

University of Mumbai



No. AAMS(UG)/ 18 of 2022-23

CIRCULAR:-

Attention of the Principals of the Affiliated Colleges, Directors of the Recognized Institutions in Faculty of Science & Technology is invited to this office circular No. UG/52 of 2021 dated 21st January, 2021 relating to the revised Scheme (Rev-2019 'C' Scheme) for the B.E. in Chemical Engineering (Sem. III to VIII).

They are hereby informed that the recommendations made by the Ad-hoc Board of Studies in Chemical Engineering at its meeting held on 13th November, 2021 and subsequently passed by the Board of Deans at its meeting held on 27th December 2021 vide item No. 6.10 have been accepted by the Academic Council at its meeting held on 28th December, 2021 vide item No. 6.10 and that in accordance therewith, the reduced syllabus for B.E. (Chemical Engineering) (Rev-2019 'C' Scheme for Direct Second Year (Sem.III) as Direct Second Year (DSE) students admission is delayed by the six months due to COVID-19 situation, has been brought into force with effect from the academic year 2021-22 only. (The same is available on the University's website www.mu.ac.in).

MUMBAI – 400 032

4th May, 2022

To

The Principals of the Affiliated Colleges, and Directors of the Recognized Institutions in Faculty of Science & Technology.

A.C/6.10/28/12/2021

No. AAMS(UG)/ 18 -A of 2022-23

4th May, 2022

Copy forwarded with Compliments for information to:-

- 7) The Dean, Faculty of Science & Technology,
- 8) The Chairman, Board of Studies Chemical Engineering,
- 9) The Director, Board of Examinations and Evaluation,
- 10) The Director, Board of Students Development,
- 11) The Director, Department of Information & Communication Technology,
- 12) The Co-ordinator, MKCL.

(Sudhir S. Puranik)
REGISTRAR

Copy for information and necessary action :-

1. The Deputy Registrar, College Affiliations & Development Department (CAD),
2. College Teachers Approval Unit (CTA),
3. The Deputy Registrar, (Admissions, Enrolment, Eligibility and Migration Department (AEM),
4. The Deputy Registrar, Academic Appointments & Quality Assurance (AAQA)
5. The Deputy Registrar, Research Administration & Promotion Cell (RAPC),
6. The Deputy Registrar, Executive Authorities Section (EA)
He is requested to treat this as action taken report on the concerned resolution adopted by the Academic Council referred to the above circular.
7. The Deputy Registrar, PRO, Fort, (Publication Section),
8. The Deputy Registrar, Special Cell,
9. The Deputy Registrar, Fort Administration Department (FAD) Record Section,
10. The Deputy Registrar, Vidyanagari Administration Department (VAD),

Copy for information :-

1. The Director, Dept. of Information and Communication Technology (DICT), Vidyanagari,
He is requested to upload the Circular University Website
2. The Director of Department of Student Development (DSD),
3. The Director, Institute of Distance and Open Learning (IDOL Admin), Vidyanagari,
4. All Deputy Registrar, Examination House,
5. The Deputy Registrars, Finance & Accounts Section,
6. The Assistant Registrar, Administrative sub-Campus Thane,
7. The Assistant Registrar, School of Engg. & Applied Sciences, Kalyan,
8. The Assistant Registrar, Ratnagiri sub-centre, Ratnagiri,
9. P.A to Hon'ble Vice-Chancellor,
10. P.A to Pro-Vice-Chancellor,
11. P.A to Registrar,
12. P.A to All Deans of all Faculties,
13. P.A to Finance & Account Officers, (F & A.O),
14. P.A to Director, Board of Examinations and Evaluation,
15. P.A to Director, Innovation, Incubation and Linkages,
16. P.A to Director, Department of Lifelong Learning and Extension (DLLE),
17. The Receptionist,
18. The Telephone Operator,

Copy with compliments for information to :-

19. The Secretary, MUASA
20. The Secretary, BUCTU.

AC – 28/12/2021

Item No. - 6.10

UNIVERSITY OF MUMBAI



Bachelor of Engineering (Chemical Engineering)

**Direct Second Year (Sem. III) Admitted Students for the
current Academic Year 2021-22 Only due to Covid
Pandemic**

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

**Under
FACULTY OF SCIENCE & TECHNOLOGY**

University of Mumbai
Program Structure for B.E. Chemical Engineering (Revised 2021-2022)
Semester III

Course code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			Total
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	
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	<p>Module: Laplace Transform</p> <p>1.1 Definition of Laplace transform, Condition of Existence of Laplace transform,</p> <p>1.2 Laplace Transform (L) of Standard Functions like e^{at}, $\sin(at)$, $\cos(at)$, $\sinh(at)$, $\cosh(at)$ and t^n, where $n \geq 0$.</p> <p>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).</p> <p>1.4 Evaluation of integrals by using Laplace Transformation.</p> <p>Self-learning topics: Heaviside's Unit Step function, Laplace Transform. of Periodic functions, Dirac Delta Function.</p>	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	06

	6.3 Bender Schmidt method Self-learning Topics: Analytical methods of solving two and three dimensional problems.	
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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. Chand Publication
8. Laplace transforms, Murray R. Spiegel, Schaum's Outline Series.

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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-	04

	Conductance, specific conductance, equivalent conductance, molar conductance. Effect of dilution and temperature on conductance. Transport number, moving boundary method and numerical. Conductometry: Principle and types of titrations - Acid-base and precipitation	
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. 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 $[\text{Fe}(\text{CO})_5]$ and $[\text{Fe}_2(\text{CO})_9]$ w.r.t preparation, properties, structure and bonding.	08
03	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.	03
04	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. Numerical based on solvent extraction.	05
	TOTAL	20

❖ **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
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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	Fluid and its properties, 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. Boundary layer formation in straight tube, Transition length for laminar and turbulent flow.	03
2	Bernoulli's equation, Euler's equation, Modified Bernoulli's equation.	03

	Practical Application of Bernoulli's Equation (Venturimeter & Orificemeter)	
3	Derivation of Hagen – Poiseuille equation, Friction factor, Darcy-Weisbach equation, Moody diagram, Equivalent diameter for circular and non-circular ducts. Major and minor losses	04
4	Flow of Compressible Fluids: Mach number, Sonic, Supersonic and Subsonic flow, Continuity equation and Bernoulli's equation Flow past immersed bodies: Drag Forces, Coefficient of Drag, One dimensional motion of particle through fluid, Terminal Settling Velocity, Stoke's law, Stagnation Point.	04
5	Classification of pumps, Centrifugal Pump- Construction & working, Characteristics of pumps (curves), Cavitation, NPSH, NPSHA, NPSHR, Priming. Power Consumption in Agitation: Purpose of Agitation, Types of Impellers, Prevention of Swirling, Power Curves, Power Number	04
	TOTAL	18

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 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 module 3).
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 and 2.
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.
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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	Review of First Law of Thermodynamics for flow and non flow processes.	04
2	Concepts of heat engine, heat pump and refrigerator, Carnot Cycle and Carnot Principle	04
3	Concept of Exergy, Applications of Exergy	02

4	Equations of state for non-ideal gases: van der Waals equation of state. Redlich-Kwong equation of state.	03
5	Maxwell's Equations, Enthalpy and Entropy departure functions (van der Waals and Redlich-Kwong EOS), Fugacity and fugacity coefficient (van der Waals and Redlich-Kwong EOS)	06
	TOTAL	19

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 Thermodynamic 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.

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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. Density, specific volume, specific gravity, concentration & composition of mixtures and solutions. Ideal Gas law, Dalton's law, Amagat's law and Raoult's law.	02

2	Material Balance without Chemical Reactions: Solving material balance problems for various unit operations (Absorption, Distillation, Extraction and Crystallization)	03
3	Material Balance with Chemical Reactions: Concept of limiting and excess reactants, conversion and yield, selectivity and degree of completion of reaction.	04
4	Recycle, Bypass and Purge Operations: Material Balance calculations for both with and without chemical reactions.	02
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.	04
6	Combined Material and Energy Balance: Material and energy balance for binary distillation.	01
	TOTAL	16

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 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 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 module 3).
5. Only **Four questions need to be solved**.

Recommended Books

1. Narayan, K. V. and Lakshmikutty, B. "Stoichiometry and Process Calculations", 1st edition, Prentice Hall of India Pvt. Ltd., New Delhi (2006)
2. Bhatt, B. I. and Thakore, S. B., "Stoichiometry, 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, Molarity 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 Five)

Experiment no.	Details of Experiment	Lab Hours
1	Volumetric analysis: Preparation of standard solutions and to find normality, strength and deviation factor.	3
2	Titrimetric analysis: Analysis of talcum powder for Mg content by EDTA method	3
3	Potentiometric Titrations Titration of strong acid and strong base potentiometrically.	3
4	Organic estimations Estimation of phenol /Aniline	3
5	Gravimetric estimation of Nickel as Ni D.M.G.	3
6	Preparation. Preparation of Methyl Salicylate	3
7	Nitration of Aromatic compounds: Nitration of Nitrobenzene/Acetanalide	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 Four)

Experiment No.	Details of Experiment	Lab Hours
1	To determine the coefficient of discharge for Orifice meter.	3
2	To determine minor losses in pipes.	3
3	To find out Reynolds number for the fluid flow using Reynolds's apparatus	3
4	To study the characteristics of centrifugal pumps.	3
5	To verify Bernoulli's theorem.	3
6	To determine the coefficient of discharge for horizontal Venturi meter.	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.

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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 Excel for 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 four)

Experiment no.	Details of Experiment	Lab Hours
1	Heat of reaction and Hess's law of heat summation	3
2	Measurement of Dew Point Temperature	3
3	Demonstration of vapor pressure	3
4	Freezing point depression	3
5	Boiling point elevation	3
6	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

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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	02
2	Natural Product Industries and Biodiesel Processing: Manufacture of ethanol by fermentation of molasses Biodiesel production by base-catalysed transesterification process	02
3	Manufacture of Acids: Sulphuric Acid (DCDA Process), Nitric Acid Manufacture of Fertilizers: Urea	03
4	Chloro-Alkali Industries: Manufacture of Caustic Soda Manufacture of Soda Ash (Solvay Process)	03
5	Basic Building Blocks of Petrochemical Industry: Introduction to Petroleum Refining Catalytic Cracking by Fluidized Catalytic Cracking Unit (FCCU)	02
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	02
	TOTAL	14

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-Bromo nitrobenzene from Bromobenzene	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.

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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 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 shall 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