Enclosure V

SHRI MANIBHAI VIRANI & SMT. NAVALBEN VIRANI SCIENCE COLLEGE (AUTONOMOUS), RAJKOT

Department of Industrial Chemistry

M. Sc. Industrial Chemistry

Semester - I		
Course Code	**Course Title**	**Course Credit**
19PICCC101	**Core 1: Stoichiometry & Transport Phenomena**	**4 Credits**

Course Description:

A chemical or process plant is required to carry out transformation of raw material into desired products effectively, economically and safely. Therefore, this course deals with the fundamental concepts of industrial stoichiometry with and without chemical reactions and transportation of fluids as well. It also consists of designing of various flow meters, pressure devise and vacuum producing devises for industrial applications..

Course Purpose:

1. To understand and apply the basic concept of fluid flow and its applications in chemical industries.
2. To formulate material balance to solve for compositions and flow rates of process streams.
3. To understand fluid particles system and equipment's in chemical industries.
4. Derive energy balance for chemical processes and integrate with material balance calculations to solve the industrial problems..

Course Outcomes: Upon completion of this course, the learner will be able to

CO No.	CO Statement	Blooms taxonomy Level (K_1 to K_6)
CO_1	Understand the elementary concepts material and energy balance with and without chemical reactions.	K1, K2
CO_2	Understand and use process calculations for batch and continuous processes.	K1, K2
CO_3	Know the Design of fluid systems, flow meters, pressure vessels and vacuum producing devices.	K1, K2, K3
CO_4	Understand the basic phenomena for calculations of Rayleigh's and Buckingham π methods for momentum transfer operations.	K1, K2, K3
CO_5	Understand the advanced consideration for designing fluidized bed columns and apply concepts of mass, momentum and energy conservation to flows.	K3

Course Content	Hours
Module-I :: Industrial Stoichiometry (With Chemical Reaction)	12 hrs
• Material and Energy balance calculation for processes with chemical reactions recycle purge and by-pass operations • Batch and continuous operations.	
Module-II : Industrial Stoichiometry (Without Chemical Reaction)	12 hrs
• Material and Energy balance calculation for processes without chemical reactions recycle purge and by-pass operations • Batch and continuous operations.	
Module-III : Transportation Of Fluids	12 hrs
• Boundary layer concept, Types of fluid, flow pattern, Reynolds experiments. • Construction, Working and power calculation for reciprocating and centrifugal pumps. • Use of air vessels in pumps, Priming, Cavitation, Vapor locking and NPSH. • Design of Flow meters, Pressure and Vacuum producing devices.	
Module-IV : Momentum Transfer Operations-I	12 hrs
• Dimensionless analysis using Rayleigh's and Buckingham π method • Motion of particles through fluids, calculations of Rayleigh's and Buckingham π method	
Module-V : Momentum Transfer Operations-II	12 hrs
• Terminal settling velocity of particles settling under Stokes. • Intermediate and Newton's range in free & hindered settling. • Mechanism of fluidization. • Design of fluidized bed columns.	

Suggested laboratory experiments:
• Not applicable

Pedagogic tools:
• Chalk and Board
• LCD and Videos.
• Instruments

Text books
1. K.A Gavhane, Introduction to process calculations (Stoichiometry), ISBN-9788190639668, Nirali Prakashan, 13th Edition, 2015. pp. 3.1-4.4. 2. Bhatt, H. T and vora S. M., 2004, Stoichiometry, India. Tata Mcgraw Hill Co. 3. Sachdeva, R.C, 2009, Fundametals of Engineering: Heat & Mass transfer. India. New age Science. 4. D. M., Himmelblau, 1997, Basic Principles and calculations in Chemical Engineering, New Delhi, Prentice Hall of India.
Laboratory Manual/ Book
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Suggested reading / E-resources

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Suggested MOOCs
• Stoichiometry Concepts- NPTEL • Basics of Transport Phenomena by Delft University of Technology, Public University in Delft, Netherlands.

Methods of assessing the Course Outcomes The COs of the course will be assessed through
• CIE • SEE • Assignment • Quiz • Seminar

Semester - I		
Course Code	**Course Title**	**Course Credit**
19PICCC102	**Core 2: Industrial Unit Operations**	**4 Credits**

Course Description:
This course provides the introduction of Unit Operations and the essential background required to follow the specialized topics that follow.
The content of the course is as follows:

- Basic principles of diffusion and mass transfer
- Mass transfer theory applied to Gas absorption, distillation, extraction, drying, and filtration.
- Basic principles of heat transfer phenomenon in conduction, convection & radiation mode.
- Heat exchange equipment design.

Course Purpose:
The purpose of this course is to deepen the student's knowledge of the unit operations with a focus on mass transfer operation and heat transfer operation. This course will introduce student to fundamental principles of chemical processes analysis. The course will expose industrial chemist to various unit operations so as to enable them to improve the design and operation of the chemical industry.

Course Outcomes: Upon completion of this course, the learner will be able to

CO No.	CO Statement	Blooms taxonomy Level (K_1 to K_6)
CO_1	Learn fundamentals of mass transfer operations.	K1,
CO_2	Apply principles of mass transfer to equipments used in gas absorption, distillation column, extraction, drying, and filtration operation.	K1, K2
CO_3	Understand fundamentals of heat transfer operations..	K1
CO_4	Apply empirical equations to solve heat transfer problems in conduction, convection and radiation modes.	K1, K2, K3
CO_5	Design and analyze the performance of heat exchangers.	K3

Course Content	Hours
Module-I : Mass Transfer Operations-1	12 hrs
• Local and Overall Mass Transfer co-efficient: • Gas Absorption: Choice of solvent for absorption, Minimum Liquid – gas ratio for absorbers, HETP in continuous contact equipments. • Distillation: Use of McCabe Thiele method in the design of multistage tray towers, q-	

line equation, Effect of reflux ratio. • Liquid Extraction: Choice of solvent for extraction Binodal solubility curves, Calculations for single stage and multi stage cross &countercurrent extraction.	
Module-II : Mass Transfer Operations-2	12 hrs
• Drying: Rate of batch drying, Calculations for cross and through circulation drying, Rate of drying for continuous driers, Hold up in rotary driers. • Filtration: Theory of Filtration, Filtration, Filtration in centrifuges.	
Module-III : Heat Transfer – Conduction	12 hrs
• Local and Overall heat transfer co-efficient: Introduction to thermal diffusivity, Thermal insulators, Critical Radius of insulation, Fourier's law of heat conduction. • Three Dimensional heat conduction equations in rectangular, Effect of variable thermal conductivity, Heat transfer from extended surfaces.	
Module-IV : Heat Transfer – Convection	12 hrs
• Newton's law of heat convection Free and Forced Convection Calculation involving convection mode of heat transfers in rectangular. • Understanding of overall Heat transfer coefficient for combined conduction & convection mode. • Dropwise and film condensation, Heat transfer in Condensation on vertical, horizontal, inclined plates.	
Module-V : Heat Transfer – Radiation	12 hrs
• Terminologies in radiation mode of Application for Planck's distribution law, Stefan Boltzmann Law and Kirchhoff's law. • Radiation Shields, LMTD correction factors, Design of single and multi-pass exchangers, Effectiveness and number of transfer units for heat exchangers.	

Suggested laboratory experiments:
• Not applicable

Pedagogic tools:
• Chalk and Board
• PowerPoint presentation and Videos.

Text books
1. K. A. Gavhane, 2009. *Unit Operations – II*. Pune: Nirali Prakashan 2. Robert E Treybal, 1981. *Mass Transfer Operations*. USA: McGraw Hill 3. McCabe & Smith, 2001. *Unit Operations in Chemical Engineering*. USA: McGraw Hill 4. Ravi S. Tank, 2016, Industrial Chemistry (Unit Operations), USA:Create Space
Laboratory Manual/ Book
• Not Applicable

Suggested reading / E-resources
• Ullmann's Encyclopedia of Industrial Chemistry
• Perry's Chemical Engineers' Handbook • Albright's Chemical Engineering Handbook • Chemical Engineering Learning Resources by msubbu (http://msubbu.in/lecturenotes.html)

Suggested MOOCs
• Introduction to Unit Operations (www.openlearning.com) • Mass Transfer Opeartion-I (http://www.iitg.ac.in/cet/moocs.html)

Methods of assessing the Course Outcomes The COs of the course will be assessed through
• Short answer type questions • Open ended questions • Problem solving • Presentations/ Report Writing • Oral examination • Multiple choice questionnaires • Mid Semester and End Semester written examination

Semester - I		
Course Code	**Course Title**	**Course Credit**
19PICCC103	**Core 3: Organic & Retro Synthesis**	**4 Credits**

Course Description: Course comprises of formation, reaction and stability of organic intermediates, organic name reactions and rearrangements. Disconnection analysis and synthesis of various organic molecules using strategies I to IV.

Course Purpose: Understand the organic reactions and rearrangements. Able to write mechanism and applications of organic reactions and apply disconnection and design the synthesis.

Course Outcomes: Upon completion of this course, the learner will be able to

CO No.	CO Statement	Blooms taxonomy Level (K_1 to K_6)
CO_1	Understand the formation and reactivity and stability of nucleophiles, electrophiles, carbene, nitrene, ylides and alkynes.	K1,
CO_2	Design syntheses of organic molecules and prediction of mechanism for organic reactions.	K1, K2
CO_3	Learn Principles, mechanism and applications of various name reactions.	K3,K4
CO_4	Learn principles and mechanism of rearrangements and their applications	K3, K4
CO_5	Design the disconnection and synthesis of various organic aromatic molecules.	K5

Course Content	Hours
Module-I : Free Radicals, Carbocation, Carbanions, Nitrene &Their Reactions	12 hrs

- Introduction, Formation, Stability and name Reactions involving following intermediates: Free radicals, Carbocation, Carbanions & Nitrene.

Intermediates	Name reactions
Free radicals	Birch Reduction
	Grignard Reaction
Carbocation	Baeyer-Villiger Oxidation
	Vilsmeier-Haack
Carbanions	Junjappa-Ila Annulation & Heteroannulation
	Dieckmann
Carbenes	Arndt-Eistert
	Reimer-Tiemann

<table>
<tr><td>Module-II : Enamines, Carbenes, Phosphorus Ylides, Benzyne &Their Reactions</td><td>12 hrs</td></tr>
<tr><td>Introduction, Formation, Stability and name Reactions involving following intermediates: Enamines, Carbenes, Phosphorus Ylides & Benzyne
<table>
<tr><th>Intermediates</th><th>Name reactions</th></tr>
<tr><td rowspan="3">Phosphorus ylides</td><td>Mitsunobu reaction</td></tr>
<tr><td>Wittig</td></tr>
<tr><td>Appel</td></tr>
<tr><td rowspan="2">Nitrenes</td><td>Hofmann Bromamide</td></tr>
<tr><td>Schmidt</td></tr>
<tr><td rowspan="3">Enamines</td><td>Mannich</td></tr>
<tr><td>Pictet–Spengler</td></tr>
<tr><td>Storke Enamines</td></tr>
<tr><td>Benzyne</td><td>Diels Alder</td></tr>
</table></td><td></td></tr>
<tr><td>Module-III : Rearrangements</td><td>12 hrs</td></tr>
<tr><td>• Principles, Reactions, Mechanism and applications of following rearrangements
<table>
<tr><td>Claisen</td><td>Favorskii</td></tr>
<tr><td>Cope</td><td>Stevens</td></tr>
<tr><td>Pinacol- pinacolone</td><td>Wolff</td></tr>
<tr><td>Benzilic acid</td><td>1,2-Wittig</td></tr>
<tr><td>Fries</td><td>Schlosser</td></tr>
<tr><td>Curtius</td><td>Beckmann</td></tr>
<tr><td>Lossen</td><td></td></tr>
</table>
•</td><td></td></tr>
<tr><td>Module-IV : Disconnection Approach Strategy I & II</td><td>12 hrs</td></tr>
<tr><td>• Basic principle: Synthesis of Aromatic Compounds,
• Strategy I: The order of events. One group C-X disconnections
• Strategy II: Chemo selectivity.</td><td></td></tr>
<tr><td>Module-V : Disconnection Approach Strategy III & IV</td><td>12 hrs</td></tr>
<tr><td>• Strategy III: Reversal of Polarity, Cyclisation reaction,
• Strategy IV: Protecting groups, one group C-C disconnection: Alcohols and Carbonyl compounds</td><td></td></tr>
</table>

Suggested laboratory experiments:
• Not applicable

Pedagogic tools:
• Chalk and Board
• LCD and Videos.

Text books
• Ahluwalia, V. K. 2010. Organic Reaction Mechanism. India: Narosa Publishing House.
• Kurti, L. and Czako, B. 2005. Strategic Applications of Named Reactions in Organic Synthesis:

Background and Detailed Mechanism. USA : Elsevier Academic Press.

- Bansal, R. K. 2007. A Textbook of Organic Chemistry. India: New Age International Pvt. Ltd.
- Warren, S. and Wyatt, P. 2009. Organic Synthesis – The disconnection approach, 2nd edition. Cambridge: Willey.

Laboratory Manual/ Book

- Not Applicable

Suggested reading / E-resources

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Suggested MOOCs

- Organic chemistry-1 & 2 on SWAYAM

Methods of assessing the Course Outcomes

The COs of the course will be assessed through

- Assignments
- Test
- Seminar
- Quiz

Semester - I		
Course Code	**Course Title**	**Course Credit**
19PICCC104	**Core Practical 1: HTO, MTO**	**3 Credits**

Course Description:
The practical course provides experience in a number of important chemical engineering unit operations ensuring a thorough understanding of the principles of unit operation and the appropriate theory.
The course includes experiment design and development, experimental execution, data and error analysis, skills development in oral presentation, technical report writing, and team-building. The experiments are designed to illustrate the principles of heat transfer operation and mass transfer operation.

Course Purpose:
The purpose of this course is to
1. Demonstrate skills in safe operation of laboratory equipment.
2. Analyze experimental data and observed phenomena.
3. Communicate experimental findings through formal written reports in high quality, and communicate with other team members
4. Work as part of a team in a mature and professional manner.

Course Outcomes: Upon completion of this course, the learner will be able to

CO No.	CO Statement	Blooms taxonomy Level (K_1 to K_6)
CO_1	Plan experiments and present the experimental data meaningfully.	K1, K2
CO_2	Apply theoretical concepts for data analysis and interpretation.	K2, K3
CO_3	Visualize and understand chemical engineering unit operations related to heat transfer operation, and mass transfer operation.	K3
CO_4	To critically evaluate data collected.	K3, K4
CO_5	Employ safe laboratory practices handling laboratory glassware, equipment, and chemical reagents to perform common laboratory techniques.	K5

Suggested laboratory experiments:

Heat Transfer Operations:
1. To find the critical radius of insulation thickness on a cylinder.
2. To determine the Emissivity measurement of grey surface at different temperatures.
3. To find out heat transfer coefficient and heat transfer rate from vertical in natural convection and

to find emissivity of the cylinder surface.

4. To determine the Thermal conductivity of insulating powder (Asbestos) at various heat inputs.
5. To determine the thermal conductivity of poor conducting material, say asbestos sheet.
6. To determine the overall heat transfer coefficient of the composite wall & compare the same with that calculated from the equation.
7. To study and compare temperature distribution, heat transfer rate, overall heat transfer coefficient in parallel flow and counter flow heat exchanger.
8. To determine the value of Stefan Boltzmann constant for radiation heat transfer.
9. To plot the radial temperature distribution and to determine the thermal conductivity of pipe insulation.
10. To determine the thermal conductivity of a good conductor material, any brass.
11. To determine the variation of temperature along the length of pin fin under forced convection.
12. To determine the values of heat transfer coefficient under forced condition and to find theoretical values of temperature along the length of fin and effectiveness and efficiency of the pin-fin for insulated and boundary condition.
13. To determine and compare surface heat transfer coefficient for
    a) drop wise condensation & b) film wise condensation
14. To determine the average theoretical and experimental value of coefficient of heat transfer for forced convection for the fluid flowing through a pipe.

Mass Transfer Operation:

15. To determine the distribution coefficients of carbon tetra chloride solvent for 20% aqueous acetic acid solution
16. To determine the distribution coefficients of Ethyl Acetate solvent for 20% aqueous acetic acid solution
17. To determine the distribution coefficients of Benzene solvent for 20% aqueous acetic acid solution
18. To develop solubility curve for the Ternary System Water(A) –CTC (B)-Acetic Acid(C)
19. To develop solubility curve for the Ternary System Water(A) –$CHCl_3$ (B)-Acetic Acid(C)
20. To develop solubility curve for the Ternary System Water(A) –Benzene (B)-Acetic Acid(C)
21. To determine the theoretical number of stages required for extracting acetic acid from its 10% solution of acetic acid in chloroform (50 ml) using water as solvent so as to limit its concentration in the final Raffinate to almost zero % and % recovery of acetic acid from its mixture using calculated number of stages in multistage cross current extraction.
22. To determine the quantity of Oil Present in a Oil Bearing Material.

Pedagogic tools:
• Chalk and Board
• PowerPoint Presentation and Videos.

Text books
• Not Applicable
Laboratory Manual/ Book
• Manual of Industrial Chemistry Department, Shree M. & N. Virani Science College (Autonomous), Rajkot

Suggested reading / E-resources
• Not Applicable

Suggested MOOCs
• Not Applicable

Methods of assessing the Course Outcomes The COs of the course will be assessed through
• Performance in conduction of experiment. • Record book. • MCQ/Quiz. • Viva Voce. • Mid Semester & Semester End Practical Exam.

Semester - I		
Course Code	**Course Title**	**Course Credit**
19PICCC105	**Core Practical 2: OS, FM**	**3 Credits**

Course Description:
The practical course provides experience in a number of important chemical/pharmaceutical engineering unit operations and organic synthesis ensuring a thorough understanding of the principles of fluid mechanics and chemistry.
The course includes experiment design and development, experimental execution, data and error analysis, skills development in oral presentation, technical report writing, and team-building. The experiments are designed to illustrate the principles of fluid mechanics, and organic synthesis.

Course Purpose:
The purpose of this course is to
1. Demonstrate skills in safe operation of laboratory equipment.
2. Analyze experimental data and observed phenomena.
3. Communicate experimental findings through formal written reports in high quality, and communicate with other team members
4. Work as part of a team in a mature and professional manner.

Course Outcomes: Upon completion of this course, the learner will be able to

CO No.	CO Statement	Blooms taxonomy Level (K_1 to K_6)
CO_1	Plan experiments and present the experimental data meaningfully.	K1, K2
CO_2	Apply theoretical concepts for data analysis and interpretation.	K2, K3
CO_3	Visualize and understand chemical engineering unit operations related to fluid and particle mechanics, and mass transfer operations such as extraction.	K3
CO_4	To critically evaluate data collected to determine the identity, purity, and yield of products.	K3, K4
CO_5	Employ safe laboratory practices handling laboratory glassware, equipment, and chemical reagents to perform common laboratory techniques, including recrystallization, vacuum filtration, aqueous extraction, thin layer chromatography, column chromatography.	K5

Suggested laboratory experiments:

Fluid Mechanics:
1. To determine the Reynolds number for flowing fluid using a Closed Circuit Reynolds Apparatus.
2. To determine the coefficient of discharge for a flow meter using closed circuit venturimeter and orifice meter apparatus.

3. To verify Bernoulli's theorem using Bernoulli's apparatus.
4. To calculate and study the energy losses in pipe fittings such as sudden contraction, sudden enlargement, bends & elbows and to determine flow through a Rotameter.
5. To calculate and study the energy loss due to pipe friction.
6. To determine coefficient of discharge Cd for notches and weirs of different shapes.

Organic Synthesis:

7. To prepare Benzilic acid from Benzil (Benzil-Benzilic acid rearrangement)
8. To Prepare Hippuric acid from Glycine. (Benzoylation)
9. To Prepare Phenylurea from Aniline.
10. To Prepare 3-Methyl-1-phenyl-5-pyrazolone from Ethyl acetoacetate. (Cyclization)
11. To Prepare Resacetophenone from Resorcinol.
12. To Prepare m-Nitroaniline from m-Dinitrobenzene (Selective Reduction)
13. To Prepare p-Bromoacetanilide from Acetanilide (Bromination)
14. To prepare Acetanilide from Aniline (N-Acetylation)
15. To Prepare p-Bromo aniline from p-Bromoacetanilide (Hydrolysis)
16. To prepare p-Nitro acetanilide from Acetanilide (Nitration)
17. To Prepare p-Bromonitrobenzene from Bromobenzene (Nitration)
18. To Prepare p-Nitroaniline from p-Nitroacetanilide (Hydrolysis)
19. To prepare t-Butylchlrode from t-Butanol (Functional Grp Conv. Chlorination)
20. To Prepare Benzaldine aniline (Schiff Base) from Aniline. (Solvent free reaction)
21. To prepare Benzalacetophenone (Chalcone) from Acetophenone. (Carbanion)

Pedagogic tools:

- Chalk and Board
- PowerPoint Presentation and Videos.

Text books

- Not Applicable

Laboratory Manual/ Book

- Manual of Industrial Chemistry Department, Shree M. & N. Virani Science College (Autonomous), Rajkot

Suggested reading / E-resources

- Not Applicable

Suggested MOOCs

- Not Applicable

Methods of assessing the Course Outcomes

The COs of the course will be assessed through

- Performance in conduction of experiment.
- Record book.
- MCQ/Quiz.
- Viva Voce.
- Mid Semester & Semester End Practical Exam.

Semester II			
Course Code	**Course title**	**Course hrs.**	**Credit**
19PICCC201	**Core 4: Heterocyclic Chemistry**	**04 hrs/wk**	**04 Credits**

Course Description:

Heterocyclic compounds are very interesting due to their distinct structure and the availability of this kind of heterocyclic structures in medicinal drugs. So the technique of synthesis of heterocyclic compounds is important in the synthesis of different drugs. This course gives the quantitative ideas about the synthesis, properties and uses of such heterocyclic compounds like pyrrole, pyridine, thiophene, furan, benzofused heterocycles etc.

Course Purpose:

1. To understand basic knowledge of heterocyclic chemistry and nomenclature.
2. To understand IUPAC nomenclature for various heterocyclic compounds.
3. To demonstrate various synthesis and chemical reactivity heterocyclic compounds.
4. To analyse disconnection of heteroaromatic compounds.

Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	**CO Statement**	**Blooms taxonomy Level (K_1 to K_6)**
CO_1	Understand basic concept of heterocyclic chemistry and nomenclature of heterocyclic compounds using systematic IUPAC nomenclature including Five member, Six member, Benzofused five membered and six membered heterocycle.	K1, K2
CO_2	Describing the classification of heterocyclic compounds according to their different types.	K1, K2
CO_3	Practice to draw the heterocyclic compound's structure from name and identify the name from structure using IUPAC system.	K2, K3
CO_4	Showing the multiple methods of preparation of heterocyclic compounds.	K3, K4
CO_5	Identify and recognize the chemical properties and reactivity of heterocyclic compounds using heterocyclic concept. Analyse the disconnection of heteroaromatic compounds.	K4

Course Content	Hours
Module-I : Five Membered Heterocycles	**12 hrs**
• Nomenclature, Synthesis, Reactivity and Reactions of: 5 membered Heterocycles containing. • TWO heteroatoms (Pyrazole, Imidazole, Thiazole, Isothiazole, Oxazole, Isoxazole). • More than two hetero atoms (1,2,4-Triozole, 1,3,4- Oxadiazoles, 1,3,4- Thiadiazoles)	
Module-II: Six Membered Heterocycles	**12 hrs**
• Nomenclature, Synthesis, Reactivity and Reactions of: • 6 membered Heterocycles containing Nitrogen (Pyridine, Pyridazine, Pyrimidine, Pyrazine, 2H-Pyran, 2-Pyrone, Thiopyran)	
Module-III: Benzofused 5 Member Heterocycles	**12 hrs**
• Nomenclature, Synthesis, Reactivity and Reactions of: • Benzofused 5 membered Heterocycles with ONE hetero atom (Benzo(b)pyrrole, Benzo(b)Furan, Benzo(b)thiophene, Carbazole, Indazole, Isoindole)	
Module-IV: Benzofused 6 Member Heterocycles	**12 hrs**
• Nomenclature, Synthesis, Reactivity and Reactions of: • Benzo fused 6 member hetero cycles (Quinoline, Isoquinoline, Cinnoline, Quinazoline, Quinoxaline, Phthalazine, Chromone, Coumarin)	
Module-V: Disconnection of Aromatic Heterocycles	**12 hrs**
• Disconnection approaches for • Aromatic 5 & 6 membered Heterocyclic compounds.	

Suggested laboratory experiments:
• Included in core practical-4

Pedagogic tools:
• Chalk and Board, direct explanation. • Power point presentation, LCD and Videos.

Reference Books:

1. Parikh, Arun., Parikh, Hansa and Khunt, Ranja. 2013. *The essence of Heterocycles*. India: NEW AGE INTERNATIONAL PUBLISHERS.
2. Warren, Stuart and Wyatt, Paul. 2009. *Organic Synthesis – The disconnection approach, 2nd Edition*. Cambridge: Willey.
3. Albert, Adrien, 1968. *Heterocyclic Chemistry: An Introduction*. London: The Athlone Press.
4. JOULE, JOHN. MILLS, KEITH. 2013. *Heterocyclic Chemistry at a Glance*, UK :John Wiley & Sons

Laboratory Manual/ Book
• Not applicable.

Suggested reading / E-resources
• https://www.khanacademy.org/science/organic-chemistry/stereochemistry-topic
Suggested MOOCs
• Heterocyclic chemistry- NPTEL • Heterocyclic chemistry- Swayam

Methods of assessing the Course Outcomes The COs of the course will be assessed through
• Continuous Internal Assessment
• Semester End Evaluation

CIA Components	**Marks**
Test – 1 (2 modules, 1 ½ hours, set for 30 marks)	5
Test – 2 (5 modules, 3 hours, set for 60 marks)	15
Assignment	10
Seminar	5
Class activity: Reaction Paper	5
Grand Total	**40**

Semester - II		
Course Code	**Course Title**	**Course Credit**
19PICCC202	**Core 5: Mechanical Operations**	**3 Credits**

Course Description:
The objective of this course is to study the basic mechanical operation (crushing, grinding, screening, etc.) takes place during the process in chemical industry. This subject provides the fundamental knowledge regarding to particle size reduction and average particle size by various methods and also details of construction & working of equipment's used for mechanical operations.

Course Purpose:
1. To describe importance of size reduction in chemical industry.
2. To understand construction & working of various equipment's used for mechanical operations.
3. To analyze the particles reduce in equipments.
4. To calculate the power consumption of equipment's used for mechanical operations.

Course Outcomes: Upon completion of this course, the learner will be able to

CO No.	CO Statement	Blooms taxonomy Level (K_1 to K_6)
CO_1	To build basic knowledge of various mechanical operations.	K1, K2
CO_2	To review the practical importance and relevance of unit operations used for crushing, grinding and size separation in chemical industry.	K1, K2
CO_3	To separate the particles based on its size in equipments.	K1, K2, K3
CO_4	To study a detailed overview of equipment used to perform various mechanical operations and problems associated during the implementation and applications.	K1, K2, K3
CO_5	To build a bridge between theoretical and practical concept used in industry	K2, K3, K4

Course Content	Hours
Module-I : Fundamentals of Size Reduction	**9 Hrs**
• Introduction to comminution, • Units and dimensions involved in size reduction, • Importance of size reduction, • Specific properties of solids for size reduction, • Crushing efficiency, mechanical efficiency, • Principles of size reduction, • Energy and power consumption required for size reduction, work index,	

• Laws of crushing.	
Module-II : Size Reduction Equipments	**9 Hrs**
• Classification of size reduction equipment, Reduction Ratio, • Principle, Construction & working of crushing and grinding equipment viz., o Jaw crushers, o Gyratory crushers, o Hammer mill, o Crushing rolls, o Ball mills.	
Module-III : Screening Operation	**9 Hrs**
• Introduction to Screening, terminologies, • Ideal and Actual screens, • Tyler standard screen and US standard screen, • Differential screen analysis and cumulative screen analysis, • Classification of screening equipment's particle size distribution, particle size measurement, • Vibro-Screen, Grizzlies, Trommels, • Mass balance over screens. • Effectiveness of a screen • Capacity of a screen.	
Module-IV : Handling of Materials	**9 Hrs**
• Introduction, • Open circuit and closed circuit grinding, • Storage of solids: o Bulk Storage, o Bin Storage, o Protected and unprotected piles, o Silos, • Grade Efficiency, Cut Size and Sharpness of cut, • Construction of Grade Efficiency Curve.	
Module-V : Separation of Mixtures	**9 Hrs**
• Introduction, • Classification of separation methods for different types of mixtures like solid-solid, Solid-solid sigma mixture, solid-gas, solid-liquid. • Gravity Settling Tanks, • Jigging, • Electrostatic precipitators, • Cyclone separators, • Bag filters,	

• Scrubbers.	

Suggested laboratory experiments:
• Included in core practical 3:

Pedagogic tools:
• Chalk and Board • LCD and Videos • Instruments

Text books
1. Gavhane K. A. (2009), "*Unit Operations-I"*, NiraliPrakashan, ISBN 978-81-90639-66-8. 2. Swain AK-PatraH- Roy GK (2011), "*Mechanical Operations*", Tata McGraw Hill Education Private Limited, ISBN(13):978-0-07-070022-2. 3. Kiran D Patil (2009), "*Mechanical Operations: Fundamental Principles and Applications*", NiraliPrakashan, ISBN:978-93-80064-09-0. 4. Narayanan C. M. & Bhattacharya B. C., (1999) "Mechanical operations for chemical engineers", Khanna Publishers. 3rd Ed. 5. McCabe, Smith and Harriot (2014), "*Unit Opertaions of Chemical Engineering*", McGraw Hill Education Publication, ISBN 0071247106, 9780071247108.

Laboratory Manual/ Book
• Not applicable.

Suggested reading / E-resources
• NPTEL

Suggested MOOCs
• Mechanical Operations – NPTEL

Methods of assessing the Course Outcomes The COs of the course will be assessed through
• CIA • SEE

CIA Components	**Marks**
Test – 1 (2 modules, 1 ½ hours, set for 30 marks)	5
Test – 2 (5 modules, 3 hours, set for 50 marks)	15
Assignment	10
Seminar	10
Class activity: Application Cards	10
Grand Total	**50**

Semester - II		
Subject Code	**Course Title**	**Course Credit**
19PICCC203	**Core 6: TECHNOLOGIES IN CHEMICAL INDUSTRIES**	**3 Credits**

Course Description:

The course will describe in details membrane separation technology and wide range of applications including water treatment and desalination. The course covers: global need for membrane technology, Microfiltration, ultrafiltration, nanofiltration and reverse osmosis membrane processes and current applications in water treatment. It also covers nanotechnology, formulation and fermentation technologies.

Course Purpose:

5. To apply essential knowledge of various chemical technologies.
6. To understand the technology used in various chemical industries.
7. To understand working principle of various types of membranes used and its applications
8. To understand synthesis and characterization of nano materials
9. To understand fermentation technology

Course Outcomes: Upon completion of this course, the learner will be able to

CO No.	CO Statement	Blooms taxonomy Level (K_1 to K_6)
CO_1	Apply resources and need for membrane technology in water treatment in other process industrial plants.	K1, K2
CO_2	Understand the principles of nanotechnology; characterization of nano structured materials; and tools and equipment for producing and assembling at the nano scale.	K1, K2
CO_3	To cultivate interest in the research and development of nanotechnology for future advancement of the career.	K1, K2
CO_4	Understand the formulation technology used in Agrochemical industries	K1, K2, K3, K4
CO_5	To promote interests of the fermentators, types of reactors in fermentation industries.	K1, K2, K3

Course Content	Hours
Module-I : Membrane Technology-I	**9 Hrs**
• Introduction of membrane technology. Classification of membranes and membrane processes. Basic operating principles and applications of various membrane processes – Micro filtration, Ultra filtration, Nano filtration, Reverse Osmosis, Dialysis.	
Module-II : Membrane Technology-II	**9 Hrs**
• Classification of membranes and membrane processes. Basic operating principles and applications of various membrane processes –Membrane Distillation, Pervaporation, gas permeation, liquid membranes	
Module-III : Introduction To Nanotechnology	**9 Hrs**
• Introduction, Physical methods of synthesis of Nano materials. Mechanical &Vapor deposition, Chemical methods of synthesis of Nano materials. Colloids & Colliding solutions, Synthesis of Colloids, Synthesis of metal Nano particles, Properties and Applications.	
Module-IV : Industrial Formulations	**9 Hrs**
• Study of Agrochemical Industries with respect to their Classification, Raw materials, manufacturing process of at least four products of each class with special emphasis on chemistry and manufacturing principles: • Insecticides. • Pesticides. • Fungicides. • Weedicides.	
Module-V : Fermentation Technologies	**9 Hrs**
• Process calculations and Stoichiometry. Metabolic engineering, Transport in reactors. Design & Working of Bioreactor. Types of reactors, Sterilization, utilities: steam air water, Specific industrial process involving microbes. Industrial Production processes of various biochemical.	

Suggested laboratory experiments:
• Included in core practical 3:

Pedagogic tools:
• Chalk and Board
• LCD and Videos.

Text books

1. Nath, Kaushik. 2008. *Membrane Separation Processes*. New Delhi: Prentice Hall India Ltd.
2. C. Poole, F. Owens, 2009. *Introduction to Nanotechnology*, Panama: John Wiley and Sons
3. Strathmann, H. 2004. *Ion-Exchange Membrane Separation Processes*, Volume-9 : Amsterdam, Elesveir Science:.
4. Cardew PT & Le MS, 1998. *Membrane Processes: A Technology Guide*. ,London, Royal Soc. of Chemistry.

Laboratory Manual/ Book

- .Not Applicable

Suggested reading / E-resources

1. Cardew PT & Le MS, 1998. *Membrane Processes: A Technology Guide*. ,London, Royal Soc. of Chemistry.
2. https://www.awwa.org/conferences-education/distance-learning/elearning.aspx

Suggested MOOCs

- Texas A&M Engineering, Introduction to Membrane technology

Methods of assessing the Course Outcomes

The COs of the course will be assessed through

- CIA
- SEE

CIA Components	Marks
Test – 1 (2 modules, 1 ½ hours, set for 30 marks)	5
Test – 2 (5 modules, 3 hours, set for 50 marks)	15
Assignment	10
Seminar	10
Class activity: Quiz	10
Grand Total	**50**

Semester - II		
Course Code	**Course Title**	**Course Credit**
19PICCC204	**Core-7** **UNIT PROCESSES & REAGENTS**	**3 Credits**

Course Description:

A chemical or process plant is required to carry out conversion of raw material into desired products effectively, economically viable and safely. Therefore, this course deals with the advanced concepts of chemical process industries like halogenation, alkylation & acylation, oxidation, hydrogenation & reduction, nitration, sulphonation & esterification and reagents etc. This course also deals with the new technologies and new immerging developments in chemical processes industries.

Course Purpose:

1. To understand the manufacturing of various inorganic and organic chemicals, the process flow diagram and various process parameters.
2. To identify and solve engineering problems during production and understanding the mechanisms of various unit processes.
3. To be able understanding of preparation, structures, mode of actions and applications of reagents used in organic reactions and rearrangements including LAH, DEAD, NBS, Sodamide, DCC, DCI, TPP and LTA.

Course Outcomes: Upon completion of this course, the learner will be able to

CO No.	CO Statement	Blooms taxonomy Level (K_1 to K_6)
CO_1	Remember the advanced concepts of unit processes like Halogenation, Alkylation & Acylation	K1, K2, K3,
CO_2	Understand the advanced concepts of unit processes like Oxidation, Hydrogenation & Reduction	K1, K2,
CO_3	Apply the advanced concepts of unit processes like Nitration, Sulphonation & Esterification	K1, K2, K3,
CO_4	Apply the advanced concepts of organic reagents-I	K2, K3
CO_5	Apply the advanced concepts of organic reagents-II	K2, K3, K4

Course Content	Hours
Module-I : Halogenation, Alkylation & Acylation:	**09 hrs**
Principle, Reagents, Mechanism, Kinetics, Applications involving Industrial Product manufacturing using following Unit processes: • Halogenation • Alkylation • Acylation	

Module-II : Oxidation, Hydrogenation & Reduction:	**09 hrs**
Principle, Reagents, Mechanism, Kinetics, Applications involving Industrial Product manufacturing using following Unit processes: • Oxidation • Hydrogenation • Reduction	
Module-III : Nitration, Sulphonation & Esterification:	**09 hrs**
Principle, Reagents, Mechanism, Kinetics, Applications involving Industrial Product manufacturing using following Unit processes: • Nitration • Sulphonation • Esterification	
Module-IV : Reagents-I:	**09 hrs**
Preparation, Properties, Mechanism of Action & Applications involving name reaction or rearrangement of following Reagents: • $LiAlH_4$ • Dicyclohexylcarbodiimide (DCC) • Diethylazodicarboxylate (DEAD) • Carbonyldiimidazole (CDI)	
Module-V : Reagent-II:	**09 hrs**
Preparation, Properties, Mechanism of Action & Applications involving name reaction or rearrangement of following Reagents: • N-Bromosuccinamide • Sodamide • Triphenylphosphene • Lead tetra acetate	

Suggested laboratory experiments:
• Included in core practical 4.

Pedagogic tools:
• Chalk and Board
• LCD and Videos.

Text books

1. Agrawal, O. P., (1996). "*Organic Chemistry: Reactions And Reagents"*. India: GOEL Publishing House.
2. Groggins, P. H. (1995). "*Unit Processes in Organic Synthesis"*. India: Tata McGraw Hill.
3. Finar, I., (2005). *Organic Chemistry*, 5th Edition, Delhi: Pearson education.
4. Furter, William F, (2014) "*Chemical process industry*", DOI:https://doi.org/10.1036/1097-8542.127600.

5. Bradford P., Michael G., Frank G, (2013), *"Name Reactions and Reagents in Organic Synthesis"*, Second Edition, ISBN:9780471739876.
6. Organic Reactions and Organic Reactions and Their Mechanisms Their Mechanisms, http://polymer.zju.edu.cn/attachments/2012-11/01-1352193505-80382.pdf

Laboratory Manual/ Book

- .Not Applicable

Suggested reading / E-resources

1. Information Sources in Chemical Industries- http://shodhganga.inflibnet.ac.in/bitstream/10603/120094/12/12_chapter%205.pdf
2. Chemical Process Industries- file:///C:/Users/admin/Downloads/HS2109.pdf
3. Chemistry Reagent Manual- http://www.sgtbkhalsadu.ac.in/colleges/dbtevents/1127260320121552021.pdf
4. Oxidation and Reduction- https://chem.ucr.edu/documents/curricularmaterials/neumantextbook/Chapter17.pdf

Suggested MOOCs

- Organic Chemistry- SWAYAM
- Organic Chemistry I- MIT - Massachusetts Institute of Technology, USA.
- Basics of the Chemical Industry-AIChE
- Applied Chemistry 3-Part Series- DuPont Sustainable Solutions (DSS), USA.
- Industrial Chemical Technology-Carnegie Mellon University, Pennsylvania.
- Chemistry and Biochemistry-NPTEL.

Methods of assessing the Course Outcomes

The COs of the course will be assessed through

- CIA
- SEE

CIA Components	Marks
Test – 1 (2 modules, 1 ½ hours, set for 30 marks)	5
Test – 2 (5 modules, 3 hours, set for 50 marks)	15
Assignment	10
Seminar	10
Class activity: Reaction Paper	10
Grand Total	**50**

Semester - II		
Course Code	**Course Title**	**Course Credit**
19PICCC205	**Core-Practical-3 MO & TCI**	**3 Credits**

Course Description:
A chemical or process plant is required to carry out transformation of raw material into desired products effectively, economically feasible and safely. Therefore, this course deals with the advanced concepts of size reduction operations. It also deals with the concept for preparation of Nano-particles of metal oxides.

Course Purpose:
1. To understand the advanced concepts of Mechanical operations.
2. To plan out synthetic procedure for NPs synthesis.

Course Outcomes: Upon completion of this course, the learner will be able to

CO No.	CO Statement	Blooms taxonomy Level (K_1 to K_6)
CO_1	Remember the advanced concepts of Mechanical crushers.	K1, K2, K3,
CO_2	Understand the advanced concepts of Mechanical shakers.	K1, K2,
CO_3	Apply the advanced concepts of Mechanical separator.	K1, K2, K3,
CO_4	Apply the advanced concepts of preparation of Metallic oxides NPs.	K2, K3
CO_5	Apply the advanced concepts of characterization of NPs.	K2, K3

Course Content	Hours
Mechanical Operations: 1. To crush the given raw material in a Jaw Crusher and to determine average particles size and reduction ratio. 2. To crush the given material in a Roll Crusher and to determine the average particle size and Reduction ratio 3. To analyze a given sample using Sieve Shaker and find the average particle size 4. To study operation of Ball Mill and to calculate the reduction ratio and to find the average particle size 5. To calculate the efficiency of a cyclone separator. 6. To calculate the power requirement of roll crusher with the help of law of crushing and grinding 7. To calculate the power requirement of Jaw crusher with the help of law of crushing and grinding. 8. To calculate the power requirement of Ball Mill with the help of law of crushing and	**72 Hrs**

grinding. **Technologies in Chemical Industries:** 9. To Prepare and characterize the ZnO nanoparticle 10. To Prepare and characterize the CuO nanoparticle 11. To Prepare and characterize the Fe_2O_3 nanoparticle 12. To Prepare and characterize the NiO nanoparticle	

Suggested laboratory experiments:
• Not Applicable

Pedagogic tools:
• Chalk and Board
• LCD and Videos.

Text books
1. Laboratory Manuals of Department of Industrial Chemistry, Atmiya University.

Laboratory Manual/ Book
• .Not Applicable

Suggested reading / E-resources
• Not Applicable

Suggested MOOCs
• Not Applicable

Methods of assessing the Course Outcomes
The COs of the course will be assessed through
• CIA • SEE

CIA Components:

Sr. No.	Component	Content	Duration (if any)	Marks	Sub Total
A	Test	After completion of 70-80% of course	3 hours	40	20
B	Performance			10	10
C	Record book			5	5
D	Vivo Voce			5	5
				Grand Total	**40**

Semester - II		
Course Code	**Course Title**	**Course Credit**
19PICCC206	**Core-Practical-4 MS, PC**	**3 Credits**

Course Description:
A chemical or process plant is required to carry out transformation of raw material into desired products effectively, economically feasible and safely. Therefore, this course deals with the advanced concepts of Name reactions and rearrangements for multistage synthesis of various chemicals. It is also deals with the physico-chemical exercise like potentiometry, conductometry, refractometry and polarimetry.

Course Purpose:
1. To understand the advanced concepts of Name reactions and rearrangements.
2. To plant out chemical reactions for multistage synthesis of various chemicals.
3. To be able understand concepts of potentiometry, conductometry, refractometry and polarimeter.

Course Outcomes: Upon completion of this course, the learner will be able to

CO No.	CO Statement	Blooms taxonomy Level (K_1 to K_6)
CO_1	Remember the advanced concepts of Name reactions & rearrangements.	K1, K2, K3,
CO_2	Understand the advanced concepts of multistage synthesis.	K1, K2,
CO_3	Apply the advanced concepts of physico-chemical excersice.	K1, K2, K3,
CO_4	Apply the advanced concepts of Potentiometry, conductometry and refractometry.	K2, K3
CO_5	Apply the advanced concepts of polarimeter.	K2, K3, K4

Course Content	Hours
Multistage Synthesis: 1. To prepare Dihydropyridine derivative (Hantzch pyridine synthesis). 2. To prepare Dihydropyrimidine derivative (Biginelli reaction) 3. To prepare Benzanilide from Benzophenone (Beckmann rearrangement). (Two step) 4. To prepare Acredon from Phthalic acid. (Six step) 5. To prepare 2,3-diphenyl thiazolidine from benzalidine aniline (Schiff base). (Two step) 6. To prepare p-amino benzene sulfonamide (sulfanilamide) from acetanilide. (Three step) 7. To prepare 7-Hydroxy-4-methyl Coumarin from resorcinol. (Two step)	**72 Hrs**

8. To prepare 2-phenyl indole from acetophenone.(Two step) 9. To prepare Benzilic acid from benzoin. (Two step) 10. To prepare 2-Formyl Pyrrole from Pyrrole (Vilsmeier-Haack) 11. To prepare 3-Formyl Indole from Indole (Vilsmeier-Haack) 12. To prepare N-Acetyl Indole from Indole.(Acetylation) 13. To prepare 3-Acetyl Indole from Indole. (Acetylation) **Physico- Chemical Exercise:** 1. To determine the amount of Paracetamol in a given tablet using Spectrophotometer. 2. To examine Lambert- Beer law in concentrated solutions using Spectrophotometer. 3. To scan the absorption spectrum of $KMnO_4$ and to determine the wave length of maximum absorption using Spectrophotometer. 4. To determine the concentration of an unknown solution of optically active compound using Polarimeter. 5. To determine the dissociation constant of saturated benzoic acid by pH metry. 6. To determine the concentration of sodium acetate by conductometry. 7. To determine the concentration and amount of acid in a mixture of HCl and CH_3COOH by pH metry. 8. To determine the specific and molecular rotation of cane sugar and intrinsic rotation using Polarimeter. 9. To determine the concentration of saturated benzoic acid by Conductometry. 10. To determine the normality and dissociation constant of the given saturated benzoic acid by Potentiometry. 11. To determine the concentration and amount of acid in a mixture of HCl and CH_3COOH by Potentiometry. 12. To determine the molar refraction and refractive index of a given NaCl salt using Refractometer. 13. To study the variation of refractive index with composition of given liquids and also to determine the composition of unknown mixture using Refractometer.	

Suggested laboratory experiments:
• Not Applicable

Pedagogic tools:
• Chalk and Board
• LCD and Videos.

Text books
1. Laboratory Manuals of Department of Industrial Chemistry, Atmiya University.

Laboratory Manual/ Book
• .Not Applicable

Suggested reading / E-resources
• Not Applicable

Suggested MOOCs
• Not Applicable

Methods of assessing the Course Outcomes
The COs of the course will be assessed through
• CIA • SEE

CIA Components:

Sr. No.	Component	Content	Duration (if any)	Marks	Sub Total
A	Test	After completion of 70-80% of course	3 hours	40	20
B	Performance			10	10
C	Record book			5	5
D	Vivo Voce			5	5
				Grand Total	**40**

M.Sc. Industrial Chemistry

Semester - III		
Subject Code	**Course Title**	**Course Credit**
19PICCC301	**Core 8: POLYMER CHEMISTRY & TECHNOLOGY**	**3 Credits**

Course Description:
This course examines the use of polymers and demonstrates how their properties are controlled by their molecular structure. The students will learn how this structure determines which polymer to use for a particular product. Students will also explore the manufacturing techniques used and the use of polymerization can be used to control the structure of polymers.

Course Purpose:

10. To understand various polymerization techniques
11. To understand the manufacturing process of thermosetting and thermoplastic polymers
12. To understand the process of biodegradable and non biodegradable polymers.
13. To understand the various uses of different polymers in day to day life.

Course Outcomes: Upon completion of this course, the learner will be able to

CO No.	CO Statement	Blooms taxonomy Level (K_1 to K_6)
CO_1	Understand step-growth and chain polymerization, with respect to mechanism and kinetics.	K1, K2
CO_2	Understand polymer manufacturing processes	K1, K2
CO_3	Produce synthetic polymers	K1, K2
CO_4	Understand extrusion process of polymer	K1, K2, K3
CO_5	Create biodegradable and non biodegradable polymers	K1, K2, K3

Course Content	Hours
Module-I : Basics of Polymers &Its Characterization	09 hrs
• Introduction of polymer includes monomer, Oligomer, Various polymerisation techniques, heating and solubility behavior of polymer, Classification of polymers. Determination Molecular weight, tensile strength, viscosity.	
Module-II : Polymer Processing	09 hrs
• Calendaring, • Casting, • Thermoforming, • Foaming, • Spinning of Fibres: Melt Spinning, Dry Spinning, Wet Spinning.	
Module-III : Polymer Extrusion	09 hrs

• Requirements of polymer for extrusion. • Single screw and double screw plasticizing extruder zones in extrusion, breaker plates, extruder screw. PVC extruder. • Die and calibration equipment prime mover for extrusion, co extrusion, extrusion coating, extrusion film blowing reactive extrusion. • Extrusion blow moulding for PET bottles, wire drawing-PVC, spinning-various types and applications. • Application of various extruded products.	
Module-IV : Biodegradable Polymers	09 hrs
• Manufacturing process, properties and application of following polymers: • Class-I: • PLA (Poly lactic acid), • PGA(Poly Glycolic Acid), • PHA(Poly Hydroxy Alkanoate), • PHBV (Poly Hydroxy Butyrate-co-β-HydroxyValerate), • PBSA(Poly Butylene Succinate, Adipate)	
Module-V : Non-Biodegradable Polymers	09 hrs
• Manufacturing process, • properties and application of following polymers: • Class-II, • Polyethene, • Polyvinylchloride, • Polyamides, • Polyesters, • Phenolic • Epoxy resins.	

Suggested laboratory experiments:
• Not Applicable

Pedagogic tools:
• Chalk and Board
• LCD and Videos.

Text books

1. Gowariker, V., Viswanathan N. V., Sreedhar, J., (2005), "*Polymer Science",* Reprint: New Age International Pvt. Ltd., ISBN: 085226-3074.
2. Crawford, R. J. (1998), "*Plastic Engineering",* 3rd Edition: Elsevier, ISBN: 9780080524108.
3. McCrum, N. G., (1988), "*Principles of polymer engineering"*, Vol.1:C, P. Buckley Oxford University press., ISBN: 978-0-19-8565260.
4. Brydson, J. (2000), "*Plastic Materials"*, seventh edition: Butter worth-Hienemann, ISBN:0750641320.

Laboratory Manual/ Book

- Not Applicable

Suggested reading / E-resources
1. Royal Society of Chemistry http://www.rsc.org/journals-books-databases/about-journals/polymer-chemistry/ 2. American Chemical Society https://pmse.sites.acs.org/resources.htm 3. Stanford libraries http://library.stanford.edu/guides/polymer-science-and-engineering

Suggested MOOCs
• Material science and engineering https://www.edx.org/course/materials-science-engineering-misisx-mse1x

Methods of assessing the Course Outcomes The COs of the course will be assessed through
• CIA • SEE • Assignments • Quiz • Seminar

CIA Components	**Marks**
Test – 1 (2 modules, 1 ½ hours, set for 30 marks)	5
Test – 2 (5 modules, 3 hours, set for 60 marks)	15
Assignment	10
Seminar	10
Class activity: Application Cards	10
Grand Total	**50**

M.Sc. Industrial Chemistry

Semester - III		
Subject Code	**Course Title**	**Course Credit**
19PICCC302	**Core 9: CHEMICAL REACTION ENGINEERING**	**3 Credits**

Course Description:
This course introduces students to application of homogeneous reactions and heterogeneous reactions concepts to the chemical reactor design. It will examine some problems related to multiple reactions and percentage conversion of products. This course applies the concepts of reaction rate, stoichiometry and equilibrium to the analysis of chemical, derivation of rate expressions from reaction mechanisms and equilibrium or steady state assumptions, design of chemical reactors.

Course Purpose:
1. To train students how to analyse chemical reactors and reaction systems
2. To provide practice at developing critical and creative thinking skills related to reaction engineering
3. To Designing experiments involving chemical reactors, and analyzing and interpreting data
4. To be able to understand mechanism of solid catalyzed reactions.

Course Outcomes: Upon completion of this course, the learner will be able to

CO No.	CO Statement	Blooms taxonomy Level (K_1 to K_6)
CO_1	Apply concepts in reaction kinetics and classify reactions according to different properties.	K1, K2
CO_2	Calculate the reaction rate constant and reaction activation energy using given temperature-based data.	K1,K2, K3
CO_3	Designing experiments involving chemical reactors, and analyzing and interpreting data.	K1,K2, K3,K4
CO_4	Determine conversion and yield for chemical reactions.	K2, K3,K4
CO_5	Apply kinetic concepts in heterogeneous reactions.	K2, K3,K4

Course Content	Hours
Module-I : Fundamentals Of Reaction Engineering	09 hrs
• Factors affecting reactor designing, Single and multiple Reactions. • Elementary and Non-elementary reactions. • Catalyzed and non-catalyzed reactions.	
Module-II : Kinetics Of Homogeneous Reactions	09 hrs

• Molecularity and order of reactions. • Kinetic Models for non-elementary reactions. • Temperature dependency and reaction rate prediction from Arrhenius, transition and collision theories.	
Module-III : Reactor Desinging-1	09 hrs
• Space velocity, space time, mean residence time. • Flow patterns in reactor, Contacting pattern for two phase system. • Design of ideal batch. • CSTR and Plug Flow Reactors and RTD.	
Module-IV : Reactor Desinging-2	09 hrs
• Non ideal Reactors-Residence time distribution. • E, C, F curves, segregation model, dispersion model. • Chemical reaction and dispersion, tank-in- series model.	
Module-V : Kinetics Of Heterogeneous Reactions	09 hrs
• Langmuir adsorption isotherm equation, BET theory. • Effect of transport processes on selectivity in series and parallel reactions, Rate equation for surface reactions. • Mechanism of solid catalysed gas phase reaction (LHHW model), Progressive conversion model. • Unreacted core model, porosity, density and particle size of catalyst.	

Suggested laboratory experiments:
• Not Applicable

Pedagogic tools:
• Chalk and Board
• LCD and Videos.

Text books

1. KA Gavhane, 2013. *Chemical reaction engineering-II*. Pune: NiraliPrakashan
2. H. Scott Fogler, 2001. *Elements of Chemical Reaction Engineering.*USA: Prentice Hall
3. Octave Levenspeil, 2001, *Chemical Reaction Engineering*. New York:John Wiley & Sons
4. J.M. Smith, 1984. *Chemical Engineering Kinetics*. United states of America: McGraw Hill

Laboratory Manual/ Book
• Not Applicable

Suggested reading / E-resources
1. http://umich.edu/~elements/5e/ 2. http://wwwresearch.sens.buffalo.edu/karetext/title/title.shtml 3. http://ocw.ump.edu.my/course/view.php?id=59

Suggested MOOCs
• Chemical Reaction Engineering-NPTEL

• Chemical Reaction Engineering-SWAYAM

Methods of assessing the Course Outcomes The COs of the course will be assessed through
• CIA • SEE • Assignments • Quiz • Seminar

CIA Components	**Marks**
Test – 1 (2 modules, 1 ½ hours, set for 30 marks)	5
Test – 2 (5 modules, 3 hours, set for 60 marks)	15
Assignment	10
Seminar	10
Class activity: Application Cards	10
Grand Total	**50**

M.Sc. Industrial Chemistry

Semester - III		
Subject Code	**Course Title**	**Course Credit**
19PICCC303	**Core 10: INSTRUMENTAL TECHNIQUES OF ANALYSIS**	**4 Credits**

Course Description:
This course focuses on instrumental methods of analysis and provides a sound foundation of application of modern analytical techniques. This unit is important to all who rely on the use of instrumental analysis in the field of chemical science. Modules within this course include spectrometric methods such as IR, UV, MS and NMR and chromatographic methods such as Gas and Liquid chromatography.

Course Purpose:
1. To understand various spectrometric techniques
2. To understand various chromatographic techniques
3. To understand theoretical background of each analytical technique.
4. To understand separation of organic compounds based on separation techniques.

Course Outcomes: Upon completion of this course, the learner will be able to

CO No.	CO Statement	Blooms taxonomy Level (K_1 to K_6)
CO_1	Understand to identify the basic components of spectroscopic instrumentations.	K1, K2
CO_2	Demonstrate a working knowledge of spectrometry techniques.	K1, K2
CO_3	Understand a working knowledge of chromatography techniques.	K1, K2
CO_4	Understand the processes responsible for NMR chemical shifts and splitting patterns	K1, K2, K3,K4
CO_5	Understand the basic concepts of GC and HPLC techniques and its applications.	K1, K2, K3,K4

Course Content	Hours
Module-I : UV-Vis Spectroscopy	12 hrs
• Introduction to spectroscopy, Electromagnetic spectrum, Interaction of electromagnetic radiation with molecular system, Electronic excitation, Beer- Lambert law, Chromophores and auxochromes, Absorption of simple chromophores. Instrumentation and applications to quantitative analysis.	

Module-II : IR Spectroscopy	12 hrs
• Principle, Modes of vibrations, sampling techniques, selection rules, Absorption frequencies of common functional groups, instrumentation, Application to structure determination.	
Module-III : Mass Spectroscopy	12 hrs
• Introduction, Ion formation, Mass spectral fragmentation of organic molecules, Mac-Lafferty, rearrangement of isotope ions, nitrogen rule the mass spectral fragmentation of organic molecule for structure determination.	
Module-IV : ^{1}H & ^{13}C NMR Spectroscopy	12 hrs
• General introduction and definition; chemical shift; spin –spin interaction; shielding and deshielding mechanism of measurement; chemical shift values and correlation for protons bonded to carbons, J- Coupling, Types of solvents, Instrumentations, Sampling methods and applications. Structure determination of organic compounds using 1 H & 13 C NMR spectroscopic data.	
Module-V : Gas & Liquid Chromatographic Techniques	12 hrs
• Gas Chromatography; theory and instrumentation, Column types, Solid/liquid stationary phases, types of detectors, Applications (Clinical and petrochemical) and problems. • High performance Liquid Chromatography; Theory and instrumentation, adsorption chromatography, liquid-liquid partition techniques, Microbore, capillary and affinity techniques, size exclusion, ion-pair, Applications and problems.	

Suggested laboratory experiments:
• Not Applicable

Pedagogic tools:
• Chalk and Board
• LCD and Videos.

Text books

1. Khistariya A.V., Savant M.M., Patel R.N. (2017), *"Spectroscopy (UV,IR, NMR, Mass)"*, India: Bharat Publishing house. ISBN: 978-93-5236-290-5
2. Chatwal, G. R. (2011), "Instrumental methods of chemical analysis". India: Himalaya Publishing House. ISBN: 9350248360.
3. Kalsi, P. S. (2006), "Spectroscopy of organic compounds". New Delhi: New Age International Pvt Ltd Publishers; 6 th edition. ISBN: 8122415431.
4. Kemp, W. (1991), "Organic Spectroscopy", UK: Palgrave Macmillan. ISBN: 33351954X
5. Pecsok, R. L. and Shields, D. (1977), "Modern Methods of chemical analysis", New York: John Wiley & Sons Inc. ISBN: 0471676624.

Laboratory Manual/ Book
• Not Applicable

Suggested reading / E-resources
1. Royal Society of Chemistry https://www.rsc.org/journals-books-databases/about-journals/analytical-methods/

2. American Chemical Society
3. Stanford libraries http://library.stanford.edu/guides/analytical-chemistry

Suggested MOOCs

- Advance analytical course-NPTEL
- Application of Spectroscopic Methods in Molecular structure determination-NPTEL

Methods of assessing the Course Outcomes

The COs of the course will be assessed through

- CIA
- SEE
- Assignments
- Quiz
- Seminar

CIA Components	**Marks**
Test – 1 (2 modules, 1 ½ hours, set for 30 marks)	5
Test – 2 (5 modules, 3 hours, set for 60 marks)	15
Assignment	10
Seminar	10
Class activity: Application Cards	10
Grand Total	**50**

M.Sc. Industrial Chemistry

Semester - III		
Course Code	**Course Title**	**Course Credit**
19PICCC304	**Core 11: Industrial Safety & Management (Self study)**	**3 Credits**

Course Description:
This course is essential for effective functioning of students in their professional career in industries. This course gives knowledge about the techniques and methodologies needed for prevention of occurrences of unsafe operations and accidents. This course also includes concept of disaster management and process shutdown management.

Course Purpose:
1. To Understand of Intrinsic & Extrinsic Safety rules including hazards-Toxicity, Flammability, Fire, Explosions, Sources of Ignition, Pressure, Hazard and Risk assessment methods and MSDS.
2. To understand and identifying safety devices including Pressure Relief Valve, Rupture Disks, Blow down Systems, Flare Systems, Flame arresters, Deflagration arresters and Explosion suppression, Personal Safety Devices.
3. To analysis Process Safety using basic fundamentals including HAZAN and HAZOP comparison, Risk analysis and Estimation, Safety check list and Computer based quantitative risk analysis.
4. To achieve knowledge of principles of GMP and GLP and its application in pharmaceutical industries including Guidelines, classification, Various Schedule (X, O, M), Violation of GMP and GLP.

Course Outcomes: Upon completion of this course, the learner will be able to

CO No.	CO Statement	Blooms taxonomy Level (K_1 to K_6)
CO_1	Understand Intrinsic & Extrinsic Safety, Hazards, Risk assessment methods and MSDS.	K2, K3
CO_2	Understand the various process safety devices and process safety analysis method.	K2, K3
CO_3	Understand the importance of GLP & GMP in industries	K2, K3
CO_4	Apply the knowledge when necessity of shut down the plant	K2, K3
CO_5	Understand the disaster management	K3, K4

Course Content	Hrs
Module-I: Process Safety • Intrinsic & Extrinsic Safety. • The hazards-Toxicity, Flammability, Fire, Explosions. • Sources of Ignition, Pressure. • Hazard and Risk assessment methods and MSDS	09 Hrs
Module-II: Safety Devices & Process Safety Analysis • Pressure Relief Valve, Rupture Disks, Blow down Systems, Flare Systems, Flame arresters, Deflagration arresters and Explosion suppression, Personal Safety Devices. • Process Safety Analysis: HAZAN and HAZOP comparison, Risk analysis and Estimation, Safety check list, Computer based quantitative risk analysis.	09 Hrs
Module-III: GLP & GMP in Pharmaceutical Industries • GMP: Introduction, Various Schedule (X, O, M), Guidelines, Violation of GMP. • GLP: Introduction, Principles, Resources, Guideline, Violation.	09 Hrs
Module-IV: Shutdown Management • Shutdown Management: Introduction, Types of Shutdown, Resource Planning, activity detail, Material procurement, Preparation Pert/Bar chart, Pre-shutdown work, • Evacuation of Plant and Handing over, Start of work & Review, Pressure testing and handing over, commissioning, Post-shutdown review.	09 Hrs
Module-V: Disaster Management • Disaster Management: Introduction, Classification, Disaster preparation, Prevention, Management, Natural disaster mitigation.	09 Hrs

Suggested laboratory experiments:

- Not applicable

Pedagogic tools:
• Chalk and Board
• LCD and Videos.
• Instruments

Text books:

1. S.Rao, 2009, *Energy Technology-Conventional &Non-Conventional Systems*, India: Khanna publishers
2. F.P. Less, 1980, *Loss Prevention in chemical process industries,* Butterworth: Heiremann
3. D.W. Perry, R.H. Perry, 2007, *Chemical Engineers Handbook,* NY: McGraw Hill
4. S. Willing, J. Stocker, 1997, Good Manufacturing Practices, USA: Marcel Dekker
5. J.J. Keller, 1999, *Safety Managers Handbook,* American Management Association International
6. R.E. Johnstone, 1957, *Pilot Plant Models and Scale up Methods in Chemical Engineering,* US: McGraw-Hill
7. P. Carson, C. Mumford, 1988, *Safe Handling of Chemicals in Industry*, NY: Longman scientific technical

Laboratory Manual/ Book

Not applicable.

Suggested reading / E-resources

- **www.oshatrain.org**

Suggested MOOCs

- https://www.iti.com/safety
- https://www.alcumusgroup.com
- **Industrial Safety Engineering - NPTEL**

Methods of assessing the Course Outcomes

CIA Components	**Marks**
Test – 1 (2 modules, 1 ½ hours, set for 30 marks)	5
Test – 2 (5 modules, 3 hours, set for 60 marks)	15
Assignment	10
Seminar	10
Class activity: Application Cards	10
Grand Total	**50**

M.Sc. Industrial Chemistry

Semester - III		
Course Code	**Course Title**	**Course Credit**
19PICDC301	**DSE-Core-1** **CHEMICAL TECHNOLOGY-I**	**4 Credits**

Course Description:
A chemical or process plant is required to carry out transformation of raw material into desired products effectively, economically feasible and safely. Therefore, this course deals with the advanced concepts of chemical technology comprising drugs & pharmaceutical, dyes & intermediate, essential oil and isolation of natural products and heat treatments & Non-destructive testing technology etc. This course also deals with the new technologies and new immerging developments in chemical technology.

Course Purpose:
1. To apply Knowledge of advanced concepts of drugs and pharmaceuticals industries.
2. To understand the technology used in various chemical technology industries.
3. To understand scientific literature, new technologies and new developments in chemical technology.
4. To design process flow synthesis reaction schemes/diagrams/process block diagrams for the manufacture of various chemicals from process description.

Course Outcomes: Upon completion of this course, the learner will be able to

CO No.	CO Statement	Blooms taxonomy Level (K_1 to K_6)
CO_1	Analyze the advanced concepts of drugs and pharmaceuticals-I	K3, K4, K5,
CO_2	Analyze the advanced concepts of drugs and pharmaceuticals-II	K4, K5
CO_3	Analyze the advanced concepts of essential oil and isolation of natural products	K4, K5
CO_4	Evaluate the advanced concepts of dyes and intermediates	K4, K5
CO_5	Evaluate the advanced concepts of heat treatments & non-destructive testing technology	K4, K5

Course Content	Hours
Module-I : Drugs and Pharmaceuticals-I:	12 hrs
• Synthesis of any four drugs from each category: o Antibiotics, o Analgesics, o Antipyretics, o Anti-inflammatory and o Anti T.B.	
Module-II : Drugs and Pharmaceuticals-II:	12 hrs
• Synthesis of any four drugs from each category: o Antimalarial, o Antihypertensive, o Antidiabatic and o Anticancer	
Module-III : Essential Oil and Isolation of Natural Products:	12 hrs
• Essential oils: Source, constituents, isolation and uses. • Isolation of Natural Products of commercial importance: Methods used. Isolation of nicotine from tobacco waste, Citric from lemon grass, Neem extract and eucalyptus oil.	
Module-IV : Dyes and Intermediates:	12 hrs
• Introduction and Synthesis of following dyes: o Azo, o Anthraquinone, o Vat, o Stilbene o Reactive.	
Module-V : Heat Treatments & Non-Destructive Testing Technology:	12 hrs
• Principle of Heat treatment, various heat treatments of materials, Non-destructive testing of materials including visual inspection, hardness testing, and liquid penetrate method, eddy current, radiographic and ultrasonic method.	

Suggested laboratory experiments:
• Not Applicable

Pedagogic tools:
• Chalk and Board
• LCD and Videos.

Text books

1. Young, G. (2014), "*Essential Oils Desk Reference",* 6th Edition: Life Science Publishing., ISBN-10: 0989499774
2. Lednicer, D., (1998), "*The Organic Chemistry of Drug Synthesis"*, Volume 7, New york: Wiley.ISBN: 978-0-471-24510-0
3. Agrawal, B. K. (1988), "*Introduction to Engineering Materials"*, Tata McGraw-Hill Education, ISBN, 0074515055
4. Sharma, B. K. (1997) "*Industrial chemistry",*Goel publishing house, ISBN: 8187224002, 9788187224006.
5. Althouse, Andrew D., Carl H., William A. Bowditch, (2004) "*Modern Welding", 10th Edition,* Goodheart-Wilcox Co. Inc.
6. *"Fundamentals of Machine Tools" (*1976*)*, *Training Circular Number 9-524 (TC 9-524)*, Headquarters, Department of the Army, Washington D.C.
7. Giachino and Weeks, (1985) "*Welding Skills", 5th Edition,* American Technical Publishers Inc., Chicago, IL.
8. *"Naval Construction Force Welding Materials Handbook",(1991)* P-433, Naval Facilities Engineering Command, Department of the Navy, Washington D. C.
9. *"Operator's Manual for Welding Theory and Application",* (1976*) Training Manual 9-237 (TM 9- 237),* Department of the Army Technical Manual, Headquarters, Department of the Army, Washington D.C.

Laboratory Manual/ Book

- .Not Applicable

Suggested reading / E-resources

3. Heat Treatments- http://navybmr.com/study%20material/14250a/14250A_ch2.pdf
4. Essential oil- https://www.21drops.com/pages/essential-oils-guide
5. A Brief History of Natural Products and Organic Chemistry- http://www.wou.edu/chemistry/courses/online-chemistry-textbooks/ch105-consumer-chemistry/ch105-chapter-6-hydrocarbons/.
6. Virtual Pharmaceutical Library- https://www.researchgate.net/profile/Dr_Mayank_Trivedi2/publication/280033376_Virtual_Pharmaceutical_Library_Information_Sources_and_Services_on_Internet/links/55a4b60108ae5e82ab1f4d09/Virtual-Pharmaceutical-Library-Information-Sources-and-Services-on-Internet.pdf.
7. Dyes & intermediates- https://chemexcil.in/dyes-dye-intermediates.

Suggested MOOCs

- Painting- SWAYAM
- Fundamentals of Material Processing - I- SWAYAM.
- Chemical Principles - NPTEL.
- Advanced Textile Printing Technology- NPTEL.
- Medicinal Chemistry- NPTEL.

Methods of assessing the Course Outcomes

The COs of the course will be assessed through

- CIA
- SEE
- Assignments
- Quiz
- Seminar

CIA Components	**Marks**
Test – 1 (2 modules, 1 ½ hours, set for 30 marks)	5
Test – 2 (5 modules, 3 hours, set for 60 marks)	15
Assignment	10
Seminar	5
Class activity: Reaction Paper	5
Grand Total	**40**

SEMESTER III		
Course Code	**Course Title**	**Course Credit**
19PICDC302	**DSE –Core 1: PHARMACEUTICAL TECHNOLOGY**	**4 Credits**

Course Description:

This course focuses on several topics in pharmaceutical technology will contain: Various types of drug formulations such as tablet, capsules, sterile dosage form, cosmetology and cosmetic preparations and liquid dosage forms.

Course Purpose:

1. Understand & write formulations and evaluations methods for various types tablets & capsules
2. Illustrate requirement for preparation of sterile dosages & liquid dosage forms
3. Understand and Describe cosmeticology and their preparations

Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	**CO Statement**	**Blooms taxonomy Level (K_1 to K_6)**
CO_1	Discuss the fundamental principles for dosage form design, drug release and drug delivery.	K1, K2
CO_2	Classify different dosage forms and apply principles of pharmaceutical science in formulation and dispensing the various dosage forms	K2, K3
CO_3	Apply the engineering principles for formulation of solutions, suspensions and emulsions, granules and tablets	K3
CO_4	Formulate the dosage forms for a given API based on its properties	K3, K4
CO_5	Develop a formulation process for a given API	K4, K5

Course Content	Hours
Module-I : Tablet:	12 hrs
(a) Definition, Advantages and disadvantages, Introduction to types of tablets**,** formulation of different types of tablets; excipients, granulation techniques, machinery for large scale granulation and compression, physics of tablet making, In process controls, processing problems and remedies, **(b)** Evaluation (Pharmacopoeial and nonpharmacopoeial test) and equipments. Introduction of mouth dissolving tablets, buccal tablets, floating tablets, tablets of colon drug delivery, matrix tablets. **(c) Coating of Tablets:** Objectives, types of coating, film forming materials, formulations of coating solution, equipments for coating, coating process, evaluation of coated tablets , coating defects.	
Module-II : Capsules	12 hrs
Hard Capsules: Definitions, Advantages, disadvantages, Ideal requirements, Production of Hard capsules (Gelatin and non-gelatin e.g. vegetable), Capsule storage, size of capsules, formulation and methods of capsule filling, problems and remedies, quality control. **Soft Gelatin Capsules:** Formulation of shell and capsule coat, and quality control.	
Module-III : Sterile Dosage Forms	12 hrs
Definitions, Advantages, Disadvantages, Ideal requirements and Formulation of sterile dosage forms, Water for injection-Preparation, Design and requirements for production area- Aseptic techniques, sources of contamination and methods of prevention, design of aseptic area, laminar flow benches, containers and closures, methods of filling including form fill and seal technology. Evaluation of sterile dosage forms.	
Module-IV : Cosmeticology and Cosmetic Preparations	12 hrs
Fundamentals of cosmetic science, formulation, preparation and packaging of cosmetics for skin - Sunscreen, moisturizers, cold cream, and vanishing cream, hair - Shampoo and conditioners, dentifrice- powders, gels, paste and manicure preparations like- nail polish, lipsticks, eye lashes, baby care products, shaving cream, hygienic products.	
Module-V : Liquid Dosage Forms	12 hrs
Introduction, advantages and disadvantages, types of additives used vehicles, stabilizers, preservatives, suspending agents, emulsifying agents, solubilizers, colors, flavors, etc.	

Suggested laboratory experiments:

- Note: Included in DSE core practical

Pedagogic tools:

- Chalk and Board, Power point presentation, models
- LCD and Videos.

Text books

1. The Theory and Practice of Industrial Pharmacy by L Lachman, H Lieberman. (4th Edition edition, 2014) (ISBN: 9788123922898).

Reference Books:

1. Kanig. Gennaro, Alfonso R., Remington: The Science and Practice of Pharmacy, Vol-I & II, Lippincott Williams & Wilkins, New York. (21st Revised edition, 2005) (ISBN: 9780781746731).
2. Pharmaceutical Dosage Forms and Drug Delivery Systems by Ansel (10^{th} edition, 2013) (ISBN: 9781451188769).
3. Pharmaceutics: The Science of Dosage Form Design by Michael E. Aulton (2^{nd} edition, 2001) (ISBN: 9780443055171).

Laboratory Manual/ Book

- Not applicable

Suggested reading / E-resources

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Suggested MOOCs

- 1. Pharmaceutical Technology – Swayam
- 2. Pharmaceutical Technology - NPTEL

Methods of assessing the Course Outcomes

- Continuous Internal Assessment (CIA)
- Semester End Evaluation (SEE)

Component of CIA

Sr. No	CIA Component	Content	Duration	Marks	Total Marks
1	Test-I	Two Modules	1.5 hrs	5 (Set for 30)	20
	Test-II	All modules	3 hrs	15 (Set for 60)	
2	Assignment	-	-	10 (Mark on 20)	20
3	Class Activity Quiz	-	-	10	
					40

M.Sc. Industrial Chemistry

Semester - III		
Course Code		**Course Credit**
19PICCC305	**Core Practical 5: CT, PC & RE**	**3 Credits**

Course Description:

Dyes and polymer industries are well known chemical industries of the globe. They have major contribution to global economy. Therefore, this course deals with the advanced concepts preparation of various dyes and its dyeing on relevant substrates. Synthesis of various polymers by **suspension, emulsion, bulk and solution polymerization techniques. It is also deals with the advanced concepts of reaction engineering.**

Course Purpose:

3. To understand the **advanced concepts of synthesis of** various dyes.
4. To understand the **advanced concepts of** dyeing process.
5. **To understand** the **advanced concepts of polymer preparation by suspension and emulsion techniques.**
6. **To understand** the **advanced concepts of polymer preparation by Emulsion and bulk techniques.**
7. **To understand** the **advanced concepts of Reaction Engineering.**

Course Outcomes: Upon completion of this course, the learner will be able to

CO No.	CO Statement	Blooms taxonomy Level (K_1 to K_6)
CO_1	Create the **advanced concepts of synthesis of** various dyes.	K2, K3
CO_2	**Apply** the **advanced concepts of** dyeing processes of synthesized dye.	K2, K3, K4
CO_3	**Analyze** the **advanced concepts of polymer preparation by suspension and emulsion techniques.**	K2, K3, K4
CO_4	**Evaluate** the **advanced concepts of polymer preparation by Emulsion and bulk techniques.**	K2, K3, K4
CO_5	**Creat** the **advanced concepts of Reaction Engineering.**	K2, K3, K4

Course Content

Chemical Technology:

1. Preparation of Crysodine-G dye.
2. Preparation of Reactive Red dye.
3. Preparation of Naphthol Blue Black 6B dye.
4. Preparation of Aniline Yellow dye.
5. Preparation of Acid Black 10 BX dye.
6. Preparation of Orange-I dye.
7. Preparation of Orange-II dye.
8. Preparation of Fast Red A.
9. Dyeing of cotton with direct dye Congo Red.
10. Dyeing of cotton with direct dye Fast Red A.
11. Dyeing of cotton with direct dye Methylene Blue.
12. Dyeing of cotton with direct dye Aniline Black.
13. Dyeing of cotton with direct dye Brilliant Green.
14. Dyeing of cotton with direct dye Crystal Violet.

Polymer Chemistry:

1. To prepare Polystyrene by suspension polymerization.
2. To prepare Polystyrene by solution polymerization.
3. To prepare Polystyrene by emulsion polymerization.
4. To prepare Poly acrylonitrile by solution polymerization.
5. To prepare Polymethamethacrylate by bulk polymerization.
6. To prepare Polysulfide rubber. (Thiokol).

Reaction Engineering:

1. To determine the reaction velocity constant for the reaction between acetone and iodine.
2. To determine heat and entropy of vaporization of a given liquid by a kinetic approach
3. To determine the kinetic parameters of the reaction and the temperature coefficient of the reaction between $KBrO_3$ and KI.
4. To determine the kinetic parameters of the reaction and the temperature coefficient of the reaction between $K_2S_2O_8$ and KI.

Suggested laboratory experiments:

- Not Applicable

Pedagogic tools:

- Chalk and Board
- LCD and Videos.

Text books

1. Laboratory Manuals of Department of Industrial Chemistry, Atmiya University.

Laboratory Manual/ Book

- Not Applicable

Suggested reading / E-resources

- Not Applicable

Suggested MOOCs

- Not Applicable

Methods of assessing the Course Outcomes

The COs of the course will be assessed through

- CIA
- SEE

Methods of assessing the Course Outcomes

The COs of the course will be assessed through

- Performance in conduction of experiment.
- Record book.
- MCQ/Quiz.
- Viva Voce.
- Mid Semester & Semester End Practical Exam.

M.Sc. Industrial Chemistry

Semester - III		
Course Code		**Course Credit**
19PICCC306	**Core Practical 6: ITA**	**1 Credit**

Course Description:
The purity of any chemical product is required to carry out transformation of raw material into desired products effectively, economically feasible and safely. Therefore, this course deals with the advanced concepts of analytical separation of mixture of amino acids by ascending chromatography, Radial chromatography, analytical separation and measurement of the R_f values.

Course Purpose:

1. To understand the **advanced concepts of** ascending chromatography.
2. To understand the **advanced concepts of** analytical separation.
3. To understand the separation of the given mixture of amino acids.
4. To understand the **advanced concepts of** Radial chromatography.
5. To understand the **advanced concepts of** measurement of the R_f value.

Course Outcomes: Upon completion of this course, the learner will be able to

CO No.	CO Statement	Blooms taxonomy Level (K_1 to K_6)
CO_1	Create the **advanced processes for separation of amino acids by of** ascending chromatography.	K1, K2, K3, K4
CO_2	Evaluate the advanced concepts of analytical separation.	K2, K3, K4
CO_3	**Apply advanced knowledge of** separation of mixture of amino acids.	K2, K3, K4
CO_4	Create the **advanced processes for separation of amino acids by of** Radial chromatography.	K2, K3, K4
CO_5	**Apply advanced concepts of** measurement of the R_f value.	K2, K3, K4

Course Content	Hours
INSTRUMENTAL TECHNIQUES OF ANALYSIS	

PAPER CHROMATOGRAPHY

1. To separate the given mixture of amino acid by ascending chromatography and measure R_f value. (Threonine + Methionine).
2. To separate the given mixture of amino acid by Radial chromatography and measure the R_f value. (Tyrosine + Methionine).
3. To separate the given mixture of amino acid by ascending chromatography and measure R_f value. (Threonine + Lysine).
4. To separate the given mixture of amino acid by Radial chromatography and measure the R_f value. (Threonine + Arginine).
5. To separate the given mixture of amino acid by ascending chromatography and measure R_f value. (Histidine + Lysine).
6. To separate the given mixture of amino acid by Radial chromatography and measure the R_f value. (Arginine + Lysine).
7. To separate the given mixture of amino acid by ascending chromatography and measure R_f value. (Arginine+ Tyrosine).
8. To separate the given mixture of amino acid by Radial chromatography and measure the R_f value. (Arginine + Histidine).
9. To separate the given mixture of amino acid by ascending chromatography and measure R_f value. (Leusine + Lysine)
10. To separate the given mixture of amino acid by Radial chromatography and measure the R_f value. (Arginine + Leusine).
11. To separate the given mixture of amino acid by ascending chromatography and measure the R_f value. (Arginine + Leusine).
12. To separate the given mixture of amino acid by ascending chromatography and measure the R_f value. (Arginine + Histidine).

LIST OF EQUIPMENTS/INSTRUMENTS/ GLASSWARES:

1. Ascending Chromatography chamber
2. Radial Chromatography chamber
3. Hot air dryer.
4. Sprayer
5. Petridis, Beaker.

Suggested laboratory experiments:
• Not Applicable

Pedagogic tools:
• Chalk and Board
• LCD and Videos.

Text books

1. Laboratory Manuals of Department of Industrial Chemistry, Atmiya University.

Laboratory Manual/ Book
• .Not Applicable

Suggested reading / E-resources
• Not Applicable

Suggested MOOCs
• Not Applicable

Methods of assessing the Course Outcomes The COs of the course will be assessed through
• CIA • SEE

Methods of assessing the Course Outcomes The COs of the course will be assessed through
• Performance in conduction of experiment. • Record book. • MCQ/Quiz. • Viva Voce. • Mid Semester & Semester End Practical Exam.

M.Sc. Industrial Chemistry

Semester - IV		
Course Code	**Course Title**	**Course Credit**
19PICCC401	**Core 12: DISSERTATION**	**10 Credits**

Objectives:

1. To develop new scientific tools, concepts and theories to solve and understand research problems.
2. To equip students with research methodology essential for pursuing research degree (Ph.D & M.Phil) and research in R&D institutes.
3. To enable students in writing various research reports, thesis, dissertation, research papers, articles, essays and poster presentation.

M.Sc. Industrial Chemistry

Semester - IV		
Course Code	**Course Title**	**Course Credit**
19PICCC402	**Core 13: PROCESS DYNAMICS & CONTROL**	**4 Credits**

Course Description:
Process Dynamics & control is the study and application of automatic control in the field of chemical engineering. The primary objective of process dynamics & control is to maintain a process at the desired operating conditions, safely and efficiently, while satisfying environmental and product quality requirements. Proper application of process control can actually improve the safety and profitability of a process. Even though rapidly decreasing costs of digital devices and increasing computer speed have enabled high- performance measurement and control systems, it is not an easy task to achieve this because modern plants tend to be difficult to operate due to high complexity and highly integrated process units.

Course Purpose:
1. A process is a dynamical system, whose behavior changes over time. Control systems are needed to handle such changes in the process. Thus, it is important to understand the process dynamics when a control system is designed.
2. Mathematically, the process dynamics can be described by differential equations. Unsteady-state (or transient) process behavior then corresponds to a situation, where (at least some) time derivatives of the differential equations are nonzero.
3. The sole purpose of process control in industrial operations is to contribute to safety, minimized environmental impact, and optimize processes by maintaining process variable near the desired values.

Course Outcomes: Upon completion of this course, the learner will be able to

CO No.	CO Statement	Blooms taxonomy Level (K_1 to K_6)
CO_1	To demonstrate fundamental understanding of process control.	K3, K4, K5, K6
CO_2	Know the concept related process, steady state, unsteady state, feed-back control.	K4, K5, K6
CO_3	Use Laplace Transform and other properties of it.	K4, K5, K6
CO_4	Obtain transfer functions related to the first order system.	K4, K5, K6
CO_5	Analyze a chemical reactor system controlled with the advanced control strategies.	K4, K5, K6

Course Content	Hours
Module-I : Fundamentals of Process Control:	12 hrs
• Introduction to system, manual system & automatic system, • Terminologies, • Transfer function, • Open loop and closed loop systems, • Transportation lag.	
Module-II : Modes of Control Action:	12 hrs
• Development of block diagrams, • Stability of control systems, • Modes of control action: o ON-OFF Control, o Proportional Control, o Integral Control, o Derivative Control.	
Module-III : Laplace Transform:	12 hrs
• Introduction to Laplace Transform, • Laplace transform derivation for step function, impulse function, exponential function, • Laplace transform of derivatives and its application.	
Module-IV : First Order System Dynamics:	12 hrs
• Derivation for equation of transfer function: o Mercury thermometer system, o Liquid level control (SISO & SITO), o Mixing system without chemical reaction, o Mixing system with chemical reaction, o Non-interacting system, o Interacting system.	
Module-V : Application of Process Control:	12 hrs
• Control Valves-Sizing, • Sensitivity, • linear and Non-linear valve, • Advanced control strategies: Cascade, forward feed.	

Suggested laboratory experiments:
• Not Applicable

Pedagogic tools:
1. Chalk and Board
2. LCD and Videos.

Text books

1. Bhagade S &Nageshwar G,(2011),"*Process Dynamics & Control*", PHI Learning Pvt Ltd., ISBN : 978-81-203-4405-1
2. Sarkar P, (2015),"Advanced *Process Dynamics & Control*", Eastern Economy Edition, PHI Learning Pvt Ltd., ISBN: 978-81-203-4993-3
3. Coughanowr DR, (1991), "*Process Systems, Analysis and Control*", Second Edi,Mc.Graw Hill International Edition, ISBN : 0070132127, 9780070132122
4. StephenopoulisG, (1984),"*Chemical Process Control: An Introduction to Theory and Practice*", Prentice hall, ISBN: 0131286293, 9780131286290
5. Patranasbis D., (2006), "*Principles of process Control*", Second Edition, McGraw Hill Publishing Company Ltd., ISBN: 0-07-462333-8

Laboratory Manual/ Book

- .Not Applicable

Suggested reading / E-resources

1. https://open.umich.edu/find/open-educational-resources/engineering/che-466-process-dynamics-controls
2. http://www.gatewayinstitute.co.in/reference-books/2nd-Seborg-Process-Dynamics-and-Control-2004.pdf
3. https://archive.org/details/ChemicalProcessDynamicsAndControls/page/n31

Suggested MOOCs

1. Chemical Process Control, NPTEL.
2. Process Dynamics & Control - SWAYAM.

Methods of assessing the Course Outcomes

The COs of the course will be assessed through

1. CIA
2. SEE
3. Assignments
4. Quiz
5. Seminar

CIA Components	**Marks**
Test – 1 (2 modules, 1 ½ hours, set for 30 marks)	5
Test – 2 (5 modules, 3 hours, set for 60 marks)	15
Assignment	10
Seminar	10
Class activity: Application Card	10
Grand Total	**50**

M.Sc. Industrial Chemistry

Semester - IV		
Course Code	**Course Title**	**Course Credit**
19PICCC403	**Core 14: ADVANCE ORGANIC CHEMISTRY**	**4 Credits**

Course Description:
A chemical or process plant is required to carry out transformation of raw material into desired products effectively, economically and safely. Therefore, this course deals with the advanced concepts of organic chemistry like **stereoisomerism, cyclostereoisomerism,** green chemistry, **methods in organic synthesis and oxidizing & reducing reagents.**

Course Purpose:
1. Differentiate chiral and achiral molecules. Identify the stereocenters in a molecule and assign the configuration as R or S using CIP rule. Assign configuration using D & L, E & Z, Cis& Trans and P & M notation.
2. Aware the students for chemical processes designing developed and run in a sustainable way using twelve principles of green chemistry.
3. Enable the student to understand principles of organic synthesis and reagents used for oxidation & reduction.

Course Outcomes: Upon completion of this course, the learner will be able to

CO No.	CO Statement	Blooms taxonomy Level (K_1 to K_6)
CO_1	**Understand the advanced concepts of stereoisomerism.**	K3, K4, K5, K6
CO_2	**Analyze the basic technology of cyclostereoisomerism.**	K4, K5, K6
CO_3	**Apply the fundamental technology of** green chemistry.	K4, K5, K6
CO_4	**Evaluate and create the concepts of methods in organic synthesis.**	K4, K5, K6
CO_5	**Evaluate and create the basic concepts of oxidizing & reducing reagents.**	K4, K5, K6

Course Content	Hours
Module-I : Stereoisomerism	12 hrs
• Symmetry, Classification, racemic modification, molecules with one & two chiral centres; Configuration nomenclature, D L, R S and E Z nomenclature. Axial and planer chirality and helicity (P & M); Stereochemistry and configurations of allenes, spiranes, and biphenyls compounds	
Module-II : Cyclostereoisomerism	12 hrs
• Configurations, conformations and stability of cyclohexanes (mono-, di-, and trisubstituted), cyclohexenes and cyclohexanones. Asymmetric induction: Cram's, Prelog's and Horeau's rules	
Module-III : Green Chemistry	12 hrs
• Principles of Green Chemistry and its applications, environmentally benign reaction like Strecker synthesis, Reformatsky reaction, Grignard reaction and Dieckmann condensation. Principles of microwave assisted organic synthesis: Knoevenagel Condensation, Beginelli Reaction, Ugi Coupling, Miyaura Coupling, and Stille Coupling. Reactions in ionic liquids: Diels Alder Reactions, Knoevenagel Condensation, Friedel Crafts Alkylation	
Module-IV : Methods in Organic Synthesis	12 hrs
• Applications of Pd(0) and Pd(II) complexes in organic synthesis- Stille, Suzuki and Sonogashira coupling, Heck reaction and Negishi Coupling.	
Module-V : Oxidizing & Reducing Reagents:	12 hrs
• Reductions: Stereochemistry, stereo selection and mechanism of the following reagents: Sodium borohydride, sodium cyanoborohydride and DIBAL. • Oxidations: Scope of the following oxidizing reagents with relevant applications and mechanisms: SeO_2, $Tl(NO_3)_3$, Sharpless epoxidation.	

Suggested laboratory experiments:
• Not Applicable

Pedagogic tools:
3. Chalk and Board
4. LCD and Videos.

Text books

1. Nasipuri, D. (2011) *Stereochemistry of Organic Compounds: Principles and Applications,* New Delhi: New Age International Publishers. ISBN: 190657491X
2. March, J. and Smith M. B. (2008) *Advanced organic Chemistry – Reaction mechanism & structure*, New Jersey: John Wiley & Sons, Inc. ISBN: 0471720917.
3. Carruthers, W. and Coldham, I. (2004), *Modern Methods of Organic synthesis.* UK: Cambridge University Press. ISBN: 0521778301.
4. Finar, I. L. (2002), *Organic Chemistry.* Vol. 1 & 2, New Jersey: Pearson Education. ISBN: 8177585428.

5. Hassner, A. and Stumer, C. (1994), *New Organic Synthesis based on Name reaction and unnamed reaction.* New York: Pergamon press. ISBN:9780080966304.

Laboratory Manual/ Book

- .Not Applicable

Suggested reading / E-resources

1. Advanced Organic Chemistry, https://www.pdfdrive.com/advanced-organic-chemistry-free-e11722788.html.
2. March's Advanced Organic Chemistry - http://rushim.ru/books/mechanizms/march6ed.pdf.
3. Advanced Organic Chemistry – chemistlibrary – https://chemistlibrary.files.wordpress.com/2015/07/advanced-organic-chemistry-4ed-2000-part-a-structure-and-mechanisms-carey-sundberg.pdf
4. Advanced Organic Chemistry - https://link.springer.com/book/10.1007/978-0-387-44899-2

Suggested MOOCs

1. Advanced Organic Chemistry, MIT open courseware, Massachusetts Institute of Technology, Cambridge, UK.
2. Organic Chemistry III (Reaction Mechanisms 2) - SWAYAM.
3. Co-ordination chemistry (chemistry of transition elements) - SWAYAM.
4. Stereochemistry- SWAYAM.
5. Quantum Chemistry- SWAYAM.

Methods of assessing the Course Outcomes

The COs of the course will be assessed through

1. CIA
2. SEE
3. Assignments
4. Quiz
5. Seminar

CIA Components	Marks
Test – 1 (2 modules, 1 ½ hours, set for 30 marks)	5
Test – 2 (5 modules, 3 hours, set for 60 marks)	15
Assignment	10
Seminar	10
Class activity: Reaction Paper	10
Grand Total	**50**

M.Sc. Industrial Chemistry

Semester - IV		
Course Code	**Course Title**	**Course Credit**
19PICDC401	**DSE-Core-2** **CHEMICAL TECHNOLOGY-II**	**4 Credits**

Course Description:
A chemical or process plant is required to carry out transformation of raw material into desired products effectively, economically and safely. Therefore, this course deals with the advanced concepts of chemical technology comprising various chemical industries like ceramics, refreactories, soap, Detergents, paints, pigments and sugar etc. This course also deals with the new technologies and new developments in chemical technology.

Course Purpose:
1. To apply Knowledge of fundamentals of process industries.
2. To understand the technology used in various chemical technology industries.
3. To understand scientific literature, new technologies and new developments in chemical technology.
4. To design process flow diagrams/process block diagrams for the manufacture of various chemicals from process description.

Course Outcomes: Upon completion of this course, the learner will be able to

CO No.	CO Statement	Blooms taxonomy Level (K_1 to K_6)
CO_1	Understand the advanced concepts of ceramic & refractories industries.	K3, K4, K5, K6
CO_2	Analyze the basic technology of soap & detergents industries.	K4, K5, K6
CO_3	Apply the fundamental technology of paint industries.	K4, K5, K6
CO_4	Evaluate and create the concepts of pigment industries.	K4, K5, K6
CO_5	Evaluate and create the basic concepts and technology of sugar	K4, K5, K6

	industries.	

Course Content	Hours
Module-I : Ceramic and Refractories:	12 hrs
• **Ceramics:** Introduction, Classification based on reduction in porosity, Raw Materials, Manufacturing process, Glazing, Decoration, Methods of Applying colours. • **Refractories:** Introduction, Classification, properties and manufacturing Processes of refractories, Introduction, manufacturing process, properties and uses of Fire clay bricks, Silica bricks.	
Module-II : Soaps and Detergents:	12 hrs
• **Soaps:** Introduction, Raw Materials, Manufacturing process, Classification, Cleaning action, Recovery of glycerin from spent lye. • **Detergents:** Introduction, Classification, Biodegradability of surfactants, Difference between soaps and detergents, Enzyme containing detergents, Eco friendly detergents (Zeolites), Detrimental effects of detergents, Manufacture of shampoos.	
Module-III :Paints:	12 hrs
• **Paints:**Introduction, Classification based on application, raw materials for paint, manufacturing processes, setting process of paints, requirements of good paint, paint failure, PVC, Methods of application, Paint removers, Special applications of paints.	
Module-IV : Pigments:	12 hrs
• **Pigments:**Introduction, Classification, Manufacturing processes and Uses of Various types of pigments o White Pigment : White lead, TiO_2, ZnO. o Blue Pigment : Ultramarine blue, Cobalt Blue, Iron Blue. o Red Pigment : Red lead, Synthetic iron oxide o Green Pigment : Chrome green, Guignet green, Chromium oxide.	
Module-V :Sugar:	12 hrs
• Introduction, Manufacture of cane sugar, Extraction of juice, Purification of juice, Defection, Sulphitation and Carbonation, Concentration or evaporation, Crystallisation, Separation of crystals, Drying, Refining, Grades, Recovery of sugar from molasses, Bagasse, Preparation of celotex, • Manufacture of sucrose from beet root, Testing or estimation of sugar, Double sulphitation process, Double carbonation: Double sulphitation process.	

Suggested laboratory experiments:
• Not Applicable

Pedagogic tools:
• Chalk and Board
• LCD and Videos.

Text books

1. Kirk, R. E. (2004), Encyclopedia of chemical technology, 5th Edition, NY: Wiley-blackwell ISBN-13: 9780471484943.

2. Sharma, B. K. (2011), Industrial chemistry,16th Edition, India: Krishna Prakashan Media (P) Ltd., ISBN-13: 978-81-8283-120-9.
3. Poucher, W. A. (1991), Perfumes, Cosmetics & Soaps, 9th Edition, London: Chapman & Hall, ISBN-0-412-27340-3.
4. Stanburry, P. F. Whitaker A., HALLS. J., (2003), Principles of Fermentation technology, 2nd Edition, UK: Elsevier, ISBN: 0-7506-4501-6.
5. Austin, G. T, (1998) Shreve's Chemical Process Industries, 4th Edition NY: McGraw Hill, ISBN 13: 9780070571457.
6. B.K. Sharma, Industrial Chemistry,2014, ISBN: 978-93-86901-54-5, 1-1800.

Laboratory Manual/ Book

- .Not Applicable

Suggested reading / E-resources

1. Goldschmidt, Streitberger, Basics of coating Technology, BASF Handbook, ISBN-13: 978-3866309036.
2. Paints and pigments, https://nzic.org.nz/ChemProcesses/polymers/10D.pdf.
3. Entire Functions of Sugar Industryhttp://shodhganga.inflibnet.ac.in/bitstream/10603/113307/10/chapter_-5.pdf

Suggested MOOCs

- Process Technology & Process
- Chemical Technology by Coastline Community College, Community college in Fountain Valley, California.http://www.coastline.edu/academics/process-technology.

Methods of assessing the Course Outcomes

The COs of the course will be assessed through

- CIA
- SEE
- Assignments
- Quiz
- Seminar

CIA Components	Marks
Test – 1 (2 modules, 1 ½ hours, set for 30 marks)	5
Test – 2 (5 modules, 3 hours, set for 60 marks)	15
Assignment	10
Seminar	5
Class activity: Reaction Paper	5
Grand Total	**40**

Semester - IV		
Course Code	**Course Title**	**Course Credit**
19PICDC402	**DSE Core 2:** **CHEMISTRY OF SYNTHETIC DRUGS**	4 Credits

Course Description:

This course focuses on types of disease, classification and synthetic methods of known drugs, such like anticancer, infectious diseases, cardiovascular and metabolite disorder diseases, CNS disease, antiperkinson diseases, Analgesic & anti-inflammatory diseases and anesthetic drugs. A short introduction to the biological and pharmacological properties of the drugs will also be included.

Course Purpose:

1. Understand and Describe classification & synthesis of antiancer, anti-infectious, cardiovascular and metabolic disorder drugs.
2. Understand and illustrate classification & synthesis of CNS acting agents, anti-inflammatory drugs, and anesthetic agents.

Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	**CO Statement**	**Blooms taxonomy Level (K_1 to K_6)**
CO_1	Classify type of disease and drugs	K2, K3
CO_2	Employ the core subject knowledge of anticancer and anti-infectious, Cardiovascular and the drugs affecting on metabolic disease.	K2, K3
CO_3	Well acquainted with the synthesis of some important class of drugs.	K4
CO_4	Knowledge about the mechanism pathways of disease and curing by medicinal compounds.	K3, K5
CO_5	Critically evaluate modern methods of functional group transformations and the application of protecting groups in Drug synthesis.	K4, K5

Course Content	Hours
Module-I : Cancer and Infectious Diseases	12 hrs
Introduction to diseases, classification of anticancer and antiinfectiousdrugs, synthesis of the following classes of the drugs: (1) DNA alkylating agents and Aromatase Inhibitors: Anastrozole, Letrozole, Estramustine, Cisplatin. (2) Quinolone Antibiotics: Levofloxacin, Moxifloxacin. (3) Triazole Antifungals: Fluconazole. Fosfluconazole, Itraconazole, (4) Non-Nucleoside HIV Reverse Transcriptase Inhibitors: Nevirapine, Delavirdine Mesylate (5) Neuraminidase Inhibitors For Influenza: Oseltamivir Phosphate (Tamiflu)	
Module-II : Cardiovascular and Metabolic Diseases	12 hrs
Introduction to diseases, classification of drugs acting on Cardiovascular and Metabolic, synthesis of the following classes of the drugs: (1) Type 2 Diabetes: Rosiglitazone, Pioglitazone. (2) Hypertension: Losartan Potassium, Telmisartan. (3) Calcium Channel Blockers for Hypertension: Nifedipine, Irbesartan (4) Second-Generation Hmg-CoaReductase Inhibitors: Rosuvastatin, Atorvastatin. **Diuretics** (1) Thiazides(Benzothiadiazines): Chlorothiazide, Hydrochlorothiazide (2) Carbonic-Anhydrase Inhibitors: Acetazolamide, Ethoxzolamide (3) Miscellaneous Sulphonamide Diuretics: Indapamide (4) Purine or Xanthine Derivatives: Caffeine (5) Miscellaneous Diuretics- Triamterene	
Module-III : Central Nervous System Diseases	12 hrs
Introduction to diseases, classification of drugs acting on Central Nervous System &Antiparkinsonism, synthesis of the following classes of the drugs: **CNS Diseases:** (1) Antidepressant: Venlafaxine, Duloxetine. (2) Insomnia: Zolpidem, Zaleplon, Indiplon. (3) Antiepileptic: Gabapentin. (4) Attention Deficit Hyperactivity Disorder: Amphetamine. **Antiparkinsonism Agents** (1) Piperidine analogues: Cycrimine hydrochloride, Trihexyphenidyl hydrochloride (2) Pyrrolidine analogues: Procyclidine Hydrochloride (3) Phenothiazine analogues: Ethopropazine Hydrochloride (4) Miscellaneous drugs: Dopamine, Levodopa	

Module-IV : Analgesic and Anti-Inflammatory Drugs	12 hrs
Introduction to diseases, classification of Analgesic and Anti-Inflammatory Drugs, synthesis of the following classes of the drugs: **Non-Steroidal Anti-Inflammatory Drugs (NSAIDs):** (1) Heteroarylacetic acid analogues: Indomethacin, Tolmetin sodium. (2) Arylacetic acid analogues: Ibuprofen, Diclofenac sodium. (3) Arylpropionic acid analogues: Ketoprofen, Indoprofen. (4) Naphthalene acetic acid analogues: Naproxen. (5) Salicylic acid analogues: Aspirin, Benorilate. (6) Pyrazolones and pyrazolodiones: Phenazone (Antipyrine) **Antipyretic analgesics** (1) Aniline and p-Aminophenol Analogues: Paracetamol, Phenacetin. (2) Quinoline Derivatives: Cinchophen. (3) The N-Arylanthranilic Acids: Mefenamic Acid, Flufenamic Acid.	
Module-V : Anaesthetics Drugs	12 hrs
Introduction to diseases, classification of Anasthetic drugs, synthesis of the following classes of the drugs: **General Anaesthetics:** (1) Inhalation Anaesthetics: Halothane, Chloroform. (2) Intravenous Anaesthetics: Ketamine Hydrochloride,Propanidid. (3) Basal Anaesthetics: Tribromoethanol,Paraldehyde. **Local Anasthetic** (1) The Esters: Benzocaine, Procaine Hydrochloride (2) Piperidine or Tropane Derivatives: α-Eucaine, Benzamine Hydrochloride. (3) The Amides: Lignocaine Hydrochloride, Pyrrocaine Hydrochloride, (4) The Quinoline and Iso-quinoline Analogues: Dibucaine Hydrochloride, Dimethisoquin Hydrochloride. (5) Miscellaneous Type: Phenacaine Hydrochloride	

Suggested laboratory experiments:

- Not applicable

Pedagogic tools:

- Chalk and Board, Software, Case study
- LCD and Videos.

Text books

1. The Art of DrugSynthesis by Douglas S. Johnson and Jie Jack Li, John Wiley & Sons, Inc., Hoboken, New Jersey, ISBN 978-0-471-75215-8.

Reference Books:

1. Synthesis of Essential Drugs by R.S. Vardanyan and V.J. Hruby, Elsevier, ISBN: 978-0-444-52166-8.
2. Medicinal Chemistry by Ashutosh Kar, New Age International (P) Ltd, ISBN: 978-81-224-2305-7.
3. Burger's Medicinal chemistry and drug discovery, Sixth edition by Donald J. Abraham, John Wiley and Sons, Inc.

Laboratory Manual/ Book

- Not applicable

Suggested reading / E-resources

- Not applicable

Suggested MOOCs

- Not applicable

Methods of assessing the Course Outcomes

The COs of the course will be assessed through

- Assignment / Seminar
- Continuous Internal Assessment
- Semester End Evaluation

Component of CIA

Sr. No	CIA Component	Content	Duration	Marks	Total Marks
1	Test-I	Two Modules	1.5 hrs	5 (Set for 30)	20
	Test-II	All modules	3 hrs	15 (Set for 60)	
2	Assignment	-	-	10 (Mark on 20)	20
3	Class Activity Reaction Paper	-	-	10	
Total					40