VIII Semester:

S. No.	Course Code	Course Title	Category	Type	Credit	L	T	P
1.	22CHW453	Major Project OR In Lieu of the Major Project any two courses offered in the Program Electives – IV, V OR VI to be opted	Project	Practical/ Theory	6 OR 6	0 6	0 0	12 0
2.		Program Elective-IV	PE	Theory	3	3	0	0
3.		Program Elective-V	PE	Theory	3	3	0	0
4.		Program Elective-VI	PE	Theory	3	3	0	0
5.		Open Elective - II	OE	Theory	3	3	0	0
Total					**18**	**12/ 18**	**0**	**12/ 0**

Program Elective-IV		**Program Elective-V**	
22CHT934	Hydrogen and Fuel Cell Technology	22CHT933	Data Science for Chemical Engineers
22CHT938	Waste to Energy Technologies	22CHT937	Process Piping and Design
22CHT931	Advanced Separation Processes	22CHT936	Process Modeling and Simulation

Program Elective-VI	
22CHT932	Bio-Process Engineering
22CHT930	Advanced Mass Transfer
22CHT935	Polymer Process Modeling

SEMESTER – VIII
Program Elective – IV

1. Subject Code: 22CHT934 **Course Title: Hydrogen & Fuel Cell Technology**

2. Contact Hours: L: 3 T: 0 P: 0

3. Credits: 3 Semester: VIII

4. Pre-requisite: Nil.

5. Course Objective: To gain insight about hydrogen energy, fuel cells, their working principle, types of fuel cells and performance analysis.

6. Course Outcome:Upon completion of this course, the students will be able to:
   i. Gain knowledge on fuel cell working principle, types of fuel cell, voltage loss and it reason
   ii. Understand the role of fluid dynamics, reaction kinetics and mass transfer principles in fuel cell operation. Stacking of fuel cell and fuel processing for fuel cell

7. Details of Course:

Unit No.	Contents	Contact Hours
1	**Introduction to hydrogen energy systems**: Current scenario of hydrogen production, general introduction to infrastructure requirement for hydrogen production, dispensing and utilization.	**2**
2	**Hydrogen production pathways:** *Thermal*: Steam reformation, Thermo chemical water splitting, Gasification, Pyrolysis and Partial oxidation methods. *Electrochemical*: Electrolysis, Photo-electro chemical. *Biological*: Anaerobic Digestion, Fermentative Micro-organisms **Hydrogen Storag**e: General storage methods, compressed storage, Zeolites, Metal hydride storage, chemical hydride storage and cryogenic storage. **Hydrogen Utilization:** Overview of hydrogen utilization, I.C. Engines, gas turbines, hydrogen burners, power plant, refineries, domestic, marine applications, fuel cell.	**10**
3	**Introduction to Fuel Cell**: A simple fuel cell, fuel cell advantages, fuel cell disadvantages, fuel cell types basic fuel cell operation, fuel cell performance characterization and modeling, fuel cell technology, fuel cells and the environment.	2
4	**Fuel Cell Thermodynamics:** Thermodynamics review, Heat potential of a fuel: enthalpy of reaction, Work potential of a fuel: Gibbs Free Energy, Predicting eversible voltage of a fuel cell under non-Standard-state conditions, fuel cell efficiency, Thermal and Mass balances in fuel cells, Thermodynamics of reversible fuel cells	4
5	**Fuel Cell Reaction Kinetics:** Introduction to electrode kinetics, activation energy of charge transfer reactions, activation energy determines reaction rate, net rate of a reaction calculation, rate of reaction at equilibrium: exchange current density, potential of a reaction at equilibrium: Galvani potential, potential and rate: Butler–	10

	Volmer equation, exchange currents and electrocatalysis: Improving kinetic performance, simplified activation kinetics: Tafel equation. **Fuel Cell Charge Transport:** Charges move in response to forces, charge transport results in a voltage loss, characteristics of fuel cell charge transport resistance, physical meaning of conductivity, review of fuel cell electrolyte classes.	
6	**Fuel Cell Mass Transport:** Transport in electrode versus flow structure, transport in electrode: diffusive transport, transport in flow Structures: convective transport. **Overview of Fuel Cell Types:** introduction, phosphoric acid fuel cell, polymer electrolyte membrane fuel cell, alkaline fuel cell, molten carbonate fuel cell, solid-oxide fuel cell, other fuel cells	4
7	**Overview of Fuel Cell Systems:** Fuel cell subsystem, thermal management subsystem, fuel delivery/processing subsystem, power electronics subsystem, case study of fuel cell system design: stationary combined heat and power systems. **Fuel Processing Subsystem Design:** Fuel reforming overview, water gas shift reactors, carbon monoxide clean-up, reformer and processor efficiency losses, reactor design for fuel reformers and processors.	6

8. Books:

(A) Text Books

S.No.	Authors / Name of Book / Publisher	Year of Publication
1	Fuel Cell Fundamentals (3rd Ed.) by O'Hayre, Ryan/ Colella, Whitney/ Cha, Suk-Won. Wiley Publications.	2016

(B) Reference Books

S.No.	Authors / Name of Book / Publisher	Year of Publication
1	James Larminie and Andrew Dicks,Fuel Cell Systems Explained, 2ndEd., John Wiley & Sons Inc.	2000
2	Supramaniam Srinivasan, Fuel Cells: From Fundamentals to Applications, Springer.	2010
3	FranoBarbir,PEM Fuel Cells Theory and Practice, Elsevier Academic Press.	2005

1. Subject Code: 22CHT 938 **Course Title: Waste to Energy Technologies**

2. Contact Hours: L: 3 T: 0 P: 0

3. Credits: 3 Semester: VIII

4. Pre-requisite: Nil.

5. Course Objective: To provide knowledge about conversion of waste in to useful energy.

6. Course Outcomes:Upon completion of this course, the students will be able to:

i. Apply the knowledge about the operations of Waste to Energy Plants

ii. Learn about the best available technologies for waste to energy

iii. Analyse the various aspects of Waste to Energy Management Systems

7. Details of Course:

Unit No.	Contents	Contact Hours
1.	**Introduction**: Introduction to energy from waste, characterization and classificationof wastes, availability of agro based, forest, industrial, municipal solid waste in India,proximate& ultimate analyses, heating value determination of solid, liquid and gaseous fuels. **Densification:** Densification of agro and forest wastes, technological options, combustion characteristics of densified fuels, usage in boilers, brick kilns and lime kilns.	8
2.	**Waste to Energy Through Thermal Routes:** Incineration, pyrolysis and gasification and hydro-thermal liquefaction. Reactors, co-processing ofvarious types of wastes, downstream applications of products, hydrogen production,storage and utilization, gas cleanup.	8
3.	**Waste to energy through biochemical routes:** Municipal and industrial wastewater rand their energy potential, anaerobic reactor configuration for fuel gas productionfrom wastewater and sludge. Separation of methane and compression. Concept ofmicrobial fuel cells, gas generation and collection in landfills, bio-hydrogenproduction through fermentation, composting of solid wastes.	8
4.	**Waste to energy through chemical routes:** Production of bio diesel from discardedoils through trans-esterification, characterization of biodiesel, usage in CI engineswith and without retrofitting, algal biodiesel.	8
5.	**Waste Bio-refinery:** Types of bio-refineries, case studies, and concepts of Life Cycle Assessment and Techno-economical analysis.	8

8. Books:

(A) Text Books

S.No.	Authors / Name of Book / Publisher	Year of Publication
1	Rogoff, M.J. and Screve, F., "Waste-to-Energy: Technologies and Project Implementation", 2^{nd}Ed., Elsevier Store.	2011
2	Young G.C., "Municipal Solid Waste to Energy Conversion processes", John Wiley and Sons.	2010
3	Mondal, P. and Dalai, A., " Utilization of natural resources", CRC Press	2017

(B) Reference Books

S.No.	Authors / Name of Book / Publisher	Year of Publication
1	Harker, J.H. and Backhusrt, J.R., "Fuel and Energy", Academic Press Inc.	1981
2	EL-Halwagi, M.M., "Biogas Technology- Transfer and Diffusion", ElsevierApplied Science.	1986
3	Hall, D.O. and Overeed, R.P.," Biomass - Renewable Energy", John Willy andSons.	2007

1. Subject Code: 22CHT 931 **Course Title: Advanced Separation Processes**

2. Contact Hours: L: 3 T: 0 P: 0

3. Credits: 3 Semester: VIII

4. Pre-requisite: Nil.

5. Objective: To learn concept and design aspects of advanced separation techniques.

6. Course Outcomes: Upon completion of this course, the students will be able to:

   i. Choose a suitable separation technique for separation of product mixture
   ii. Understated the concept of membrane based separation technique
   iii. Understand the fundamental of ion exchange and other advanced separation techniques

7. Details of Course:

Unit No.	Contents	Contact Hours
1.	Introduction: Separation process in chemical and Biochemical Industries, Categorization of separation processes, equilibrium and rate governed processes.	4
2.	Membrane based Separation Technique (MBSTs): Historical background, physical and chemical properties of membranes, Techniques of membrane preparation, membrane characterization, various types of membranes and modules. Osmosis and osmotic pressure. Working principle, operation and design of Reverse osmosis, Ultrafiltration, Microfiltration, Nano-filtration, Electrodialysis and Pervaporation. Gas separation by membranes and liquid membranes.	14
3.	Ion Exchange: History, basic principle and mechanism of separation, Ion exchange resins, regeneration and exchange capacity. Exchange equilibrium, affinity, selectivity and kinetics of ion exchange. Design of ion exchange systems and their uses in the removal of ionic impurities from effluents.	10
4.	Reactive distillation, supercritical fluid extraction, and chromatographic separation. Pressure & temperature swing adsorption.	12

8. Books:

(A) Text Books

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	Marcel Mulder, Basic Principles of Membrane Technology, 2^{nd} Ed., Springer	1996
2.	B K Dutta, Principles of Mass Transfer and Separation Processes, PHI Learning.	2007

(B) Reference Books

S. No.	Authors / Name of Book / Publisher	Year of Publication
1.	Henry, J. D. and Li, N. N., "New Separation Techniques", AIChE Today Series, AIChE.	1975
2.	Hatton, T. A., Scamehorn, J. F. and Harvell, J. H., "Surfactant Based Separation Processes", Vol. 23, Surfactant Science Series, Marcel Dekker Inc., New York.	1989
3.	McHugh, M. A. and Krukonis, V. J., 'Supercritical Fluid Extraction", Butterworths, Boston.	1985
4.	King, C.J., "Separation Processes", Tata McGraw-Hill.	1982
5.	Sourirajan, S. and Matsura, T., "Reverse Osmosis and Ultra-filtration - Process Principles," NRC Publications, Ottawa.	1985
6.	Porter, M. C., "Handbook of Industrial MembraneTechnology," Noyes Publication, New Jersey.	1990

SEMESTER – VIII
Program Elective – V

1. Subject Code: 22CHT 933 **Course Title: Data Science for Chemical Engineers**

2. Contact Hours: L: 3 T:0 P: 0

3. Credits: 3 Semester: VIII

4. Pre-requisite: Nil

5. Course Objective: The objective of this course is to provide an understanding for the graduate student on various data science concepts, Design of experiments and optimization along with nonlinear regression.

6. Course Outcomes: Upon completing this course, the student will able to:

i. Learn the fundamental of Measures of central tendencies, measures of dispersion and perform Test of Hypothesis as well as calculate confidence interval for a population parameter for single sample and two sample cases. Understand the concept of p-values

ii. Learn non-parametric test such as the Chi-Square test for Independence as well as Goodness of Fit

iii. Compute and interpret the results of Bivariate and Multivariate Regression and Correlation Analysis, for forecasting and also perform ANOVA and F-test

iv. Develop the forecasted non-linear model using various design of experiments techniques comprising interaction effects and optimization using optimizers

7. Details of Course:

Unit No.	Contents	Contact Hours
1.	Elementary concept of statistics: Measures of Central Tendencies, Dispersion, Skewness, Kurtosis moments, uses and Limitation of moments, Theory of Probability.	8
2.	Probability Distribution: Discrete Distribution (Binomial and Poison Distribution), Continuous Distribution (Exponential Distribution and Gamma Distribution), Normal Distribution, Lidenberg-Levy Theorem	8
3.	Correlation and Regression: Pearson Product Moment Correlation, Spearman Rank Correlation coefficient, Tetrachoric, Phi coefficient, Biserial, point biserial, Partial Correlation, Linear and Non Linear Regression Models, Residual Analysis.	8
4.	Sampling Distribution: Hypothesis testing, significance tests, type I and II error, student t-test, Chi square test, analysis of variance (ANOVA).	8
5.	Design of experiments and optimization: Response Surface Methodology, Robust Design, Full Factorial Design, Static and dynamic optimization, Sequential Simplex Method, Pontryagin's maximum principle.	8

8. Books:

(A) Text Books

S. No.	Authors / Name of Book / Publisher	Year of Publication
1	Holman, J.P.“Experimental Methods for Engineers”, 8thEd., McGraw-Hill, Singapore.	2011
2	Himmelblau, D.M., “Process Analysis by Statistical Analysis,” John Wiley and Sons.	1970
3	Montgomery, D.C., “Design and Analysis of Experiments,” 10thEd., John Wiley and Sons.	2019
4	Feller, W., “An Introductionto Probability Theory,” Vols. 1 and 2, 3rdEd., John Wiley and Sons.	2008

(B) Reference Books

S. No.	Authors / Name of Book / Publisher	Year of Publication
1	Box, G.E.P., Hunter, W.G., and Hunter, J.S., “Statistics for Experimenters,” 2ndEd., John Wiley and Sons.	2005
2	Draper, N.R. and Smith, H., “Applied Regression Analysis”, Volume 1, 3rdEd., Wiley.	1998

1. Subject Code: 22CHT937 Course Title: Process Piping and Design

2. Contact Hours: L: 3 T: 0 P: 0

3. Credits: 3 Semester: VIII

4. Pre-requisite: Nil.

5. Objectives: To provide a comprehensive understanding of the principles of process piping design.

6. Course outcome: Upon completion of this course, the students will be able to:

i. Understand the concept of fluid flow in the pipe.

ii. Get a basic knowledge of the design pressure considerations, stress analysis, and sizing of the piping system.

iii. Design a complete piping system, including piping, pumping, and energy requirements for different processes as well as utilities.

7. Details of the course

Unit No.	Contents	Contact Hours
1.	Introduction to various codes (IS, BS, ASME, etc.) used in chemical process industries and utilities. Introduction to pipe schedules, Piping Material classification and specifications for Carbon Steel Piping classes, Alloy Steel Piping classes, Stainless Steel Piping classes, and Non-Metallic Piping classes. New materials for liquid and gaseous transportation.	8
2.	Newtonian and Non-Newtonian fluid flow through process pipes, Shear stress, Shear rates behaviour, apparent viscosity, and its shear dependence, Power law index, Yield Stress in fluids, Time-dependent behaviour, Thixotropic and Rheopectic behaviour, mechanical analogues, velocity pressure relationships for fluids.	7
3.	Pressure drops for the flow of Newtonian and non-Newtonian fluids through pipes, effect of Reynolds, and apparent Reynolds number.	7
4.	Pipes of circular and non-circular cross-section velocity distribution average velocity and volumetric rate of flow. Flow through curved pipes (Variable cross sections). Effects of pipe fittings on pressure losses. Pipes for sudden expansion and contraction effects, pipe surface roughness effects, pipe bends, and shearing characteristics.	7
5.	Pipeline design and power losses incompressible fluid flow, Multiphase flow, gas-liquid, solid-fluid, flow in vertical and horizontal pipelines, Lockhart-Martinelli relations, and flow pattern regimes. Plant design and piping layouts.	12

8. **Books:**

(A) Text Books

S. No.	**Authors / Name of Book / Publisher**	**Year of Publication**
1	Coulson, J.M. and Richardson, J.F., “Chemical Engineering,” Vol. I and VI, Butterworth Heinemann.	1999
2	Govier, G.W. and Aziz K., “The Flow of Complex Mixtures in Pipe,” 2nd Ed., Society of Petroleum Engineers.	2021

(B) Reference Books

S. No.	**Authors / Name of Book / Publisher**	**Year of Publication**
1	Green D.W. and Southard M. Z., “Perry’s, Chemical Engineers Handbook,”9th Ed., McGraw Hill, New York.	2018
2	Chhabra R. P., Richardson J.F., “Non-Newtonian Flow and Applied Rheology: Engineering Applications,” 2ndEd., Elsevier Science.	2011
3	ASME 31.3 Process Piping Petroleum Refinery	2013

1. Subject Code: 22CHT936 Course Title: Process Modeling and Simulation

2. Contact Hours: L:3 T:0 P:0

3. Credits: 3 Semester: VIII

4. Pre-requisite: Nil.

5. Objective: To study the modeling & simulation techniques of chemical processes and to gain skills in using process simulators.

6. Course Outcomes: Upon completion of this course, the students will be able to:

  i. Analyze physical and chemical phenomena involved in various process
  ii. Develop mathematical models for various chemical processes
  iii. Understood several mathematical techniques to solve and various simulation approaches
  iv. Learned the artificial intelligence based modelling

7. Details of Course:

Unit No.	Contents	Contact Hours
1.	**Introduction and Fundamentals of Process Modelling and Simulation:** industrial usage of process modelling and simulation; Classification of models, Model building, Modelling difficulties, Degree-of-freedom analysis, Selection of design variables, Macroscopic mass, energy and momentum balances; incorporation of fluid thermodynamics, chemical equilibrium, reaction kinetics and feed/ product property estimation in mathematical models. Review of numerical techniques for solving steady state and unsteady state models.	12
2.	**Model Development and Simulation of Steady State:** Lumped models of chemical process equipment like reactors, distillation, absorption, extraction columns, evaporators, and heat exchangers etc. Unsteady state lumped systems and dynamic simulation; Computer algorithms for numerical solution of steady state and unsteady state models. Microscopic balances for steady state and dynamic simulation; process modeling with dispersion; axial mixing; diffusion, etc.	16
3.	**Simulation Approach**: Sequential modular approach, Equation oriented approach, Partitioning and tearing, Use of process simulation software (Aspen Plus/ Aspen Hysys) for flow sheet simulation.	6
4.	Introduction to application of artificial intelligence based modeling methods using Artificial Neural Networks, Fuzzy logic, etc.	6

8. Books:

(A) Text Books

S. No.	Authors / Name of Book / Publisher	Year of Publication
1	Luyben, W. L., "Process Modeling, Simulation and Control for Chemical Engineers," McGraw Hill.	1998
2	Himmelblau, D. M., & Bischoff, K. B., "Process analysis and simulation: Deterministic systems," John Wiley, New York.	1968
3	Ramirez, W.F., "Computational Methods for Process Simulation," 2ndEd., Butterworth-Heinemann.	1997

(B) Reference Books

S. No.	Authors / Name of Book / Publisher	Year of Publication
1	Ingham, J., Dunn, I. J., Heinzle, E., Prenosil, J.E., Snape, J.B., "Chemical Engineering Dynamics: An Introduction to Modelling and Computer Simulation," 3rdEd., Wiley-VCH Verlag GmbH.	2007
2	Denn, M. M., Process Modeling, Longman Sc& Tech.	1987
3	Holland, C. D., "Fundamentals and Modeling of Separation Processes", Prentice Hall.	1975
4	Aris, R. and Varma, A. (Editors), "The Mathematical Understanding of Chemical Engineering Systems: Selected Papers of N. R. Amundson," Pergamon Press.	1980
5	Babu, B.V., "Process Plant Simulation," Oxford University Press.	2004

SEMESTER – VIII
Program Elective – VI

1. Subject Code: 22CHT932 **Course Title: Bioprocess Engineering**

2. Contact Hours: L:3 T:0 P:0
3. Credits: 3 Semester: VIII
4. Pre-requisite: Nil.
5. Objective: To impart the knowledge of enzyme kinetics, cell growth and application of the same for the production of biochemical products and biological wastewater treatment techniques.
6. Course Outcome: Upon completion of this course, the students will be able to:

i. Understand the role of chemical engineers in bioprocess industries.
ii. Understand concept of Enzyme and its working, cell growth kinetics and inhibition kinetics
iii. Design of downstream equipment for product separation
iv. Design of bioreactor/ fermenter

7. Details of Course:

Unit No.	Contents	Contact Hours
1.	**Introduction:** Interaction of chemical engineering principles with biological sciences. Life processes, unit of living system, microbiology, reaction in living systems, Chemicals of Life.	12
2.	**Biocatalysts:**Enzyme Kinetics, Mechanism and Inhibition models, Immobilized Enzymes-Methods, Kinetics and diffusion limitations	8
3.	**Fermentation:**Fermentation mechanisms and kinetics. **Cell Growth-**kinetic models of microbial growth and product formation, Stoichiometry of cell growth. Fermenter types; Modeling of batch and continuous fermentor. Bioreactor design, mixing phenomena in bioreactors.	12
4.	**Sterilization:** Sterilization of media and air, sterilization equipment, batch and continuous sterilize design.	2
5.	**Overview of Separation and Purification Techniques:** Biochemical product recovery and separation. Membrane separation process: reverse osmosis, dialysis, ultrafiltration; Chromatographic methods: adsorption chromatography, gel filtration, affinity chromatography etc. Electro-kinetic separation: electro-dialysis, electrophoresis.	6

8. Books:

(A) Text Books

S.No.	Authors / Name of Book / Publisher	Year of Publication
1	Shuler, M.L. and Kargi, "Bioprocess Engineering Basic Concepts," 2^{nd} Ed., Prentice Hall of India, New Delhi,	2001

(B) Reference Books

S.No.	Authors / Name of Book / Publisher	Year of Publication
1	Bailey &Ollis, Biochemical Engg. Fundamentals, 2^{nd} Ed. McGraw Hill.	2007
2	Dubey R.C., "A Textbook of Biotechnology", 5^{th} Ed. S. Chand and Co., New Delhi.	2014
3	Schugerl, K. and Bellgardt, K. V., Bioreaction Engineering: Modeling and Control, Springer Verlag, Heidelberg.	2011
4	Doran P., Bioprocess Engineering Principles, 2^{nd} Ed. Academic Press, NewYork.	2012
5	Blanch H. W. and Clark D. S., Biochemical Engineering, 2^{nd} Ed. Dekker, NewYork.	1997
6	Aiba, S., Humphrey, J. Biochemical Engineering, Academic Press.	1973

1. Subject Code: 22CHT 930 **Course Title: Advanced Mass Transfer**

2. Contact Hours: L: 3 T: 0 P: 0

3. Credits: 3 Semester: VIII

4. Pre-requisite: Nil.

5.Course Objective: To understand the principles and operation of advanced separation processes.

6. Course Outcome:Upon completion of this course, the students will be able to:

i. Solve problems related to binary and multi-component distillation.
ii. Use of operational and design aspects of enhanced distillation processes.
iii. Use the concepts of membrane separation techniques for industrial separations.
iv. Exposure to other new separation techniques - surfactant based, supercritical fluid extraction and bio-filtration.

7. Details of Course:

Unit No.	Contents	Contact Hours
1.	**Mass Transfer with Reactions:** Steady and unsteady state	7
2.	**Multi-component Multistage Distillation:** Approximate methods, Equilibrium-based methods, Rate based models for Distillation, Pseudo-components based distillation.	7
3.	**Enhanced Distillation:**Azeotropic and extractive distillation, Salt distillation, Reactive distillation, Thermally coupled distillation, Dividing wall distillation, and Cryogenic distillation.	7
4.	**Membrane Separation:** Synthesis and characterization of membranes, Transport processes in membrane, Modeling of reverse osmosis (RO), Ultrafiltration (UF) and gas separation. Pervaporation through non-porous membranes, Dialysis and electro-dialysis and hybrid membrane processes.	7
5.	**Surfactant Based Separation Processes:** Concept, modeling, design aspects and applications of Supercritical Fluid Extraction and Bio-filtration.	6

8. Books:

(A) Text Books

S.No.	Authors / Name of Book / Publisher	Year of Publication
1	Seader, J.D., and Henley, E.J., Separation Process Principles, 4th Ed., John Wiley.	2016
2	Holland, C.D., Fundamentals of Multicomponent Distllation, McGraw-Hill.	1982

(B) Reference Books

S.No.	Authors / Name of Book / Publisher	Year of Publication
1	Sherwood, T.K., Pigford, R.L., and Wilkes, C.R., Mass Transfer, McGraw Hill.	1975

1. Subject Code: 22CHT 935 **Course Title: Polymer Process Modeling**

2. Contact Hours: L:3 T:0 P:0

3. Credits: 3 Semester: VIII

4. Pre-requisite: Nil.

5. Objective: To learn variety of polymer flow process and advanced transport mechanism.

6. Course Outcomes: Upon completion of this course, the students will be able to:

i. Understand the concept of advanced transport phenomena for the case of polymers

ii. Develop and solve complex mathematical model based on fluid mechanics, heat transfer and mass transfer.

iii. Develop the ability to create analytical solution of polymer processing flow problems based on Poiseuille flow and counter flow and calculation for extrusion, calendaring, coating, injection molding, and mixing etc.

iv. Develop the ability of applying shell elemental balances and learn by simplifying the offending complexity of partial differential equation.

v. Understand and incorporation of rheological study in the model.

7. Details of Course:

Unit No.	Contents	Contact Hours
1.	Classification of Polymer Processing Operations. Simple Model Flows: Poiseuille flow and couette flow for analyzing processing operations with examples.	8
2.	Flow down a Rectangular Channel and Application to analysis of wire coating and failure of this model	8
3.	**Extrusion and Extruders:** Newtonian Isothermal Analysis, variable channel depth, adiabatic analysis, optimal design, non-Newtonian isothermal analysis, non-Newtonian adiabatic analysis, Twin screw extruder, Banbury and other mixing equipment in polymer processing.	9
4.	**Calendering:** Newtonian model of calendaring, power law model, calendar fed with a finite sheet, thermoforming, rotational molding	8
5.	Roller and Blade Coating, Film Blowing. Fiber spinning injection molding, blow molding. Compression and transfer molding. Reaction injection molding.	7

8. Books:

(A) Text Books

S. No.	Authors / Name of Book / Publisher	Year of Publication
1	Middleman, S., "Fundamentals of Polymer Processing," McGraw-Hill Book Company, NY.	1977
2	Morrison, F.A., "Understanding Rheology," Oxford University Press.	2001

(B) Reference Books

S. No.	Authors / Name of Book / Publisher	Year of Publication
1	Tadmor, Z. and Gogos C.G., "Principles of Polymer Processing," Wiley- Interscience, New York.	1979