribution of an individual's as member or leader
8. Clarity in written and oral communication.