Shri Vile Parle Kelavani Mandal's

Dwarkadas J. Sanghvi College of Engineering

(Autonomous College Affiliated to the University of Mumbai)

Scheme and detailed syllabus (DJ19)

Third Year B.Tech

in

Chemical Engineering

(Semester V and VI)

Revision: 1 (2019)
With effect from the Academic Year: 2021-2022

1st July, 2021

Shri Vile Parle Kelavani Mandal's
DWARKADAS J. SANGHVI COLLEGE OF ENGINEERING
(Autonomous College Affiliated to the University of Mumbai)
NAAC Accredited with "A" Grade (CGPA : 3.18)

Scheme for Third Year Undergraduate Program B.Tech in Chemical Engineering : Semester V (Autonomous)
(Academic Year 2021-2022)

Semester V

Sr	Course Code	Course	Teaching Scheme				Semester End Examination (A)						Continuous Assessment (B)					Aggregate (A+B)	Credits earned	
			Theory (hrs.)	Practical (hrs.)	Tutorial (hrs.)	Credits	Duration (Hrs)	Theory	Oral	Pract	Oral & Pract	SEE Total (A)	Term Test 1 (TT1)	Term Test 2 (TT2)	Avg (TT1 & TT2)	Term Work Total	CA Total (B)			
1	DJ19CHC501	Chemical Reaction Engineering -I	3	--	--	3	3	75	--	--	--	75	25	25	25	--	25	100	3	4
	DJ19CHL501	Chemical Reaction Engineering -I Laboratory	--	2	--	1	2	--	25	--	_	25	--	--	--	25	25	50	1	
2	DJ19CHC502	Mass Transfer Operation -I	3	--	--	3	3	75	--	--	--	75	25	25	25	--	25	100	3	4
	DJ19CHL502	Mass Transfer Operation -I Laboratory	--	2	--	1	2	--	25	--	_	25	--	--	--	25	25	50	1	
3	DJ19CHC503	Heat Transfer Operation -I	3	--	--	3	3	75	--	--	--	75	25	25	25	--	25	100	3	4
	DJ19CHL503	Heat Transfer Operation -I Laboratory	--	2	--	1	2	--	25	--	_	25	--	--	--	25	25	50	1	
4	DJ19CHC504	Chemical Procees Safety and Utilities	3	--	--	3	3	75	--	--	--	75	25	25	25	--	25	100	3	4
	DJ19CHL504	Chemical Procees Safety and Utilities Laboratory	--	--	1	1	--	--	--	--	--	--	--	--	--	25	25	25	1	
4@	DJ19CHEC5011	Operation Research in Chemical Engineering	3	--	--	3	3	75	--	--	--	75	25	25	25	--	25	100	3	3
	DJ19CHEC5012	Biotechnology	3	--	--	3	3	75	--	--	--	75	25	25	25	--	25	100	3	
	DJ19CHEC5013	Sustainable Technologies	3	--	--	3	3	75	--	--	--	75	25	25	25	--	25	100	3	
	DJ19CHEC5014	Advanced Material Science	3	--	--	3	3	75	--	--	--	75	25	25	25	--	25	100	3	
6#	DJ19IHL2	Professional and Business Communication Laborato	--	4	--	2	--	--	--	--	--	--	--	--	--	50	50	50	2	2
7	DJ19ILL1	Innovative Product Development - III	--	2	--	1	--	--	25	--	--	25	--	--	--	25	25	50	1	1
		Total	**15**	**12**	**1**	**22**	**21**	**375**	**100**	**--**	**_**	**475**	**125**	**125**	**125**	**175**	**300**	**775**	**22**	

@ Any 1 elective course

2 hrs. of theory (class wise) and 2 hrs of activity based laboratory (batch wise)

Prepared by Checked by **Head of the Department** **Vice Principal** **Principal**

Shri Vile Parle Kelavani Mandal's
DWARKADAS J. SANGHVI COLLEGE OF ENGINEERING

Syllabus for Third Year Chemical Engineering - Semester V (Autonomous)
(Academic Year 2021-2022)

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Pre-requisite:

- DJ19CHC401 Engineering Mathematics - IV
- DJ19CHC304 Material and Energy Balance

Objectives:

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

Outcomes:

After completion of the course students will be able to:

- Identify and analyze different types of homogeneous reactions.
- Apply the knowledge they have gained to develop kinetic models for different types of Homogeneous reactions
- Find the model equation and use this model to design the reactors used for Homogeneous reactions.
- Understand the effect of temperature on reactor performance for adiabatic and non-adiabatic operation and develop kinetic model to design the reactors for adiabatic and non-isothermal operations.

Detailed Syllabus: (unit wise)		
Unit	**Description**	**Duration(Hrs)**
1	**Introduction to kinetics and Reaction Engineering**: Classification of reactions, definitions of reactions rate, variables affecting reaction rate, speed of Chemical reactions. Kinetics of homogenous reactions: Simple reactor types, the rate equation, concentration dependent term of rate equation. Molecularity and order of reaction. Rate constant k, representation of an elementary and nonelementary reaction Kinetic models for non-elementary reactions. Testing kinetic models. Temperature dependent term of rate equations from Arrhenius theory and comparison with collision and transition state theory. Activation energy and temperature dependency Predictability of reaction rate from theory.	**10**
2	**Methods of analysis of experimental data(Batch Reactor):** For constant volume and Variable Volume Batch Reactor- Integral Method of analysis of experimental data. Differential Method of analysis of experimental data. Concept of Half Life/Fractional Life. Overall order of irreversible reaction Analysis of total pressure data. Reversible and irreversible reaction, reactions in parallel and in series. Homogeneous catalyzed reactions, Auto catalytic reactions, Shifting Order reactions	**10**
3	**Design of Reactors:** Ideal batch reactor and concept of batch time. Flow reactor and concept of space time / space velocity and holding time/residence time. Ideal Mixed Flow reactor (MFR) and Plug Flow Reactor (PFR). Design for single reactions: Single reactor performance of reversible and irreversible first order, pseudo first order, second order reactions for MFR, PFR. Analytical techniques Combination of reactors: PFR in series/ parallel, unequal size MFR in series, performance of the above for the first order and second order reactions. Semi batch reactor and Recycle Reactor. Design for complex reactions: Irreversible reactions in series and parallel with same or different order in various combinations.	**14**
4	**Temperature and pressure effects:** Single Reactions: Calculations of heats of reaction and equilibrium constants from thermodynamics, equilibrium conversion, general graphical design procedure. Optimum temperature progression, Energy balances equations in adiabatic and non-adiabatic case. Exothermic reaction in mixed flow	**08**

Books Recommended:

Textbooks:

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

Reference Books:

1. Hill C.G., Chemical Reaction Engineering.
2. Walas, Reaction Kinetics for Chemical Engineers, McGraw Hill, 1959.

Evaluation Scheme:

Semester End Examination (A):

Theory:

1. Question paper based on the entire syllabus summing up to 75 marks.
2. Total duration allotted for writing the paper is 3 hrs.

Oral Examination:

1. A student becomes eligible for oral examination after completing a minimum of five experiments and minimum of five tutorials, out of the list given.
2. Oral examination: 25Marks.

Continuous Assessment (B):

Theory:

1. Two term tests of 25 marks each will be conducted during the semester.
2. Total duration allotted for writing each of the paper is 1 hr.
3. Average of the marks scored in the two tests will be considered for final grading.

Laboratory and Tutorial: (Term work)

1. Term work shall consist of minimum five practical and minimum five tutorials from entire syllabus, which are to be given at regular intervals. Total Marks: 25
2. List of Experiments and Tutorials suggested: -

Experiment No,	Title
1	To determine the specific reaction rate of hydrolysis of methyl acetate in the presence of **HCl as catalyst**.
2	To determine the specific reaction rate of hydrolysis of methyl acetate in the presence of **H_2SO_4 as catalyst**.
3	To determine the specific reaction rate of saponification reaction between sodium hydroxide and ethyl acetate.
4	Study of second order reaction with equal initial concentration of KI and $K_2S_2O_8$ **using integral method of analysis**
5	Study of second order reaction with equal initial concentration of KI and $K_2S_2O_8$ **using differential method of analysis**
6	To determine the order of reaction **with respect to hydrogen peroxide** in the reaction between hydrogen peroxide and hydrogen iodide.
7	To determine the order of reaction **with respect to hydrogen iodide** in the reaction between hydrogen peroxide and hydrogen iodide.
8	To find out the conversion theoretically and graphically using the performance equation of given size **MFR** for second order reaction between sodium hydroxide and ethyl acetate.
9	To find out the conversion theoretically and graphically using the performance equation of given size **PFR** for second order reaction between sodium hydroxide and ethyl acetate.
10	To find out the activation energy of the hydrolysis of methyl acetate in the presence of **HCl as catalyst**.

11	To find out the activation energy of the hydrolysis of methyl acetate.

Tutorial No	Topic
1	Introduction to kinetics and reaction engg
2	Introduction to kinetics and reaction engg
3	Analysis of batch reactor data
4	Analysis of batch reactor data
5	Analysis of batch reactor data
6	Design of Reactor
7	Design of Reactor
8	Design of Reactor
9	Temperature and Pressure effect
10	Temperature and Pressure effect

The final certification and acceptance of term work will be subject to satisfactory performance of laboratory work and upon fulfilling minimum passing criteria in the term work.

Prepared by Checked by Head of the Department Principal

Syllabus for Third Year Chemical Engineering - Semester V (Autonomous)
(Academic Year 2020-2021)

Program: Third Year Chemical Engineering	**Semester: V**
Course: Mass Transfer Operations-I	**Course Code:DJ19CHC502**
Course: Mass Transfer Operations-I Laboratory	**Course Code:DJ19CHL502**

Teaching Scheme (Hours / week)				**Evaluation Scheme**						
				Semester End Examination Marks (A)			**Continuous Assessment Marks (B)**			**Total marks (A+ B)**
Lectures	**Practical**	**Tutorial**	**Total Credits**	**Theory**			**Term Test 1**	**Term Test 2**	**Avg.**	
				75			**25**	**25**	**25**	**100**
				Laboratory Examination			**Term work**		**Total Term work**	**50**
3	**2**	**-**	**4**	**Oral**	**Practical**	**Oral & Practical**	**Laboratory Work and Journal**	**Tutorial**		
				25	**--**	**-**	**10**	**15**	**25**	

Prerequisites:

- DJ19 FEC 203 Engineering Chemistry
- DJ19 FEC 202 Engineering Physics
- DJ19CHC401 Engineering Mathematics - IV

Course Objectives:

- Mass transfer basic principles
- Mass transfer mechanisms

Course Outcomes:

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

Module	**Contents**	**Contact Hours**
1	**Molecular Diffusion in Gases and Liquid:** Basics of Molecular Diffusion, Fick's First Law of Molecular Diffusion, Various fluxes and relations between them, Molecular Diffusion in binary gas mixtures- Steady state diffusion of one component in non-diffusing second component, Equimolar counter diffusion of two components. Molecular Diffusion in binary liquid solutions- Steady state diffusion of one component in non- diffusing second component, Steady State Equimolar counter diffusion of two components. Diffusivity of gases. Theoretical and	10

	experimental determination of diffusivities, Diffusivities of liquids - Theoretical Determination. Diffusion in Solids: Fick's law of diffusion in solids, Types of Solid Diffusion, Diffusion through Polymers, Diffusion through Crystalline Solids, Diffusion in Porous Solids	
2	**Mass Transfer Coefficients:** Definition of Mass Transfer Coefficient, F-Type and K-Type Mass Transfer Coefficients and relations between them, Mass Transfer Coefficients in Laminar and Turbulent Flow. Heat, Mass and Momentum Transfer Analogies and dimensionless numbers, Interphase Mass Transfer-Individual and Overall Mass Transfer Coefficients and relation between them. Methods of contacting two insoluble phases- Continuous Contact, Stage-wise Contact. Cocurrent, counter current and cross current operations, Equilibrium stage definition and concepts, equilibrium stage operations: material balance, concepts of operating line and equilibrium line, theoretical stage, point and stage efficiency, overall efficiency. Continuous contacting, concepts of HTU, NTU, HETP etc.	12
3	**Equipment for Gas-Liquid Contacting:** Classification of equipment for gas-liquid contacting, Gas dispersed and liquid continuous phase-Sparged Vessels (Bubble Columns), Mechanically Agitated Vessels, Tray Towers, Liquid dispersed phase and gas continuous phase - Venturi scrubbers, Wetted Wall Towers, Spray Towers and Spray Chambers, Packed Towers. Comparison of Packed Towers with Tray Towers.	05
4	**Gas Absorption:** Solubility of gases in liquids, Effect of temperature and pressure on solubility, Ideal and Non-ideal solutions, Choice of solvent for gas absorption, Single component gas absorption- Cross Current, Co-current, Countercurrent, Multistage Counter current Operation. Absorption with Chemical Reactions.	05
5	**Drying:** Introduction to drying, Equilibrium, Different types of moisture contents, Rate of Drying and drying curve, Batch Drying and calculation of time of drying, Continuous drying, Equipment for drying.	05

6	**Humidification and Dehumidification:** Introduction, Vapor Pressure Curve, Properties of Vapor-Gas mixtures [Understanding various terms], Theory of wet bulb temperature, Adiabatic Saturation Curves, Humidity Charts, Adiabatic operation: (Air water systems) water coolers	05

Books Recommended:

Textbooks:

1. Treybal R.E., Mass transfer operation, 3 Ed., McGraw Hill New York, 1980.
2. McCabe W.L. and Smith J.C., Unit operation in chemical engineering, 5 Ed., McGraw Hill, NewYork,1993.
3. Geankoplis C.J., Transport processes and unit operations, Prentice Hall, New Delhi 1997.

Reference Books:

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

Evaluation Scheme:

Semester End Examination (A):

Theory:

1. Question paper based on the entire syllabus summing up to 75 marks.
2. Total duration allotted for writing the paper is 3 hrs.

Oral Examination:

1. A student becomes eligible for oral examination after completing a minimum of five experiments and minimum of five tutorials, out of the list given.
2. Oral examination: 25Marks.

Continuous Assessment (B):

Theory:

1. Two term tests of 25 marks each will be conducted during the semester.
2. Total duration allotted for writing each of the paper is 1 hr.
3. Average of the marks scored in the two tests will be considered for final grading.

Laboratory and Tutorial: (Term work)

1. Term work shall consist of minimum five practical and minimum five tutorials from entire syllabus which are to be given at regular intervals. Total Marks: 25
2. List of Experiments and Tutorials suggested: -

List of Experiments suggested: -

1	Diffusivity of given liquid sample
2	Diffusion through porous solids
3	Mass Transfer Coefficient in a packed extraction column
4	Mass Transfer Coefficient in a spray extraction column
5	Mass transfer coefficient in flow process system

6	Mass transfer co-efficient in gas liquid system by evaporation
7	Efficiency of cooling and tower study of Humidification and water-cooling operations.
8	Absorption in packed tower
9	Batch drying and plot drying curve
10	Determination of mass transfer coefficient/diffusivity/ number of transfer units, HTU, HETP are envisaged.
11	Fluidized bed drier and analyze drying curve

List of Tutorials suggested: -

Tutorial No 1	Liquid Diffusion
Tutorial No 2	Gaseous Diffusion
Tutorial No 3	Mass Transfer Coefficient
Tutorial No 4	Mass Transfer Coefficient
Tutorial No 5	Drying
Tutorial No 6	Drying
Tutorial No 7	Gas absorption
Tutorial No 8	Gas absorption
Tutorial No 9	Humidification
Tutorial No 10	Humidification

The final certification and acceptance of term work will be subject to satisfactory performance of laboratory work and upon fulfilling minimum passing criteria in the term work.

Prepared by Checked by Head of the Department Principal

Syllabus for Third Year Chemical Engineering - Semester V (Autonomous)
(Academic Year 2021-2022)

Program: Third Year Chemical Engineering	**Semester: V**
Course: Heat Transfer Operations	**Course Code:DJ19CHC503**
Course: Heat Transfer Operations Laboratory	**Course Code:DJ19CHL503**

Teaching Scheme (Hours / week)				**Evaluation Scheme**						
				Semester End Examination Marks (A)			**Continuous Assessment Marks (B)**			**Total marks (A+ B)**
Lectures	**Practical**	**Tutorial**	**Total Credits**	**Theory**			**Term Test 1**	**Term Test 2**	**Avg.**	
				75			**25**	**25**	**25**	**100**
				Laboratory Examination			**Term work**		**Total Term work**	**50**
3	**2**	**-**	**4**	**Oral**	**Practical**	**Oral & Practical**	**Laboratory Work and Journal**	**Tutorial**		
				25	**--**	**-**	**10**	**15**	**25**	

Pre-requisite:

- DJ19CHC303 Chemical Engineering Thermodynamics
- DJ19CHC304 Material and Energy Balance
- DJ19CHC305 Fluid Flow
- DJ19CHC401 Engineering Mathematics - IV

Objectives:

- Basic concepts of Heat Transfer.
- Design and rating of heat Exchangers with and without phase change.

Outcomes:

After completion of the course students will be able to:

- Analyze steady state conduction, unsteady state heat transfer from solids.
- Analyze heat transfer by Convection, Radiation, Boiling and Condensation.
- Design Heat Transfer Equipment such as DPHE, STHE.
- Understand Design aspects of Condensers, Evaporators, Agitated Vessels.

Detailed Syllabus: (unit wise)		
Unit	**Description**	**Duration(Hrs)**
1	**Heat Transfer Fundamentals:** Modes of Heat Transfer, Concept of driving force and heat transfer coefficients, rate expressions for three modes i. e. conduction, convection, radiation.	**2**

2	**Conductive Heat Transfer:** Fourier's Law, Thermal conductivity, Thermal Diffusivity, Shell balance, One dimensional heat conduction in single and composite flat slab, cylinder wall, spherical wall, Critical radius of insulation. Unsteady state heat conduction, Biot Number, Fourier Number, Lumped parameter analysis, systems with negligible internal resistance, heating a body under conditions of negligible surface resistance. Heat transfer from extended surfaces, Efficiency, and Effectiveness of various types of fins.	**10**
3	**Convective Heat Transfer:** Natural and forced convection: Dimensional analysis, Thermal boundary layer, Prandtl Number, Nusselt Number, Correlations, Analogy	**9**
4	**Basics of Heat Transfer with Phase Change:** Introduction to boiling, regimes of boiling, Correlations, Introduction to condensation, Nusselt's Theory, Correlations.	**6**
5	**Radiative Heat Transfer:** Introduction, Stephan Boltzmann Law, Kirchhoff's Law, Plank's Law, Wein's Displacement Law, Rate of heat transfer by radiation, Radiation heat exchanged between surfaces.	**5**
6	**Design of Heat Transfer Equipment:** Double pipe heat exchanger (DPHE), Concept of LMTD, DPHE sizing, Construction aspects in brief for shell and tube heat exchanger (STHE), Kern's method for design of STHE, effectiveness NTU, method, TEMA standards.	**6**
7	**Heat Exchange Equipment: Construction and** Design considerations of Condensers, Evaporators. Heat transfer to Agitated tanks.	**4**

Books Recommended:

Textbooks:

1. Binay K. Datta, Heat Transfer: Principles and applications, Prentice Hall of India, 2007
2. W. L. McCabe, J. C. Smith and P. Harriot, Unit Operations of Chemical Engineering, McGraw-Hill International, 7thEdition, 2005.
3. R. Welty, C. E. Wicks, R. E.Wilson and G. Rorrer, Fundamentals of Momentum, Heat and Mass Transfer,4th Edition, Wiley India, 2007.
4. D. Q. Kern, Process Heat Transfer, McGraw hill, 1997.

Reference Books:

1. Holman J. P., S Bhattacharya, Heat Transfer, 10th Edition, McGraw Hill, 2011.
2. J. M. Coulson, J. F. Richardsons & R. K. Sinnot, Chemical Engineering Design, Vol 1 & 6, Elsevier Science & Technology Books, 1996.
3. Yunus A Cengel and Afshin J Ghajar, Heat and Mass Transfer: Fundamentals and Applications (Sie), McGrow Hill 5th Edition, 2015.

Evaluation Scheme:

Semester End Examination (A)*:*

Theory:

1. Question paper based on the entire syllabus summing up to 75 marks.
2. Total duration allotted for writing the paper is 3 hrs.

Oral Examination:

1. A student becomes eligible for oral examination after completing a minimum of five experiments and minimum of five tutorials, out of the list given.

2. Oral examination: 25Marks.

Continuous Assessment (B):

Theory:

1. Two term tests of 25 marks each will be conducted during the semester.
2. Total duration allotted for writing each of the paper is 1 hr.
3. Average of the marks scored in the two tests will be considered for final grading.

Laboratory and Tutorial: (Term work)

1. Term work shall consist of minimum five practical and minimum five tutorials from entire syllabus, which are to be given at regular intervals. Total Marks: 25
2. List of Experiments and Tutorials suggested: -

Experiment No	Title
1	Thermal Conductivity of Metal Rod
2	Heat Transfer trough composite wall
3	Newtonian Heating and Cooling
4	Heat Transfer by Natural Convection
5	Heat Transfer by Forced Convection
6	Heat Transfer in Condensation
7	Heat Transfer from Extended Surfaces
8	Stephen Boltzmann Constant
9	Double Pipe Heat Exchanger
10	Shell and Tube Heat Transfer

Tutorial No	Topic
1	Modes of Heat Transfer
2	Steady State Conduction
3	Unsteady State Conduction
4	Heat transfer by Forced Convection
5	Heat Transfer by Natural Convection
6	Heat Transfer in Boiling and Condensation
7	Heat Transfer from Extended Surfaces
8	Heat Transfer by Radiation
9	Double Pipe Heat Exchanger
10	Shell and Tube Heat Exchanger

The final certification and acceptance of term work will be subject to satisfactory performance of laboratory work and upon fulfilling minimum passing criteria in the term work.

Prepared by Checked by Head of the Department Principal

Syllabus for Third Year Chemical Engineering - Semester V (Autonomous)
(Academic Year 2021-2022)

Program: Third Year Chemical Engineering	**Semester : VI**
Course : Chemical Process Safety and Utilities	**Course Code:DJ19CHEC504**
Course : Chemical Process Safety and Utilities	**Course Code:DJ19CHEC504**

Teaching Scheme (Hours / week)				**Evaluation Scheme**						
				Semester End Examination Marks (A)			**Continuous Assessment Marks (B)**			**Total marks (A+ B)**
Lectures	**Practical**	**Tutorial**	**Total Credits**	**Theory**			**Term Test 1**	**Term Test 2**	**Avg.**	
				75			**25**	**25**	**25**	**100**
				Laboratory Examination			**Term work**		**Total Term work**	**25**
3	**-**	**1**	**4**	**Oral**	**Practical**	**Oral & Practical**	**Laboratory Work**	**Tutorial / Mini project / presentation/ Journal**		
				--	--	--		**25**	--	

Pre-requisite:

- DJ19CHC304 Material and Energy Balance
- DJ19CHC305 Fluid Flow

Objectives:

- To understand the theoretical and applied concepts of Chemical Plant Process Safety

Outcomes:

After completion of the course students will be able to:

- Know the safety hazards in a process industry
- Design ventilation systems for process area
- Analyze HAZOP of any node in a piping and instrumentation diagram
- To know the utilities in Chemical Plants

Module	**Contents**	**Contact Hours**
1	Industrial Accidents: Causative and initiating factors of accidents. Identifying the causative and initiating factors of Industrial accidents, Case studies.	**3**
	Industrial Hygiene. Definition and evaluation of toxicity and noise	**5**
	Ventilation. Local Ventilation, Dilution Ventilation. Problems on Ventilation airflow.	**1**

2	Fire. Fire triangle, Flammability characteristics of liquids and gases, Limiting oxygen concentration, ignition energy, auto ignition, auto Oxidation, adiabatic compression. Ignition sources, spray and mist. A study of fire fighting equipments.	**2**
	Explosion: Detonation, Deflagration, Confined explosion, unconfined explosion, VCE, BLEVE, Problems on energy of chemical explosion.	**5**
	Types of relief systems, Bunds	**2**
	HAZOP, How to do a HAZOP. HAZOP Checklist.	**2**
	Risk assessment: Event tree analysis, Fault tree analysis.	**2**
3	Steam generators: Properties of steam, Use of steam tables, Steam generators, Classification of boilers, Study of high pressure boilers, boiler mountings and accessories. Performance of steam generators. Distribution of steam in plant; Efficient use of steam, steam traps. Hot Oil Systems	**8**
4	Air: Reciprocating compressors, work calculations, PV Diagrams, Two stage compression system with intercooler, problems of work and volumetric efficiency. Instrument Air System, Process Air System, Vacuum producing devices	**6**

Books Recommended:

Textbooks:

1. Crowl, Daniel A. and Louvar, Joseph F.; Chemical Process Safety, Fundamentals with Applications; Pearson; Third Edition.

Reference Books:

1. Kletz, Trever; What Went Wrong, 5th Edition, Butterworth-Heinemann, 2009.

Evaluation Scheme:

Semester End Examination (A):

Theory:

1. Question paper based on the entire syllabus summing up to 75 marks.
2. Total duration allotted for writing the paper is 3 hrs.

Continuous Assessment (B):

Theory:

1. Two term tests of 25 marks each will be conducted during the semester.
2. Total duration allotted for writing each of the paper is 1 hr.
3. Average of the marks scored in both the two tests will be considered for final grading.

Prepared by Checked by Head of the Department Principal

Syllabus for Third Year Chemical Engineering - Semester V (Autonomous)
(Academic Year 2021-2022)

Program: Third Year Chemical Engineering										**Semester: V**
Department Elective: Operations Research in Chemical Engineering										**Course Code:** DJ19CHEC5011
Teaching Scheme (Hours / week)				**Evaluation Scheme**						
				Semester End Examination Marks (A)			**Continuous Assessment Marks (B)**			**Total marks (A+ B)**
Lectures	**Practical**	**Tutorial**	**Total Credits**	**Theory**			**Term Test 1**	**Term Test 2**	**Avg.**	
				75			**25**	**25**	**25**	**100**
				Laboratory Examination			**Term work**		**Total Term work**	**--**
3	**--**	**--**	**3**	**Oral**	**Practical**	**Oral & Practical**	**Laboratory Work**	**Tutorial / Mini project / presentation/ Journal**		
				--	**--**	**--**	**--**	**--**	**--**	

Pre-requisite:

- DJ19FEC101 Engineering Mathematics-I
- DJ19FEC 205Computer Programming

Objectives:

- To understand Linear Programming and its applications to OR models.
- To understand and solve network models in OR.
- To understand Game theory and its applications.
- To understand and solve Scheduling Problems as Queuing systems

Outcomes:

- Solve typical OR models using linear integer and dynamic programming techniques.
- Model and solve network ow problems in OR.
- Make decisions under various scenarios.
- Design Queuing Systems.

Module	**Contents**	**Hrs.**
1	Linear Programming: Introduction, Graphical Method of Solution, Simplex, Two-Phase Method, Duality, Revised Simplex, Sensitivity Analysis	8
2	Transportation Models: Examples of Transportation Models, The Transportation Algorithm, The Assignment Model	4
3	Network Models: Scope and Definition of Network Models, Minimal Spanning Tree Algorithm, Shortest Route Problem, CPM and PERT	6
4	Integer and Dynamic Programming: Branch and Bound Method, Travelling Salesman Problem, Introduction to Dynamic Programming, Forward and Backward Recursion, Selected Applications	6
5	Deterministic Inventory Models: Classic EOQ Model, EOQ with Price Breaks, Multi-item EOQ with	5

	Storage Limitation, Dynamic EOQ Models, No-Setup Model, Setup Model	
6	Decision Analysis and Game Theory: Decision Making under Certainty, Decision Making under Risk Decision Under Uncertainty, Game Theory	5
7	Queuing Systems: Elements of a Queuing Model, Role of Exponential Distribution, Pure Birth and Death Models, Generalized Poisson Queuing Model, Measures of Performance	6
8	Supply Chain Management in the Process Industry	2

Books Recommended:

Textbooks:

1. Hamdy A. Taha, Operations Research, 8 Ed., Prentice Hall India.
2. Thomas Edgar, Optimization of Chemical Processes, David M. Himmelbleau,2 Ed., John Wiley.

Evaluation Scheme:

Semester End Examination (A)*:*

Theory:

1. Question paper based on the entire syllabus summing up to 75 marks.
2. Total duration allotted for writing the paper is 3 hrs

Continuous Assessment (B):

Theory:

1. Two term tests of 25 marks each will be conducted during the semester.
2. Total duration allotted for writing each of the paper is 1 hr.
3. Average of the marks scored in both the two tests will be considered for final grading.

Prepared by Checked by Head of the Department Principal

Syllabus for Third Year Chemical Engineering - Semester V (Autonomous)
(Academic Year 2021-2022)

<table>
<tr><td colspan="8">Program: Third Year Chemical Engineering</td><td colspan="3">Semester : VI</td></tr>
<tr><td colspan="8">Department Elective : Biotechnology</td><td colspan="3">Course Code:DJ19CHEC6011</td></tr>
<tr><td colspan="4" rowspan="2">Teaching Scheme (Hours / week)</td><td colspan="7">Evaluation Scheme</td></tr>
<tr><td colspan="4">Semester End Examination Marks (A)</td><td colspan="3">Continuous Assessment Marks (B)</td><td rowspan="2">Total marks (A+ B)</td></tr>
<tr><td rowspan="3">Lectures</td><td rowspan="3">Practical</td><td rowspan="3">Tutorial</td><td rowspan="3">Total Credits</td><td colspan="4">Theory</td><td>Term Test 1</td><td>Term Test 2</td><td>Avg.</td></tr>
<tr><td colspan="4">75</td><td>25</td><td>25</td><td>25</td><td>100</td></tr>
<tr><td colspan="4">Laboratory Examination</td><td colspan="3">Term work</td><td rowspan="2">Total Term work</td><td rowspan="2">-</td></tr>
<tr><td>3</td><td>-</td><td>-</td><td>3</td><td>Oral</td><td>Practical</td><td>Oral & Practical</td><td>Laboratory Work</td><td>Tutorial / Mini project / presentation/ Journal</td></tr>
<tr><td></td><td></td><td></td><td></td><td>--</td><td>--</td><td>-</td><td>--</td><td>-</td><td>-</td><td></td></tr>
</table>

Pre-requisite:

- DJ19FEC103 & DJ19 FEC203 Engineering Chemistry - I and II
- DJ19CHC302 & DJ19 CHC402 Advanced Chemistry - I and II
- DJ19CHC304 Material and Energy Balance Calculations.

Objectives:

- Basic concept of biotechnology. Micro-organisms, cell structure and basic metabolism.
- Genetic Engineering
- Enzyme technology
- Bioreactor Design Concepts and Recovery of biological products.
- Applications of Biotechnology in various sectors.

Outcomes:

After completion of the course students will be able to:

- Understand cell and metabolism.
- Understand the concept of genetic engineering.
- Understand Enzymes in detail and their kinetics.
- Understand the design of bio reactors
- Understand applications of biotechnology in medical/pharmaceutical field, in agricultural, food and beverage industry, chemical industries, environment, and energy sectors.

Detailed Syllabus: (unit wise)

Unit	Description	Duration(Hrs)
1	**Introduction:** Traditional biotechnology **Microbial Cell Technology:** Classification of micro-organisms. Types of cells, Structure of cells, Basic metabolism of cells. Growth media, Lipids, Proteins, Amino acids, Nucleic acids, Carbohydrates, Macronutrients, and micronutrients and role of nutrients in cell growth Microbial cell growth kinetics, Immobilization of Cells and their kinetics. Kinetics of metabolic product synthesis by cells	**10**
2	**Genetic Engineering:** Genetic engineering- DNA as a genetic material, concept of genetic code gene therapy, Industrial genetics, Recombinant DNA technology, central dogma of information exchange. Protein engineering- Transcription, Translation & Protein synthesis	**7**
3	**Enzyme Technology:** Nomenclature and classification of enzymes. Structure of Enzymes, Enzyme kinetics. Michaels Menten Kinetics, Lock &key model, Induced fit model. Immobilization of enzymes, Immobilized enzyme kinetics. Kinetics with single substrate, Kinetics with inhibitors, Kinetics with multiple substrates	**10**
4	**Bioreactors:** Background of bioreactors, Type of bioreactors [like Airlift bioreactors, Airlift pressure cycle bioreactors, Loop bioreactor, Stirred tank bioreactors, Fluidized bed bioreactors, Trickle bed bioreactor, Bubble column fermenter] Design equations for CSTR fermenter, Two stage reactors, Reactors with non-ideal mixing, Parametric sensitivity, Multiplicity in Bio systems, Global and local stability analyses of Bioreactors Bioreactor controlling probes, Characteristics of bioreactor sensors, Temperature measurement and control, DO measurement and control, pH/redox measurement and control, Detection and prevention of the foam **Down Stream Processing:** Relevant mass transfer operations for product recovery	**10**
5	**Applications of biotechnology** **Application in health care:** Pharmaceuticals and biopharmaceuticals, antibiotics, vaccines and monoclonal antibodies, protoplast and cell fusion technologies. **Application in Biotechnology** in agriculture, food and beverage industries, chemical industries, environment, and energy sectors.	**5**

Books Recommended:

Reference Books:

1. Shuller M.L. and F. Kargi, Bioprocess Engineering, Prentice-Hall, Englewood Cliffs, NJ 1992.
2. Bailey. J.E. and Ollis D.F., Biochemical Engineering Fundamentals, 2nd Edition, McGraw Hill, New York, 1986.
3. Colin Ratledge, Basic Biotechnology, University of Hull, Bjorn Kristiansen, EU Biotech consulting, Norway, 3rd Edition, Date of publication May 2006
4. Kumar H.D., Modern Concepts of Biotechnology, Vikas Publishing House Pvt. Ltd.
5. Gupta P.K., Elements of Biotechnology, Rastogi Publications
6. Inamdar, Biochemical Engineering, Prentice Hall of India.

Evaluation Scheme:

Semester End Examination (A)*:*

Theory:

1. Question paper based on the entire syllabus summing up to 75 marks.
2. Total duration allotted for writing the paper is 3 hrs.

Continuous Assessment (B):

Theory:

1. Two term tests of 25 marks each will be conducted during the semester.
2. Total duration allotted for writing each of the paper is 1 hr.
3. Average of the marks scored in both the two tests will be considered for final grading.

-

Prepared by Checked by Head of the Department Principal

Syllabus for Third Year Chemical Engineering - Semester V (Autonomous)
(Academic Year 2021-2022)

<table>
<tr><td colspan="8">Program: Third Year Chemical Engineering</td><td colspan="4">Semester: V</td></tr>
<tr><td colspan="8">Department Elective: Sustainable Technologies</td><td colspan="4">Course Code: DJ19CHEC5013</td></tr>
<tr><td colspan="4" rowspan="2">Teaching Scheme (Hours / week)</td><td colspan="8">Evaluation Scheme</td></tr>
<tr><td colspan="4">Semester End Examination Marks (A)</td><td colspan="3">Continuous Assessment Marks (B)</td><td rowspan="2">Total marks (A+ B)</td></tr>
<tr><td rowspan="3">Lectures</td><td rowspan="3">Practical</td><td rowspan="3">Tutorial</td><td rowspan="3">Total Credits</td><td colspan="4">Theory</td><td>Term Test 1</td><td>Term Test 2</td><td>Avg.</td></tr>
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</table>

Pre-requisite:

- Interest in Environment and its impact on Human.
- Interest in green economy

Objectives:

- To study concepts of Sustainability, Environment and Social Dimensions of Sustainability.
- To impart knowledge of types and sources of solid and hazardous wastes and methods of recycling.
- To study materials for sustainability and integrating sustainability principles.
- To understand concept of zero waste.
- To understand environment friendly choices in manufacturing and operations.

Outcomes:

After completion of the course students will be able to:

- Understand the economic, technical, and societal issues involved in sustainable manufacturing.
- Understand the various technology options that can make a difference.
- To apply environment friendly choices of materials and processes' selection.
- To develop design for environment.

Detailed Syllabus: (unit wise)

Syllabus for Third Year Chemical Engineering - Semester V (Autonomous)
(Academic Year 2021-2022)

Unit	Description	Duration
1	**Sustainability**: Concepts related to Sustainability, Environmental, Economic and Social Dimensions of Sustainability, Nexus between Technology and Sustainable Development, Challenges for Sustainable Development, The global sustainability agenda, Environmental agreements and protocols, Clean Development Mechanisms (CDMs), Concept of Carbon credit, Green Building, Green chemistry and Circular economy concepts, Green catalysts.	8
2	**Green Economy**: Ways of making economy green, Ceres Principles: Greening the Corporation, Corporate Social responsibility and Corporate Environment responsibility, What can India do to promote green economy.	6
3	**Zero waste concept:** Types and sources hazardous wastes. Nature and hazard of pollutants, Waste processing /segregation, Need for waste management, Recycling Technology: Solid and hazardous waste management and treatment methods, Green processing and engineering operations, Design for recycling methods to infuse sustainability in early design phases, Life cycle analysis	8
4	**Environment friendly choices in manufacturing and operations**: Innovations for reuse, bio processing technology, Alternative product and process changes, Manufacturing practices, Sustainable Materials, Sustainable cities, Adoption of low carbon technologies - need to reduce the carbon footprint of manufacturing operations , Industrial case studies.	8
5	**Energy Sources:** Basic concepts: Conventional and Non-conventional, Renewable Energy Harvesting, Fuel cells, Biofuels, Carbon neutral fuels.	6
6	**Sustainability Assessment:** Corporate Social Responsibility, Continuous sustainability awareness programmers. Sustainability Rating Schemes, Environmental Impact Assessment (EIA), Procedures of EIA in India.	6

Books Recommended:

Textbooks:

1. "Sustainability Engineering: Concepts, Design and Case Studies, D.T. Allen, D.R. Shonnard, Prentice Hall.
2. "Engineering Applications in sustainable design and development", A.S. Bradley, A.O. Abhdeo, P. Misra
3. "Environment Impact Assessment Guidelines", Notifications of Government of India, 2006
4. "Basic concepts in Environmentsl Management", Lewis Publications, London, 1998
5. "Environmental Studies From Crisis to Cure", R. Rajagopalan, 2012
6. "Sustainable Development", M. K. Ghosh Roy; Ane Books Pvt. Ltd.
7. "Green Management", M. Karpagam, Geetha Jaikumar; Ane Books Pvt. Ltd.
8. "Essential Environmental Studies", S. P. Misra, S.N. Pandey, Sheth Publishers.

9. "Environmental Pollution Control Engineering", C.S.Rao

Reference Books:

1. "Design for Environment: A Guide to Sustainable Product Development", Joseph Fiksel, McGraw-Hill Companies.
2. "A Handbook of Environmental Management", Jon C. Lovett and David G. Ockwell, 2010
3. "Introduction to ENVIRONMENTAL MANAGEMENT" Mary K. Theodore Louis Theodore, 2013

Evaluation Scheme:
Semester End Examination (A)*:*

Theory:

1. Question paper based on the entire syllabus summing up to 75 marks.
2. Total duration allotted for writing the paper is 3 hrs.

Continuous Assessment (B):
Theory:

1. Two term tests of 25 marks each will be conducted during the semester.
2. Total duration allotted for writing each of the paper is 1 hr.
3. Average of the marks scored in both the two tests will be considered for final grading.

Prepared by Checked by Head of the Department Principal

Syllabus for Third Year Chemical Engineering - Semester V (Autonomous)
(Academic Year 2021-2022)

<table>
<tr><td colspan="8">Program: Third Year Chemical Engineering</td><td colspan="3">Semester : V</td></tr>
<tr><td colspan="8">Department Elective - Advanced Material Science</td><td colspan="3">Course Code: DJ19CHEC5014</td></tr>
<tr><td colspan="4" rowspan="2">Teaching Scheme (Hours / week)</td><td colspan="7">Evaluation Scheme</td></tr>
<tr><td colspan="4">Semester End Examination Marks (A)</td><td colspan="3">Continuous Assessment Marks (B)</td><td rowspan="2">Total marks (A+ B)</td></tr>
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</table>

Pre-requisite:

- DJ19CHC401 Engineering Chemistry-II
- DJ19FEC102 &DJ19 FEC202 Engineering Physics I and II

Objectives:

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

Outcomes:

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

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

Detailed Syllabus: (unit wise)		
Unit	**Description**	**Duration(Hrs)**
1	**Advanced Metallic Materials:** Stainless Steels: Types, properties of stainless steels, corrosion resistance and selection of stainless steels, failure of stainless steels. High Temperature Alloys: Properties and types. Titanium Alloys and Cobalt-Chromium Alloys: Composition, properties and applications. Nitinol as Shape Memory Alloy and its applications.	**06**
2	**Advanced Polymeric Materials:** Structure, preparation, and application of various conducting polymers, high temperature polymers and liquid crystal polymers. Biomedical applications of polymers such as hydrogels, polyethylene, polyurethanes, polyamides and silicone rubber.	**06**
3	**Ceramic Materials:** Properties of ceramic materials, classification of ceramic materials, ceramic crystal structures. Behaviour of ceramic materials: dielectric, semiconductor, ferroelectric, magnetic, and mechanical behaviour. Preparation and application of ceramic materials: Alumina, Partially Stabilized Zirconia, Sialon, Silicon Nitride, Silicon Carbide. Processing of Ceramics.	**07**
4	**Composite Materials:** Necessity of composite materials, classification of composite materials, types of matrix materials and reinforcements, reinforcement mechanism, choosing material for matrix and reinforcement. **Fiber Reinforced Plastic Processing:** Open Moulding Processes : Filament Winding Process, Closed Moulding Processes : Pultrusion and Pulforming, Sheet, Moulding Compound Process **Carbon-Carbon Composites :** Fabrication and Properties	**08**
5	**Metal Composites:** Advantage of metal composite over metal, types of reinforcement and matrix fabrication types, various fabrication processes: diffusion bonding process, in-situ process , mechanical behaviour and properties **Ceramic Composites:** Matrices and reinforcements, mechanical properties, fabrication methods Slurry infiltration processes, chemical vapour infiltration process	**08**
6	**Carbon Nanotubes: :** Synthesis, properties and applications. **Nanoshells:** Types, properties and applications **Nanosensors:** Assembly methods, nanosensors based on optical quantum size, electrochemical and physical properties material for appearance, corrosion and wear.**Thin Film Coatings:** Physical and chemical vapour deposition coatings, hard facing, thermal spraying, diffusion process, useful	**07**

Books Recommended:

Textbooks:

1. B.K. Agrawal, Introduction to Engineering Materials, Tata McGraw Hill Education Pvt. Ltd., 2012.

2. A.K. Bhargava, Engineering Material: Polymers, Ceramics and Composites, PHI Learning Pvt. Ltd., Second Edition 2012.

3. Dr. H.K. Shivanand and B.V. Babu Kiran, Composite Material, Asian Books Private Limited, 2010.

4. T. Pradeep, Nano: The Essentials, Tata McGraw-Hill Education Pvt. Ltd., 2010.

Reference Books:

1. William Smith, Structure and Properties of Engineering Alloys, Second Edition, McGraw Hill International Book Co.

2. William Smith, Javed Hasemi, Ravi Prakash, Material Science and Engineering, Tata McGraw Hill Education Company Ltd., 2006.

3. Kenneth G. Budinski, Michael K. Budinski, Engineering Materials Properties and Selection, 8th Edition, Prentice Hall.

4. Bowden M.J. and Tumber S.R., Polymer of High Technology, Electronics and Photonics, ACS Symposium Series, ACS, 1987.

5. Dyson, R.W., Engineering Polymers, Chapman and Hall, First Edition, 1990.
6. Chawala K.K., Composite Materials, Science and Engineering, 3rd Edition.
7. Sujata V. Bhat, Biomaterials, Narosa Publication Pvt. Ltd., Second Edition, 2005.
8. V. Raghavan, PHI Learning Private Ltd, Sixth Edition.

Evaluation Scheme:

Semester End Examination (A)*:*

Theory:

1. Question paper based on the entire syllabus summing up to 75 marks.
2. Total duration allotted for writing the paper is 3 hrs.

Continuous Assessment (B):

Theory:

1. Two term tests of 25 marks each will be conducted during the semester.
2. Total duration allotted for writing each of the paper is 1 hr.
3. Average of the marks scored in both the two tests will be considered for final grading.

The final certification and acceptance of term work will be subject to satisfactory performance of laboratory work and upon fulfilling minimum passing criteria in the term work.

Prepared by Checked by Head of the Department Principal

Syllabus for Third Year Chemical Engineering - Semester V (Autonomous)
(Academic Year 2021-2022)

<table>
<tr><td colspan="8">Program: Third Year B.Tech. in Chemical Engineering</td><td colspan="3">Semester: V</td></tr>
<tr><td colspan="8">Course:
Professional and Business Communication Laboratory</td><td colspan="3">Course Code: DCHL505</td></tr>
<tr><td colspan="4" rowspan="3">Teaching Scheme (Hours / week)</td><td colspan="7">Evaluation Scheme</td></tr>
<tr><td colspan="4">Semester End Examination Marks (A)</td><td colspan="3">Continuous Assessment Marks (B)</td><td rowspan="2">Total marks (A+ B)</td></tr>
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<tr><td>Oral</td><td>Practical</td><td>Oral & Practical</td><td>Laboratory Work</td><td>Tutorial / Mini project / presentation/ Journal</td></tr>
<tr><td>--</td><td>--</td><td>--</td><td>--</td><td>---</td><td>50</td></tr>
</table>

*2 hrs. Theory (Class wise) and 2 hrs. Tutorial (Batch wise)

Pre-requisite:

- DJ19FEC 206 Effective Communication Skills

Objectives:

- To inculcate professional and ethical attitude at the workplace
- To enhance communication and interpersonal skills
- To develop effective presentation skills
- To hone written skills for technical documentation

Outcomes:

- Plan, organize and write technical documents like reports, proposals and research papers in the prescribed format using appropriate language and style with an understanding of ethics in written communication
- Apply techniques of writing resume, participating in a group discussion and facing interviews
- Develop interpersonal skills in professional and personal situations
- Understand the documentation process of meetings and conduct meetings in a professional manner
- Understand communication across cultures and work ethics
- Design and deliver effective presentations using Power Point

Syllabus for Third Year Chemical Engineering - Semester V (Autonomous)
(Academic Year 2021-2022)

Detailed Syllabus: (unit wise)		
Unit	**Description**	**Duration**
	Unit 1: Technical Writing	
	Report Writing: Types of report, parts of formal report, collection of data and survey analysis, pre-writing of report, language and style in reports, formatting of reports, referencing in report **Proposal Writing: Types** of technical proposals, format of proposal, language and style, presentation of proposal **Technical Paper Writing:** Parts of a technical paper, language and formatting, referencing in IEEE format **Plagiarism:** Types of plagiarism, consequences of plagiarism	**08**
	Unit 2: Employment Skills	
	Group Discussion: Purpose of a GD, types of GD, criteria for evaluating a GD, Dos and Don'ts of a GD, Tips to be successful in GD **Cover Letter & Resume Writing:** Format and content of cover letter, types of resume, structure, content and formatting of resume **Interview Skills:** Types and modes of interview, Preparation for interview, Dos and Don'ts of interview, frequently asked questions during interview	**08**
	Unit 3: Introduction to Interpersonal Skills	
	Emotional Intelligence: Definition, difference between IQ and EQ, how to develop EQ **Leadership:** Types of leadership, leadership styles, case studies **Team Building:** Difference between group and team, importance of team work, strategies to be a good team player **Time Management:** Importance of time management, cultural views of time, 80/20 rule, time wasters, setting priorities and goals, **Conflict Management:** Types of conflicts, strategies to manage conflict, case studies	**05**
	Unit 4: Meetings and Documentation	
	Planning and preparation for meetings, strategies for conducting effective meetings, notice, agenda and minutes of a meeting, business meeting etiquettes	**02**
	Unit 5: Cross-cultural communication and Ethics	
	Communication across cultures, professional and work ethics, responsible use of social media, introduction to Intellectual Property Rights	**03**
	Unit 6: Presentation Skills	
	Presentation strategies, overcoming stage fear, techniques to prepare effective PowerPoint presentation	**02**

Books Recommended:

Reference Books

1. Fred Luthans, *"Organizational Behavior",* McGraw Hill, edition
2. Lesiker and Petit, *"Report Writing for Business",* McGraw Hill, edition
3. Huckin and Olsen, *"Technical Writing and Professional Communication",* McGraw Hill
4. Wallace and Masters, *"Personal Development for Life and Work",* Thomson Learning, 12th edition
5. Heta Murphy*, "Effective Business Communication",* Mc Graw Hill, edition

6. Sharma R.C. and Krishna Mohan, *"Business Correspondence and Report Writing",* Tata McGraw-Hill Education
7. Ghosh, B. N., *"Managing Soft Skills for Personality Development",* Tata McGraw Hill. Lehman,
8. Bell, Smith, "Management Communication" Wiley India Edition, 3rd edition.
9. Dr. Alex, K.," Soft Skills", S Chand and Company
10. Subramaniam, R., "Professional Ethics" Oxford University Press.

List of Assignments

1. Business Proposal (PowerPoint presentation)
2. Resume writing
3. Interpersonal Skills (documentation of activity)
4. Meetings and Documentation (Notice, Agenda, Minutes of Mock Meetings)
5. Business ethics
6. Presentation Skills

Evaluation Scheme:

Laboratory: (Term work)

Term work shall consist of 6 assignments, Group Discussion and Power Point Presentation based on the written report

The distribution of marks for term work shall be as follows:

Assignments …… (25) Marks
Project Report and Presentation…… (15) Marks
Group Discussion……. (10) Marks
TOTAL: ……... (50) Marks

The final certification and acceptance of term work will be subject to satisfactory performance of laboratory work and upon fulfilling minimum passing criteria in the term work.

Prepared by Checked by Head of the Department Principal

Syllabus for Third Year Chemical Engineering - Semester V (Autonomous)
(Academic Year 2021-2022)

<table>
<tr><td colspan="8">Program: Third Year Chemical Engineering</td><td colspan="3">Semester : V and VI</td></tr>
<tr><td colspan="8">Course : Innovative Product Development</td><td colspan="3">Course Code: DJ19ILL1</td></tr>
<tr><td colspan="4" rowspan="2">Teaching Scheme (Hours/week)</td><td colspan="7">Evaluation Scheme</td></tr>
<tr><td colspan="3">Semester End Examination Marks (A)</td><td colspan="3">Continuous Assessment Marks (B)</td><td rowspan="2">Total marks (A+ B)</td></tr>
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<tr><td>--</td><td>--</td><td>--</td><td>50</td><td>50</td><td>100</td></tr>
</table>

Objectives:

1. To acquaint the students with the process of identifying the need (considering a societal requirement) and ensuring that a solution is found out to address the same by designing and developing an innovative product.
2. To familiarize the students with the process of designing and developing a product, while they work as part of a team.
3. To acquaint the students with the process of applying basic engineering fundamentals, so as to attempt at the design and development of a successful value added product.
4. To inculcate the basic concepts of entrepreneurship and the process of self-learning and research required to conceptualise and create a successful product.

Outcome:

Learner will be able to:

1. Identify the requirement for a product based on societal/research needs.
2. Apply knowledge and skills required to solve a societal need by conceptualising a product, especially while working in a team.
3. Use standard norms of engineering concepts/practices in the design and development of an innovative product.
4. Draw proper inferences through theoretical/ experimental/simulations and analyse the impact of the proposed method of design and development of the product.
5. Develop interpersonal skills, while working as a member of the team or as the leader.
6. Demonstrate capabilities of self-learning as part of the team, leading to life-long learning, which could eventually prepare themselves to be successful entrepreneurs.
7. Demonstrate product/project management principles during the design and development work and also excel in written (Technical paper preparation) as well as oral communication.

Guidelines for the proposed product design and development:

- Students shall form a team of 3 to 4 students (max allowed: 5-6 in extraordinary cases, subject to the approval of the department review committee and the Head of the department).
- Students should carry out a survey and identify the need, which shall be converted into conceptualisation of a product, in consultation with the faculty supervisor/head of department/internal committee of faculty members.
- Students in the team shall understand the effective need for product development and accordingly select the best possible design in consultation with the faculty supervisor.
- Students shall convert the best design solution into a working model, using various components drawn from their domain as well as related interdisciplinary areas.
- Faculty supervisor may provide inputs to students during the entire span of the activity, spread over 2 semesters, wherein the main focus shall be on self-learning.
- A record in the form of an activity log-book is to be prepared by each team, wherein the team can record weekly progress of work. The guide/supervisor should verify the recorded notes/comments and approve the same on a weekly basis.
- The design solution is to be validated with proper justification and the report is to be compiled in a standard format and submitted to the department. Efforts are to be made by the students to try and publish a technical paper, either in the institute journal, "Techno Focus: Journal for Budding Engineers" or at a suitable publication, approved by the department research committee/ Head of the department.
- The focus should be on self-learning, capability to design and innovate new products as well as on developing the ability to address societal problems. Advancement of entrepreneurial capabilities and quality development of the students through the year long course should ensure that the design and development of a product of appropriate level and quality is carried out, spread over two semesters, ie during the semesters III and IV.

Guidelines for Assessment of the work:

- The review/ progress monitoring committee shall be constituted by the Head of the Department. The progress of design and development of the product is to be evaluated on a continuous basis, holding a minimum of two reviews in each semester.
- In the continuous assessment, focus shall also be on each individual student's contribution to the team activity, their understanding and involvement as well as responses to the questions being raised at all points in time.
- Distribution of marks individually for the both reviews as well as for the first review during the subsequent semester shall be as given below:
    - Marks awarded by the supervisor based on log-book : 20
    - Marks awarded by review committee : 20
    - Quality of the write-up : 10

- In the last review of the semester VI, the marks will be awarded as follows.

- Marks awarded by the supervisor (Considering technical paper writing) : 30
- Marks awarded by the review committee : 20

Review/progress monitoring committee may consider the following points during the assessment.

- In the semester V, the entire design proposal shall be ready, including components/system selection as well as the cost analysis. Two reviews will be conducted based on the presentation given by the student's team.
  - First shall be for finalisation of the product selected.
  - Second shall be on finalisation of the proposed design of the product.
- In the semester VI, the expected work shall be procurement of components/systems, building of the working prototype, testing and validation of the results based on work completed in semester V.
  - First review is based on readiness of building the working prototype.
  - Second review shall be based on a presentation as well as the demonstration of the working model, during the last month of semester VI. This review will also look at the readiness of the proposed technical paper presentation of the team.

The overall work done by the team shall be assessed based on the following criteria;

1. Quality of survey/ need identification of the product.
2. Clarity of Problem definition (design and development) based on need.
3. Innovativeness in the proposed design.
4. Feasibility of the proposed design and selection of the best solution.
5. Cost effectiveness of the product.
6. Societal impact of the product.
7. Functioning of the working model as per stated requirements.
8. Effective use of standard engineering norms.
9. Contribution of each individual as a member or the team leader.
10. Clarity on the write-up and the technical paper prepared.

- The semester reviews (V and VI) may be based on relevant points listed above, as applicable.

Guidelines for Assessment of Semester Reviews:

- The write-up should be prepared as per the guidelines given by the department.
- The design and the development of the product shall be assessed through a presentation and demonstration of the working model by the student team to a panel of Internal and External Examiners, preferably from industry or any research organisations having an experience of more than five years, approved by the Head of the Institution. The presence of the external examiner is desirable only for the 2nd presentation in semester IV. Students are compulsorily required to present the outline of the technical paper prepared by them during the final review in semester VI.

Scheme for Third Year Undergraduate Program B.Tech in Chemical Engineering : Semester VI (Autonomous)
(Academic Year 2021-2022)

Semester VI

Sr	Course Code	Course	Teaching Scheme				Semester End Examination (A)						Continuous Assessment (B)					Aggregate (A+B)	Credits earned	
			Theory (hrs.)	Practical (hrs.)	Tutorial (hrs.)	Credits	Duration (Hrs)	Theory	Oral	Pract	Oral & Pract	SEE Total (A)	Term Test 1 (TT1)	Term Test 2 (TT2)	Avg (TT1 & TT2)	Term Work Total	CA Total (B)			
1	DJ19CHC601	Chemical Reaction Engineering -II	3	--	--	3	3	75	--	--	--	75	25	25	25	--	25	100	3	4
	DJ19CHL601	Chemical Reaction Engineering -II Laboratory	--	2	--	1	2	--	25	--	_	25	--	--	--	25	25	50	1	
2	DJ19CHC602	Mass Transfer Operation -II	3	--	--	3	3	75	--	--	--	75	25	25	25	--	25	100	3	4
	DJ19CHL602	Mass Transfer Operation -II Laboratory	--	2	--	1	2	--	25	--	_	25	--	--	--	25	25	50	1	
3	DJ19CHC603	Chemical Equipment Design & Drawing	3	--	--	3	3	75	--	--	--	75	25	25	25	--	25	100	3	4
	DJ19CHL603	Chemical Equipment Design & Drawing Laboratory	--	2	--	1	2	--	25	--	--	25	--	--	--	25	25	50	1	
4	DJ19CHC604	Computer Programing & Numerical Methods	3	--	--	3	3	75	--	--	--	75	25	25	25	--	25	100	3	4
	DJ19CHL604	Computer Programing & Numerical Methods Laboratory	--	2	--	1	2	--	25	--	_	25	--	--	--	25	25	50	1	
5@	DJ19CHEC6011	Computational Fluid Dynamics	3	--	--	3	3	75	--	--	--	75	25	25	25	--	25	100	3	4
	DJ19CHEL6011	Computational Fluid Dynamics Laboratory	--	2	--	1	_	--	--	--	--	--	--	--	--	25	25	25	1	
	DJ19CHEC6012	Energy System Design	3	--	--	3	3	75	--	--	--	75	25	25	25	--	25	100	3	
	DJ19CHEL6012	Energy System Design Laboratory	--	2	--	1	_	--	--	--	--	--	--	--	--	25	25	25	1	
	DJ19CHEC6013	Chemical Engineeering Optimisation	3	--	--	3	3	75	--	--	--	75	25	25	25	--	25	100	3	
	DJ19CHEL6013	Chemical Engineeering Optimisation Laboratory	--	2	--	1	_	--	--	--	--	--	--	--	--	25	25	25	1	
	DJ19CHEC6014	Transport Phenomenon	3	--	--	3	3	75	--	--	--	75	25	25	25	--	25	100	3	
	DJ19CHEL6014	Transport Phenomenon Laboratory	--	2	--	1	_	--	--	--	--	--	--	--	--	25	25	25	1	
6	DJ19ILL2	Innovative Product Development - IV	--	2	--	1	2	--	25	--	_	25	--	--	--	25	25	50	1	1
7	DJ19A5	Environmental Studies	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Total	**16**	**12**	--	**21**	**27**	**375**	125	**--**	_	**500**	**125**	**125**	**125**	**150**	**275**	**775**	**21**	

@ Any 1 Elective Course

Prepared by Checked by **Head of the Department** **Vice Principal** **Principal**

Syllabus for Third Year Chemical Engineering - Semester V (Autonomous)
(Academic Year 2021-2022)

<table>
<tr><td colspan="8">Program: Third Year Chemical Engineering</td><td colspan="2">Semester: VI</td></tr>
<tr><td colspan="8">Course: Chemical Reaction Engineering-II</td><td colspan="2">Course Code:DJ19CHC601</td></tr>
<tr><td colspan="8">Course: Chemical Reaction Engineering-II Laboratory and Tutorial</td><td colspan="2">Course Code:DJ19CHL601</td></tr>
<tr><td colspan="4" rowspan="2">Teaching Scheme (Hours / week)</td><td colspan="6">Evaluation Scheme</td></tr>
<tr><td colspan="3">Semester End Examination Marks (A)</td><td colspan="3">Continuous Assessment Marks (B)</td><td rowspan="2">Total marks (A+ B)</td></tr>
<tr><td rowspan="3">Lectures</td><td rowspan="3">Practical</td><td rowspan="3">Tutorial</td><td rowspan="3">Total Credits</td><td colspan="3">Theory</td><td>Term Test 1</td><td>Term Test 2</td><td>Avg.</td></tr>
<tr><td colspan="3">75</td><td>25</td><td>25</td><td>25</td><td>100</td></tr>
<tr><td colspan="3">Laboratory Examination</td><td colspan="3">Term work</td><td rowspan="3">Total Term work</td><td rowspan="3">50</td></tr>
<tr><td rowspan="2">3</td><td rowspan="2">2</td><td rowspan="2">-</td><td rowspan="2">4</td><td>Oral</td><td>Practical</td><td>Oral & Practical</td><td>Laboratory Work</td><td colspan="2">Tutorial / Mini project / presentation/ Journal</td></tr>
<tr><td>25</td><td>--</td><td>--</td><td>--</td><td colspan="2">25</td><td>25</td></tr>
</table>

Pre-requisite:

- DJ19CHC501 Chemical Reaction Engineering-I

Objectives:

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

Outcomes:

After completion of the course students will be able to:

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

Detailed Syllabus: (unit wise)		
Unit	**Description**	**Duration(Hrs)**
1	**Non Ideal flow reactors:** Concept of residence time distribution (RTD), Measurement and characteristics of RTD, RTD in Ideal batch reactors, Plug Flow Reactor and CSTR. Zero Parameter Model – Segregation and Maximum mixedness model. One parameter model–Tanks in series model and Dispersion Model. Effect of dispersion on conversion for general irreversible reaction case, Diagnostic methods of analysis of flow patterns in reactors, Role of micro and macro mixing and segregation in ideal (MFR, PFR) and non-ideal reaction cases.	**12**
2	**Non Catalytic heterogeneous Reactions:** **Kinetics:** General mechanism of reaction. Various models. Specific cases with respect: (a) Film diffusion controlling. Ash diffusion controlling. (c) Chemical reaction controlling. **Design of reactors for non-catalytic reactions:** Experimental reactors for heterogeneous Reactions, Non- Catalytic Fluid Solid Reactions in Flow Reactor. Application to design of continuous solid flow reactors; various design considerations, Application of fluid bed reactors and their design consideration.	**12**
3	**Catalytic heterogeneous Reactions:** **Kinetics and mechanism** of various Heterogeneous reactions and design consideration of reactors used during different operating conditions. Properties of solid catalysts, Physical adsorption and Chemisorption, Surface area and pore size distribution, Langmuir Hinshelwood model, and General mechanism of solid catalyzed fluid phase reactions. Special cases when (a) Film resistance controls. (b) Surface phenomenon controls (c) Surface reaction controls (d) Pore diffusion controls. Concept of effectiveness factor of catalyst and its dependence on catalyst properties and kinetic parameters. Numerical based on physical properties of catalyst, Derivations for LHHW model mechanism-various cases Effectiveness factor. Numerical based on kinetics **Introduction to Catalytic Reactors**: Packed Bed Reactor Fluidized Bed, Trickle Bed and Slurry Reactor. Numerical based on Design of P a c k e d B e d Reactor (Calculation of weight/volume of catalyst).	**12**
4	**Kinetics of fluid-fluid reactions**: Reaction with mass transfer, the rate equation pertaining to fast to very slow reactions. **Applications to design:** Design of gas-liquid, liquid-liquid and gas liquid-solid reactors- Heterogeneous reactors, Bubble heterogeneous reactors, co-current and counter- current flow packed bed reactors.	**06**

Books Recommended:

Textbooks:

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

Reference Books:

1. Hill C.G., Chemical Reaction Engineering.
2. Walas, Reaction Kinetics for Chemical Engineers, McGraw Hill, 1959.

Evaluation Scheme:

Semester End Examination (A):

Theory:

1. Question paper based on the entire syllabus summing up to 75 marks.
2. Total duration allotted for writing the paper is 3 hrs.

Oral Examination:

1. A student becomes eligible for oral examination after completing a minimum of five experiments and minimum of five tutorials, out of the list given.
2. Oral examination: 25Marks.

Continuous Assessment (B):

Theory:

1. Two term tests of 25 marks each will be conducted during the semester.
2. Total duration allotted for writing each of the paper is 1 hr.
3. Average of the marks scored in both the two tests will be considered for final grading.

Laboratory and Tutorial: (Term work)

1. Term work shall consist of minimum five practical and minimum five tutorials from entire syllabus, which are to be given at regular intervals. Total Marks: 25

2. List of Experiments and Tutorials suggested: -

1	TO STUDY RTD IN A CSTR.
2	TO STUDY RTD IN A PFR.
3	TO DETERMINE VOID VOLUME, POROSITY, SOLID DENSITY OF A CATALYST PARTICLE (SILICA GEL)
4	TO FIND OUT DISPERSION NUMBER AND CO-EFFICIENT DISPERSION IN PFR.
5	TO FIND OUT DISPERSION NUMBER AND CO-EFFICIENT DISPERSION IN CSTR.
6	STUDY EXPERIMENT ON VARIOUS TYPES OF SOLID CATALYST FLUID PHASE REACTORS.
7	TO FIND SKEWNESS FACTOR OF THIS RTD.
8	STUDY OF PACKED BED, FLUID BED AND SLURRY REACTORS.
9	TYPES OF ADSORPTIONS AND THEIR APPLICATIONS, COMPARSION WITH RESPECTIVE TO REACTION KINETIC ENEGRY.
10.	To study the Shrinking of particle in a solid fluid system

Tutorial No 1	Non-ideal flow
Tutorial No 2	Non-ideal flow
Tutorial No 3	Non-ideal flow
Tutorial No 4	Non-catalytic heterogeneous reactions
Tutorial No 5	Non-catalytic heterogeneous reactions
Tutorial No 6	Non-catalytic heterogeneous reactions
Tutorial No 7	Catalytic heterogeneous reactions
Tutorial No 8	Catalytic heterogeneous reactions
Tutorial No 9	Catalytic heterogeneous reactions
Tutorial No 10	Kinetics and design of fluid-fluid reactions

The final certification and acceptance of term work will be subject to satisfactory performance of laboratory work and upon fulfilling minimum passing criteria in the term work.

Prepared by Checked by Head of the Department Principal

Syllabus for Third Year Chemical Engineering - Semester VI (Autonomous)
(Academic Year 2021-2022)

<table>
<tr><td colspan="8">Program: Third Year Chemical Engineering</td><td colspan="3">Semester: VI</td></tr>
<tr><td colspan="8">Course: Mass Transfer Operation -II</td><td colspan="3">Course Code:
DJ19CHC602</td></tr>
<tr><td colspan="8">Course: Mass Transfer Operation -II Laboratory</td><td colspan="3">Course Code:
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</table>

Pre-requisite:

- DJ19CHC303 Chemical Engineering Thermodynamics
- DJ19CHC304 Material and Energy Balance
- DJ19CHC305 Fluid Flow
- DJ19CHC401 Engineering Mathematics - IV.

Objectives:

- Design methods for distillation columns.
- Design of extractor and leaching equipment.
- Design of adsorption equipment
- Understand membrane separation.
- Understand crystallisation process.

Outcomes:

After completion of the course students will be able to:

- Students should be able to choose the separation operation and optimize the process parameters.
- Understand equilibrium in all separation process
- Design the mass transfer equipment for distillation, extraction, leaching, adsorption and crystallization processes.
- Understand principles of membrane separation processes and working.

Syllabus for Third Year Chemical Engineering - Semester VI (Autonomous)
(Academic Year 2021-2022)

Detailed Syllabus: (unit wise)		
Unit	**Description**	**Duration**
1	**Distillation**: Introduction to Distillation, Vapor-liquid Equilibrium-At constant Pressure and at constant temperature, Minimum and maximum boiling Azeotropes. Methods of distillation [binary mixtures] – Flash Distillation, Differential distillation, Rectification. Calculations of number of ideal stages in multistage counter current rectification, McCabe Thiele Method, Ponchon-Savarit method, Concepts of [Brief Discussion] Steam Distillation, Azeotropic Distillation, Extractive Distillation, Reactive Distillation, Molecular Distillation, Batch distillation rectification with fixed and variable reflux.	10
2	**Liquid-Liquid Extraction**: Introduction to Liquid-Liquid Extraction, Choice of Solvent for Liquid-Liquid Extraction, Triangular coordinate system, Ternary Equilibria [Binodal Solubility Curve with effect of temperature and pressure on it], Single and multistage cross current and counter current operation, Equipment for liquid-liquid extraction.	8
3	**Leaching**: Representation of Equilibria, Single stage and multistage cross current and counter current leaching.	4
4	**Adsorption**: Introduction to Adsorption, Types of Adsorption, Adsorption Isotherms, Single Stage Adsorption, Multistage Cross Current Adsorption, Multistage Counter Current adsorption, Break through curve.	8
5	**Crystallization**: Solubility curve, Super saturation, Effect of heat on size and growth of crystal, Rate of Crystal growth and ΔL law of crystal growth, Material and energy balance for crystallizers, Equipment for Crystallization.	6
6	**Membrane separation & Ion Exchange**: Need of membrane separation, and its advantages, Classification of membrane separation process, Various membranes and their applications, Ultrafiltration, Nanofiltration. Reverse osmosis, Pervaporation, Ion Exchange Equilibria.	6

Books Recommended:

Textbooks:

1. "Mass transfer operation", R.E. Treybal, 3 Ed., McGraw Hill New York, 1981.
2. "Separation Process Principles", J.D. Seader and E. J. Henley, 2nd Edition, Wiley, 2005.

Reference Books:

1. "Unit operation in chemical engineering", McCabe W.L. and Smith J.C., 5 Ed., McGraw Hill New York 1993.
2. J. M. Coulson, J. F. Richardsons & R. K. Sinnot, Chemical Engineering Design, Vol 1 & 6, Elsevier Science & Technology Books, 1996.
3. Yunus A Cengel and Afshin J Ghajar, Heat and Mass Transfer: Fundamentals and Applications (Sie), McGrow Hill 5th Edition, 2015.

Syllabus for Third Year Chemical Engineering - Semester VI (Autonomous)
(Academic Year 2021-2022)

Evaluation Scheme:

Semester End Examination (A)*:*

Theory:

1. Question paper based on the entire syllabus summing up to 75 marks.
2. Total duration allotted for writing the paper is 3 hrs.

Oral Examination:

1. A student becomes eligible for oral examination after completing a minimum of five experiments and minimum of five tutorials, out of the list given.
2. Oral examination: 25Marks.

Continuous Assessment (B):

Theory:

1. Two term tests of 25 marks each will be conducted during the semester.
2. Total duration allotted for writing each of the paper is 1 hr.
3. Average of the marks scored in the two tests will be considered for final grading.

Laboratory and Tutorial: (Term work)

1. Term work shall consist of minimum five practical and minimum five tutorials from entire syllabus which are to be given at regular intervals. Total Marks: 25
2. List of Experiments and Tutorials suggested: -

Experiment No.	Title
1	Verification of Rayleigh Equation
2	To determine the percentage recovery of solute by solid liquid leaching operation (multistage crosscurrent).
3	To determine the vapour-liquid equilibrium curve.
4	Li quid-Liquid Equilibrium of a Ternary Mixture (Liquid-Liquid Extraction): Determine distribution coefficient.
5	To verify Freundlich adsorption isotherm
6	To prepare the Ternary phase diagram of Binodal solubility curve and tie line relationship for ternary system.
7	To find the yield of crystals in batch crystallizer.
8	To determine the efficiency of steam distillation.
9	To carry out multistage cross current adsorption and compare with single stage operation.
10	To carry out multistage cross current operation in liquid liquid extraction and compare with single stage operation.

Tutorial No.	Topic
1	Study of vapour-liquid equilibrium curve, Azeotropes
2	Stage calculation using Mcabe Thiele Method
3	Stage calculations using Ponchon-Savarit Method.
4	Steam Distillation, Azeotropic Distillation, Extractive Distillation, Reactive Distillation, Molecular Distillation
5	Numerical based on cross current extraction
6	Numerical based on countercurrent extraction

7	Numerical based on leaching.
8	Numerical based on adsorption
9	Numerical based on crystallization
10	Membrane separation & Ion Exchange

The final certification and acceptance of term work will be subject to satisfactory performance of laboratory work and upon fulfilling minimum passing criteria in the term work.

Prepared by Checked by Head of the Department Principal

Syllabus for Third Year Chemical Engineering - Semester VI (Autonomous)
(Academic Year 2021-2022)

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<tr><td>25</td><td>-</td><td>-</td><td>10</td><td>15</td><td>25</td></tr>
</table>

Pre-requisite:

- DJ19FEC204 Engineering Drawing.
- DJ19CHC304 Material and Energy Balance Calculations.
- DJ19CHC502 Mass Transfer Operations 1
- DJ19CHC503 Heat Transfer Operation

Objectives:

- Familiarize with design preliminaries and equipment testing methods.
- Design of pressure vessels and tall vessels.
- Design of reaction vessels.
- Design of heat exchangers.
- Understand the concept of storage tank and supports.

Outcomes:

After completion of the course students will be able to:

- Understand the concept of storage tank and supports
- Understand general design considerations for process equipment design.
- To understand the basics of design and construction of mass and heat transfer equipment such as distillation column, heat exchangers, evaporators, etc.
- Able to design the agitation system components.

Syllabus for Third Year Chemical Engineering - Semester VI (Autonomous)
(Academic Year 2021-2022)

Detailed Syllabus: (unit wise)		
Unit	**Description**	**Duration**
1	**Introduction**: Introduction to chemical process equipment design, Basic consideration in process equipment design, Standards, codes & their significance, equipment classification & selection, Material of construction for chemical process equipment, Design pressure, Design temperature, Design stress & Design loads, Factor of safety, Corrosion allowance & weld joint efficiency. Methods of inspection of equipment such as Radiography, Ultrasound, Dye Penetration	8
2	**Design of pressure vessels**: Pressure vessel codes, Design of shell and its components, Vessel closure, Supports, Shell thickness determination at various heights in tall columns (Distillation columns) and study of type supports for trays. Storage vessels.	8
3	**Design of heat exchanger**: Mechanical design of shell & tube heat exchanger, Design of calendria type evaporators.	8
4	**High Pressure Vessels:** Theories of failure, Constructional method of high pressure vessels, Design of monoblock and multi layered high pressure vessels (stress distribution diagram).	6
5	**Vessels under external pressure:** Types of jackets & design of plain jacketed vessel.	6
6	**Mixing and agitation**: Types of agitators & their application. Components of agitation system, Power requirement for agitation, Design of agitation system components such as shaft, blade assembly, stuffing box and flange coupling.	6

Books Recommended:

Textbooks:

1. Introduction to Chemical Equipment Design, B.C. Bhattacharyya, CBS publications.
2. Process Equipment Design, M.V Joshi and V. V. Mahajan 3rd Edition, McMillian India Ltd.,1996
3. Process Equipment Design and Drawing by Kiran Ghadyalji, Nandu publication. Kiran Ghadyalji, Nandu publication.
4. Process Design of Equipments, 4th Edition, S.D. Dawande, Central Techno publications.
5. Introduction to Process Engineering and Design, S B Thakore and B I Bhatt, 1st Edition, Mc-Graw Hill Publications,2008

Reference Books:

1. J. M. Coulson, J. F. Richardsons & R. K. Sinnot, Chemical Engineering Design, Vol 1 & 6, Elsevier Science & Technology Books, 1996.
2. I.S.:2825-1969, "Code for Unfired Pressure Vessels"
3. Process Heat Transfer, D.Q..Kern, International Student Edition, McGraw Hill (2002).
4. Process Equipment Design, Brownell, L.E. and Young, E.H.,Wiley India (P.) Limited (2004).

5. Chemical Engineer's Handbook, Perry, R.H. and Green, D, 8th Edition, McGraw Hill, New York. (2008)

Evaluation Scheme:

Semester End Examination (A)*:*

Theory:

1. Question paper based on the entire syllabus summing up to 75 marks.
2. Total duration allotted for writing the paper is 3 hrs.

Oral Examination:

1. A student becomes eligible for oral examination after completing a minimum of five Drawings and minimum of five tutorials, out of the list given.
2. Oral examination: 25Marks.

Continuous Assessment (B):

Theory:

1. Two term tests of 25 marks each will be conducted during the semester.
2. Total duration allotted for writing each of the paper is 1 hr.
3. Average of the marks scored in both the two tests will be considered for final grading.

Laboratory and Tutorial: (Term work)

1. Term work shall consist of minimum five practical and minimum five tutorials from entire syllabus which are to be given at regular intervals. Total Marks: 25
2. List of Drawings and Tutorials suggested: -

Drawing No.	Title
1	Shell and nozzle
2	Flange.
3	Heat exchanger: assembly drawing, tube sheet layout.
4	Evaporator: Calendria type
5	Tall vessel: distillation column
6	Jacketed vessel
7	Monoblock high pressure vessel
8	Multilayered high pressure vessel
9	Agitator shaft and blade assembly
10	Flange coupling

Tutorial No.	Topic
1	Design of shell, head
2	Design of nozzle, flange
3	Design of tall vessel
4	Design of heat exchanger
5	Design of calendria type evaporator

6	Design of vessels under external pressure
7	Design of agitator shaft
8	Design of agitator stuffing box and coupling
9	Design of high pressure vessel for monoblock construction
10	Design of high pressure vessel for multilayer construction.

The final certification and acceptance of term work will be subject to satisfactory performance of laboratory work and upon fulfilling minimum passing criteria in the term work.

Prepared by Checked by Head of the Department Principal

Syllabus for Third Year Chemical Engineering - Semester VI (Autonomous)
(Academic Year 2021-2022)

Program: Third Year Chemical Engineering	**Semester: VI**
Course: Computer Programing & Numerical Methods	**Course Code: DJ19CHC604**
Course: Computer Programing & Numerical Methods Laboratory & Tutorial	**Course Code: DJ19CHL604**

Teaching Scheme (Hours / week)				**Evaluation Scheme**						
				Semester End Examination Marks (A)			**Continuous Assessment Marks (B)**			**Total marks (A+ B)**
Lectures	**Practical**	**Tutorial**	**Total Credits**	**Theory**			**Term Test 1**	**Term Test 2**	**Avg.**	
				75			**25**	**25**	**25**	**100**
				Laboratory Examination			**Term work**		**Total Term work**	**50**
3	**2**	**-**	**4**	**Oral**	**Practical**	**Oral & Practical**	**Laboratory Work**	**Tutorial / Mini project / presentation/ Journal**		
				25	**--**	**--**	**15**	**10**	**25**	

Pre-requisite:

- DJ19CHC401 Engineering Mathematics - IV
- DJ19FEC205 Computer Programming (Structured Programming Approach-SEM II)

Objectives:

- Familiarize students with the use of software in solving numerical problems.
- Develop analytical thinking in designing programs.
- Learn to interpret results of computer programs and present results in graphical form.
- Learn to formulate (and solve) equations for various chemical engineering processes/ applications.

Outcomes:

After completion of the course students will be able to:

- Develop and solve linear algebraic equations.
- Develop and solve non-linear algebraic equations.
- Develop and solve differential equations.
- Solve partial differential equations.

Detailed Syllabus: (unit wise)		
Unit	**Description**	**Duration (Hrs)**
1	**Fundamentals of Python** Variables Expressions and Arithmetic Conditional Execution Functions Read/write data from/to files Lists and Objects Program examples	**8**

2	**Solution of algebraic and transcendental equations** Regula-Falsi Method Successive substitution Secant Method Newtons Method- Single and Multi-variable Applications in Chemical Engineering	**8**
3	**Systems of linear equations** Gaussian Elimination LU Decomposition Jacobi Iteration Method Gauss-Seidel Method. Applications in Chemical Engineering	**7**
4	**Ordinary differential equations** Euler's explicit and implicit methods Runge-Kutta second and fourth order methods Predictor and Corrector Formulas Gear's Method Applications in Chemical Engineering	**9**
5	**Difference Equations** Linear and Non-linear equations Applications to Absorption, Adsorption, Extraction etc.	**5**
6	**Partial differential equations** One-dimensional unsteady state diffusion equation Problems using explicit method Relaxation Method	**5**

Books Recommended:

Textbooks:

1. S. C. Chapra and R.P. Canale, Numerical Methods for Engineers. McGraw-Hill International, 7th Edition, 2016.
2. Santosh K. Gupta, Numerical Methods for Engineers. New Age Publishers, 2nd Edition, 2010.
3. Peter Wentworth, Jeffrey Elkner, Allen B. Downey, and Chris Meyers, 'How to Think Like a Computer Scientist'. Free Online book under the terms of the GNU Free Documentation License, Version 1.3. Book Version date: October 2012.
4. Mark E. Davis, Numerical Methods and Modeling for Chemical Engineers. John Wiley & Sons, 1984.
5. H. M. Antia, Numerical Methods for Scientists and Engineers. Hindustan Book Agency, 3rd Edition, 2012.

Reference Books:

1. Bruce A. Finlayson, Introduction to Chemical Engineering Computing. Wiley- International. 2nd Edition, 2012.
2. Mark Lutz and David Ascher, Learning Python. O'REILLY Media Inc, 2nd edition, 2004.
3. John Mathews, Numerical Methods. Prentice Hall International, 2nd edition, 1992.

Evaluation Scheme:

Theory:

1. Question paper based on the entire syllabus summing up to 75 marks.
2. Total duration allotted for writing the paper is 3 hrs.

Oral Examination:

1. A student becomes eligible for oral examination after completing a minimum of five experiments and minimum of five tutorials, out of the list given.
2. Oral examination: 25Marks.

Continuous Assessment (B):

Theory:

1. Two term tests of 25 marks each will be conducted during the semester.
2. Total duration allotted for writing each of the paper is 1 hr.
3. Average of the marks scored in the two tests will be considered for final grading.

Laboratory and Tutorial: (Term work)

1. Term work shall consist of minimum five practical and minimum five tutorials from entire syllabus which are to be given at regular intervals. Total Marks: 25
2. List of Experiments and Tutorials suggested: -

1	Bisection Method
2	Regula-Falsi Method
3	Successive substitution
4	Secant Method
5	Newton Raphson method
6	Gaussian Elimination
7	Gauss Jordan Method
8	LU Decomposition
9	Jacobi Iteration Method
10	Gauss-Seidel Method
11	Euler's explicit and implicit methods
12	Runge-Kutta second and fourth order methods
13	Predictor and Corrector method for ODE
14	Linear/ Non-linear difference equations
15	Chemical Engineering application-based code

The final certification and acceptance of term work will be subject to satisfactory performance of laboratory work and upon fulfilling minimum passing criteria in the term work.

Prepared by Checked by Head of the Department Principal

Syllabus for Third Year Chemical Engineering - Semester VI (Autonomous)
(Academic Year 2021-2022)

<table>
<tr><td colspan="8">Program: Third Year Chemical Engineering</td><td colspan="3">Semester : VI</td></tr>
<tr><td colspan="8">Department Elective: Computational Fluid Dynamics</td><td colspan="3">Course Code:
DJ19CHEC6011</td></tr>
<tr><td colspan="8">Department Elective: Computational Fluid Dynamics Laboratory</td><td colspan="3">Course Code:
DJ19CHEL6011</td></tr>
<tr><td colspan="4" rowspan="2">Teaching Scheme (Hours / week)</td><td colspan="11">Evaluation Scheme</td></tr>
<tr><td colspan="6">Semester End Examination Marks (A)</td><td colspan="4">Continuous Assessment Marks (B)</td><td rowspan="2">Total marks (A+ B)</td></tr>
<tr><td rowspan="3">Lectures</td><td rowspan="3">Practical</td><td rowspan="3">Tutorial</td><td rowspan="3">Total Credits</td><td colspan="6">Theory</td><td>Term Test 1</td><td>Term Test 2</td><td>Avg.</td></tr>
<tr><td colspan="6">75</td><td>25</td><td>25</td><td>25</td><td>100</td></tr>
<tr><td colspan="6">Laboratory Examination</td><td colspan="3">Term work</td><td rowspan="3">Total Term work</td><td rowspan="3">25</td></tr>
<tr><td rowspan="2">3</td><td rowspan="2">2</td><td rowspan="2">--</td><td rowspan="2">4</td><td colspan="2">Oral</td><td>Practical</td><td colspan="2">Oral & Practical</td><td>Laboratory Work</td><td>Tutorial / Mini project / presentation/ Journal</td></tr>
<tr><td colspan="2">--</td><td>--</td><td colspan="2">--</td><td>15</td><td>10</td><td>25</td></tr>
</table>

Pre-requisite:

- DJ19FEC101 Engineering Mathematics - I
- DJ19FEC201 Engineering Mathematics - II
- DJ19FEC205 Computer Programming

Objectives:

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

Outcomes:

After completion of the course students will be able to:

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

Module	Contents	Contact Hours
1	Module: Introduction Contents: Advantages of Computational Fluid Dynamics Typical Practical Applications Equation Structure Overview of CFD	**02**
2	Module: Preliminary Computational Techniques Contents: Discretization Approximation to Derivatives Accuracy of the Discretization Process Wave Representation, Finite Difference Method	**04**

3	Module: Theoretical Background Contents: Convergence Consistency Stability Solution Accuracy Computational Efficiency	**06**
4	Module: Weighted Residual Methods Contents: General Formulation Least Squares, Galerkin and Sub domain Formulations. Weak form of Galerkin Method	**06**
5	Module: Finite Element Method Contents: Piece-wise Continuous Trial Functions One Dimensional Linear and Quadratic Elements One Dimensional Heat Transfer Tri-diagonal Matrix Algorithm	**06**
6	Module: Two Dimensional Elements Quadrilateral Elements Steady State Heat Transfer in Two Dimensions Alternating Direction Implicit Method Potential Flow in Two Dimensions	06
7	Module: Finite Volume Method One Dimensional Diffusion Two Dimensional Diffusion Diffusion With Convection and The Upwind Scheme	06
8	Module: Pressure Velocity Coupling in Steady Flows The Staggered Grid The Momentum Equation The Simple Algorithm	06

Books Recommended:

Textbooks:

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

Reference Books:

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

Evaluation Scheme:

Semester End Examination (A)*:*

Theory:

1. Question paper based on the entire syllabus summing up to 75 marks.
2. Total duration allotted for writing the paper is 3 hrs.

Continuous Assessment (B):

Theory:

1. Two term tests of 25 marks each will be conducted during the semester.
2. Total duration allotted for writing each of the paper is 1 hr.
3. Average of the marks scored in the two tests will be considered for final grading.

Laboratory and Tutorial: (Term work)

1. Term work shall consist of minimum five practical and minimum five tutorials from entire syllabus which are to be given at regular intervals. Total Marks: 25
2. List of Experiments and Tutorials suggested: -

1	Study on the accuracy of finite difference approximations.
2	Solution of one-dimensional diffusion equation using finite differences.
3	Solution of one-dimensional diffusion equation using Galerkin method.
4	Solution of one-dimensional diffusion equation by the sub-domain method.
5	Solution of one-dimensional diffusion equation by the least squares method.
6	Study of approximation by linear elements.
7	Study of approximation by quadratic elements.
8	Steady diffusion in two-dimensions.
9	Application of TDMA.
10	FVM in one dimension.
11	FVM in two dimensions.
12	FVM for diffusion with convection.

The final certification and acceptance of term work will be subject to satisfactory performance of laboratory work and upon fulfilling minimum passing criteria in the term work.

Prepared by Checked by Head of the Department Principal

Syllabus for Third Year Chemical Engineering - Semester VI (Autonomous)
(Academic Year 2021-2022)

Program: Third Year Chemical Engineering	**Semester: VI**
Department Elective: Energy System Design	**Course Code: DJ19CHEC6012**
Department Elective: Energy System Design Laboratory	**Course Code: DJ19CHEL6012**

Teaching Scheme (Hours / week)				**Evaluation Scheme**						
				Semester End Examination Marks (A)			**Continuous Assessment Marks (B)**			**Total marks (A+ B)**
Lectures	**Practical**	**Tutorial**	**Total Credits**	**Theory**			**Term Test 1**	**Term Test 2**	**Avg.**	
				75			**25**	**25**	**25**	**100**
				Laboratory Examination			**Term work**		**Total Term work**	**25**
3	**2**	**-**	**4**	**Oral**	**Practical**	**Oral & Practical**	**Laboratory Work**	**Tutorial / Mini project / presentation/ Journal**		
				--	**--**	**--**	**15**	**10**	**25**	

Pre-requisite:

- DJ19CHC504 Chemical Process Safety and Utilities
- DJ19CHC503 Heat Transfer Operation

Objectives:

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

Outcomes:

After completion of the course students will be able to:

- Understand energy conservation needs and use appropriate renewable energy systems when required.
- Design an energy system to meet the desired needs within realistic constraints such as economic, environmental, social, ethical, health and safety, manufacturability and sustainability.
- Analyse energy performance of various equipment used in the chemical industry for energy conservation.
- Function on multidisciplinary teams, identify, formulate and solve engineering problems, related to energy.

Detailed Syllabus: (unit wise)		
Unit	**Description**	**Duration (Hrs.)**
1	Global Energy Scenario: national and international.	**Assignment**
2	Renewable Energy Systems- Solar, Wind, Hydro, Biomass, Geothermal, Tidal	**3**
3	Energy Audit: Energy audit methodology, Types of instrumentation used in energy audit, Safety considerations during energy audit, Post audit analysis.	**3**

4	Energy Efficient Technologies: Energy efficient techniques for lighting system, motors, belt and drives system, fans and pumps system, compressed air system; steam system, refrigeration system.	**3**
5	Energy Integration in The Process Industries: Temperature Pinch analysis, concept of minimum number of heat exchangers, Heat Exchanger Network design, Threshold approach temperature difference, targeting for number of shells, Area targets, Optimum approach temperature difference.	**13**
6	Heat Integration in Process Units: Multiple effect evaporators: Material and Energy Balance for single and up to triple effect, Heat integration of (MEE) with background process. Heat integration MEE with and without vapour recompression: mechanical vapour re-compression, thermal vapour re-compression. Distillation column: heat integration in distillation column- multiple effect distillation, heat pumping, vapour re- compression, Reboiler flashing. Different arrangements of heat integration of columns with background process.	**12**
7	Co-generation: Definitions, topping cycle, bottoming cycle, combined cycle. Steam turbine system, gas turbine system, combined gas steam turbine system, diesel engine system. Heat integration and cogeneration.	**5**
8	Waste Heat Recovery (WHR): Waste heat sources, quality and classification of waste heat and its applications. Benefits of WHR. WHR equipments like recuperators, radiation/convective hybrid recuperator, ceramic recuperator, heat wheel, heat pipe, waste heat boiler.	**3**

Books Recommended:

Textbooks:

1. Robin Smith, Chemical Process Design and Integration, Wiley India, 2005. [Module: 3, 4, 5, 6]
2. Serth, Robert W., Process Heat Transfer Principles and Applications, Elsevier Science & Technology Books, 2007. [Module: 3]
3. Wayne C. Turner, Steve Doty (Ed.), Energy Management Hand Book, John Wiley and Sons, 2000.

Reference Books:

1. B. K. Hodge and Robert Taylor, Analysis and Design of Energy Systems, Pearson. 3rd Edition, 1999.

Evaluation Scheme:

Semester End Examination (A)*:*

Theory:

1. Question paper based on the entire syllabus summing up to 75 marks.
2. Total duration allotted for writing the paper is 3 hrs.

Continuous Assessment (B):

Theory:

1. Two term tests of 25 marks each will be conducted during the semester.
2. Total duration allotted for writing each of the paper is 1 hr.
3. Average of the marks scored in the two tests will be considered for final grading.

Laboratory and Tutorial: (Term work)

1. Term work shall consist of minimum five practical and minimum five tutorials from entire syllabus which are to be given at regular intervals. Total Marks: 25

List of Experiments and Tutorials suggested: -

1	Renewable energy systems: Solar, Wind, Hydro
2	Renewable energy systems: Biomass, Geothermal, Tidal
3	Energy Audit: Industry-1, Industry-2 etc
4	Energy Efficiency
5	Composite curve method for MER targets
6	PTA method for MER targets

7	HEN synthesis
8	Multiple effect evaporator
9	Heat integration: Distillation columns
10	Co-generation

The final certification and acceptance of term work will be subject to satisfactory performance of laboratory work and upon fulfilling minimum passing criteria in the term work.

Prepared by Checked by Head of the Department Principal

Syllabus for Third Year Chemical Engineering - Semester VI (Autonomous)
(Academic Year 2021-2022)

Program: Third Year Chemical Engineering	**Semester: VI**
Department Elective: Chemical Engineering Optimization	**Course Code: DJ19CHEC6013**
Department Elective: Chemical Engineering Optimization Laboratory	**Course Code: DJ19CHEL6013**

Teaching Scheme (Hours / week)				**Evaluation Scheme**						
				Semester End Examination Marks (A)			**Continuous Assessment Marks (B)**			**Total marks (A+ B)**
Lectures	**Practical**	**Tutorial**	**Total Credits**	**Theory**			**Term Test 1**	**Term Test 2**	**Avg.**	
				75			**25**	**25**	**25**	**100**
				Laboratory Examination			**Term work**		**Total Term work**	**25**
3	**2**	**--**	**4**	**Oral**	**Practical**	**Oral & Practical**	**Laboratory Work**	**Tutorial / Mini project / presentation/ Journal**		
				--	**--**	**--**	**15**	**10**	**--**	

Pre-requisite:

- DJ19FEC101 Engineering Mathematics - I
- DJ19FEC201 Engineering Mathematics - II
- DJ19FEC205 Computer Programming
- DJ19CHC502 Mass Transfer Operation-I
- DJ19CHC503 Heat Transfer Operation

Objectives:

- Solve single and multi-variable optimization problems in chemical engineering.
- Solve constrained optimization problems in chemical engineering.

Outcomes:

After completion of the course students will be able to:

- Formulate and solve single and multi-variable optimization problems in chemical engineering
- Formulate and solve typical non-linear optimization problems in chemical engineering, with and without constraints.

Detailed Syllabus: (unit wise)

Unit	**Description**	**Duration (Hrs)**
1	**Single Variable Optimization** Analytical methods, Necessary and sufficient conditions, Numerical methods, Fibonacci and Golden section methods	**10**
2	**Multi-Variable Optimization** Necessary and sufficient conditions, Examples on two variable objective functions, Numerical methods, Uni-variant search method Steepest descent method, Powell's method of Conjugate Directions	**12**

3	**Constrained Optimization** Equality constraints, Lagrange multipliers, Inequality constraints Karush–Kuhn–Tucker conditions	**10**
4	**Quadratic Programming** SQP, Flow-sheet optimization, EO based approach	**10**

Books Recommended:

Textbooks:

1. Edgar, Himmelblau and Lasdon, Optimization of Chemical Processes. McGraw-Hill Higher Education, 2nd edition, 2001.
2. Suman Dutta, Optimization in Chemical Engineering. Cambridge University Press, 2016.
3. H. M. Antia, Numerical Methods for Scientists and Engineers. Hindustan Book Agency, 3rd Edition, 2012.

Reference Books:

1. Lorenz T. Biegler, Nonlinear Programming: Concepts, Algorithms, and Applications to Chemical Processes. SIAM, 2010.
2. Gabriela Corsano, Jorge M. Montagna, Oscar A. Iribarren and Pio A. Aguirre, Mathematical Modeling Approaches for Optimization of Chemical Processes. Nova Science Publishers, 2009.

Evaluation Scheme:

Semester End Examination (A)*:*

Theory:

1. Question paper based on the entire syllabus summing up to 75 marks.
2. Total duration allotted for writing the paper is 3 hrs.

Continuous Assessment (B):

Theory:

1. Two term tests of 25 marks each will be conducted during the semester.
2. Total duration allotted for writing each of the paper is 1 hr.
3. Average of the marks scored in the two tests will be considered for final grading.

Laboratory and Tutorial: (Term work)

1. Term work shall consist of minimum five practical and minimum five tutorials from entire syllabus which are to be given at regular intervals. Total Marks: 25
2. List of Experiments and Tutorials suggested: -

1	Single variable optimization by Golden section method.
2	Single variable optimization by Fibonacci method.
3	Uni-variate search in two dimensions.
4	Steepest descent in two dimensions.
5	Conjugate directions in two dimensions.
6	Equality constraints in two dimensions.
7	Inequality constraints in two dimensions.
8	EO formulation in flow sheet optimization.
9	Sequential Modular approach in flow sheet optimization.
10	KKT conditions in n-dimensions.

The final certification and acceptance of term work will be subject to satisfactory performance of laboratory work and upon fulfilling minimum passing criteria in the term work.

Prepared by Checked by Head of the Department Principal

Syllabus for Third Year Chemical Engineering - Semester VI (Autonomous)
(Academic Year 2021 - 2022)

<table>
<tr><td colspan="8">Program: Third Year Chemical Engineering</td><td colspan="3">Semester : VI</td></tr>
<tr><td colspan="8">Department Elective: Transport Phenomena</td><td colspan="3">Course Code: DJ19CHEC6014</td></tr>
<tr><td colspan="4" rowspan="3">Teaching Scheme (Hours / week)</td><td colspan="7">Evaluation Scheme</td></tr>
<tr><td colspan="4">Semester End Examination Marks (A)</td><td colspan="3">Continuous Assessment Marks (B)</td><td rowspan="2">Total marks (A+ B)</td></tr>
<tr><td rowspan="2">Lectures</td><td rowspan="2">Practical</td><td rowspan="2">Tutorial</td><td rowspan="2">Total Credits</td><td colspan="4">Theory</td><td>Term Test 1</td><td>Term Test 2</td><td>Avg.</td></tr>
<tr><td colspan="4">75</td><td>25</td><td>25</td><td>25</td><td>100</td></tr>
<tr><td rowspan="3">3</td><td rowspan="3">2</td><td rowspan="3">--</td><td rowspan="3">4</td><td colspan="3">Laboratory Examination</td><td colspan="2">Term work</td><td rowspan="2">Total Term work</td><td rowspan="2">25</td></tr>
<tr><td>Oral</td><td>Practical</td><td>Oral & Practical</td><td>Laboratory Work and journal</td><td>Tutorial</td></tr>
<tr><td>--</td><td>--</td><td>--</td><td>10</td><td>15</td><td>--</td></tr>
</table>

Prerequisites:

- DJ19FEC101 Engineering Mathematics - I
- DJ19FEC201 Engineering Mathematics - II

Objectives:

- Understand the constitutive equations for fluid flow, heat and mass transfer
- Know the molecular transport mechanisms of fluid flow, heat and mass transfer
- Understand the use of computer algebra system to solve equations.

Outcomes:

After completion of the course students will be able to:

- Analyze the constitutive equations and solve the resulting differential equations
- Use any computer algebra system to analyze the system of equations.

Module	Contents	Contact Hours
1	**Introduction:** Importance of transport phenomena, Introduction to analogies between momentum, heat and mass transfer. Introduction of molecular and convective flux, equation of continuity, motion and energy.	6
2	**Momentum Transport:** Introduction of viscosity and mechanism of momentum transport: Newton's law of viscosity, Newtonian & Non-Newtonian fluids, Pressure and temperature dependence of viscosity, theory of viscosity of gases and liquids. Velocity distribution in laminar flow: Shell momentum balances and boundary conditions a) Flow of falling film b) Flow through the circular tube c) Flow through an annulus d) Flow in a narrow slit e) Adjacent flow of two immiscible fluids	10

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

Books Recommended:

Textbooks:

1. Bodh Raj; Introduction to Transport Phenomena, PHI Learning, First Edition.

Reference Books:

1. Bird, R.B, Stewart, W.E and Lightfoot, E.N.; Transport Phenomena, John Wiley & Sons Inc.; Second Edition.

Evaluation Scheme:

Semester End Examination (A)*:*

Theory:

1. Question paper based on the entire syllabus summing up to 75 marks.
2. Total duration allotted for writing the paper is 3 hrs.

Continuous Assessment (B):

Theory:

1. Two term tests of 25 marks each will be conducted during the semester.
2. Total duration allotted for writing each of the paper is 1 hr.
3. Average of the marks scored in the two tests will be considered for final grading.

Laboratory and Tutorial: (Term work)

1. Term work shall consist of minimum five practical and minimum five tutorials from entire syllabus which are to be given at regular intervals. Total Marks: 25

Prepared by Checked by Head of the Department Principal

Syllabus for Third Year Chemical Engineering - Semester VI (Autonomous)
(Academic Year 2021-2022)

<table>
<tr><td colspan="8">Program: Third Year Chemical Engineering</td><td colspan="4">Semester : V and VI</td></tr>
<tr><td colspan="8">Course : Innovative Product Development</td><td colspan="4">Course Code: DJ19ILL2</td></tr>
<tr><td colspan="4" rowspan="2">Teaching Scheme (Hours/week)</td><td colspan="8">Evaluation Scheme</td></tr>
<tr><td colspan="3">Semester End Examination Marks (A)</td><td colspan="4">Continuous Assessment Marks (B)</td><td rowspan="2">Total marks (A+ B)</td></tr>
<tr><td rowspan="3">Lectures</td><td rowspan="3">Practical</td><td rowspan="3">Tutorial</td><td rowspan="3">Total Credits</td><td colspan="3">Theory</td><td>Term Test 1</td><td>Term Test 2</td><td>Avg.</td></tr>
<tr><td colspan="3">--</td><td>--</td><td>--</td><td>--</td><td>--</td></tr>
<tr><td colspan="3">Laboratory Examination</td><td colspan="3">Semester review</td><td rowspan="2">Total</td><td rowspan="3">100</td></tr>
<tr><td rowspan="2">--</td><td rowspan="2">--</td><td rowspan="2">--</td><td rowspan="2">--</td><td>Oral</td><td>Practical</td><td>Oral & Practical</td><td>Review 1</td><td>Review 2</td></tr>
<tr><td>--</td><td>--</td><td>--</td><td>50</td><td>50</td><td>100</td></tr>
</table>

Objectives:

1. To acquaint the students with the process of identifying the need (considering a societal requirement) and ensuring that a solution is found out to address the same by designing and developing an innovative product.
2. To familiarize the students with the process of designing and developing a product, while they work as part of a team.
3. To acquaint the students with the process of applying basic engineering fundamentals, so as to attempt at the design and development of a successful value added product.
4. To inculcate the basic concepts of entrepreneurship and the process of self-learning and research required to conceptualise and create a successful product.

Outcome:

Learner will be able to:

1. Identify the requirement for a product based on societal/research needs.
2. Apply knowledge and skills required to solve a societal need by conceptualising a product, especially while working in a team.
3. Use standard norms of engineering concepts/practices in the design and development of an innovative product.
4. Draw proper inferences through theoretical/ experimental/simulations and analyse the impact of the proposed method of design and development of the product.
5. Develop interpersonal skills, while working as a member of the team or as the leader.
6. Demonstrate capabilities of self-learning as part of the team, leading to life-long learning, which could eventually prepare themselves to be successful entrepreneurs.
7. Demonstrate product/project management principles during the design and development work and also excel in written (Technical paper preparation) as well as oral communication.

Guidelines for the proposed product design and development:

- Students shall form a team of 3 to 4 students (max allowed: 5-6 in extraordinary cases, subject to the approval of the department review committee and the Head of the department).
- Students should carry out a survey and identify the need, which shall be converted into conceptualisation of a product, in consultation with the faculty supervisor/head of department/internal committee of faculty members.
- Students in the team shall understand the effective need for product development and accordingly select the best possible design in consultation with the faculty supervisor.
- Students shall convert the best design solution into a working model, using various components drawn from their domain as well as related interdisciplinary areas.
- Faculty supervisor may provide inputs to students during the entire span of the activity, spread over 2 semesters, wherein the main focus shall be on self-learning.
- A record in the form of an activity log-book is to be prepared by each team, wherein the team can record weekly progress of work. The guide/supervisor should verify the recorded notes/comments and approve the same on a weekly basis.
- The design solution is to be validated with proper justification and the report is to be compiled in a standard format and submitted to the department. Efforts are to be made by the students to try and publish a technical paper, either in the institute journal, "Techno Focus: Journal for Budding Engineers" or at a suitable publication, approved by the department research committee/ Head of the department.
- The focus should be on self-learning, capability to design and innovate new products as well as on developing the ability to address societal problems. Advancement of entrepreneurial capabilities and quality development of the students through the year long course should ensure that the design and development of a product of appropriate level and quality is carried out, spread over two semesters, ie during the semesters V and VI.

Guidelines for Assessment of the work:

- The review/ progress monitoring committee shall be constituted by the Head of the Department. The progress of design and development of the product is to be evaluated on a continuous basis, holding a minimum of two reviews in each semester.
- In the continuous assessment, focus shall also be on each individual student's contribution to the team activity, their understanding and involvement as well as responses to the questions being raised at all points in time.
- Distribution of marks individually for the both reviews as well as for the first review during the subsequent semester shall be as given below:
    - Marks awarded by the supervisor based on log-book : 20
    - Marks awarded by review committee : 20
    - Quality of the write-up : 10

- In the last review of the semester VI, the marks will be awarded as follows.

- Marks awarded by the supervisor (Considering technical paper writing) : 30
- Marks awarded by the review committee : 20

Review/progress monitoring committee may consider the following points during the assessment.

- In the semester V, the entire design proposal shall be ready, including components/system selection as well as the cost analysis. Two reviews will be conducted based on the presentation given by the student's team.
  - First shall be for finalisation of the product selected.
  - Second shall be on finalisation of the proposed design of the product.
- In the semester VI, the expected work shall be procurement of components/systems, building of the working prototype, testing and validation of the results based on work completed in semester V.
  - First review is based on readiness of building the working prototype.
  - Second review shall be based on a presentation as well as the demonstration of the working model, during the last month of semester VI. This review will also look at the readiness of the proposed technical paper presentation of the team.

The overall work done by the team shall be assessed based on the following criteria;

1. Quality of survey/ need identification of the product.
2. Clarity of Problem definition (design and development) based on need.
3. Innovativeness in the proposed design.
4. Feasibility of the proposed design and selection of the best solution.
5. Cost effectiveness of the product.
6. Societal impact of the product.
7. Functioning of the working model as per stated requirements.
8. Effective use of standard engineering norms.
9. Contribution of each individual as a member or the team leader.
10. Clarity on the write-up and the technical paper prepared.

- The semester reviews (V and VI) may be based on relevant points listed above, as applicable.

Guidelines for Assessment of Semester Reviews:

- The write-up should be prepared as per the guidelines given by the department.
- The design and the development of the product shall be assessed through a presentation and demonstration of the working model by the student team to a panel of Internal and External Examiners, preferably from industry or any research organisations having an experience of more than five years, approved by the Head of the Institution. The presence of the external examiner is desirable only for the 2nd presentation in semester VI. Students are compulsorily required to present the outline of the technical paper prepared by them during the final review in semester VI.

Syllabus for Third Year Chemical Engineering - Semester VI (Autonomous)
(Academic Year 2021-2022)

<table>
<tr><td colspan="8">Program: Third Year Chemical Engineering</td><td colspan="3">Semester: VI</td></tr>
<tr><td colspan="8">Course: Environmental Studies</td><td colspan="3">Course Code: DJ19A5</td></tr>
<tr><td colspan="8"></td><td colspan="3"></td></tr>
<tr><td colspan="4" rowspan="2">Teaching Scheme (Hours / week)</td><td colspan="7">Evaluation Scheme</td></tr>
<tr><td colspan="4">Semester End Examination Marks (A)</td><td colspan="3">Continuous Assessment Marks (B)</td><td rowspan="2">Total marks (A+ B)</td></tr>
<tr><td rowspan="3">Lectures</td><td rowspan="3">Practical</td><td rowspan="3">Tutorial</td><td rowspan="3">Total Credits</td><td colspan="4">Theory</td><td>Term Test 1</td><td>Term Test 2</td><td>Avg.</td></tr>
<tr><td colspan="4">-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td colspan="4">Laboratory Examination</td><td colspan="3">Term work</td><td rowspan="2">Total Term work</td><td rowspan="2">-</td></tr>
<tr><td rowspan="2">1</td><td rowspan="2">-</td><td rowspan="2">-</td><td rowspan="2">-</td><td>Oral</td><td>Practical</td><td>Oral & Practical</td><td>Laboratory Work</td><td>Tutorial / Mini project / presentation/ Journal</td></tr>
<tr><td>-</td><td>-</td><td>-</td><td>-</td><td>--</td><td>-</td></tr>
</table>

Pre-requisite:

- Interest in Environment and its impact on human
- Interest in recycling technology

Objectives:

- Understand environmental issues such as depleting resources, pollution, ecological problems and the renewable energy scenario.
- Familiarise environment related legislation**.**

Outcomes:

After completion of the course students will be able to:

- Understand how human activities affect environment
- Understand the various technology options that can make a difference.

Syllabus for Third Year Chemical Engineering - Semester VI (Autonomous)
(Academic Year 2021-2022)

Detailed Syllabus: (unit wise)		
Unit	**Description**	**Duration**
1	**Social Issues and Environment:** Ecological footprint and Carrying Capacity, Depleting nature of Environmental resources such as soil, water minerals and forests, Carbon emissions and Global Warming.	4
2	**Technological growth for Sustainable Development:** Social, Economic and Environmental aspects of Sustainable Development, Renewable Energy Harvesting, Concept of Carbon credit, Green Building, Power and functions of Central Pollution Control Board and State Pollution Control Board	5
3	**Recycling Technology:** Solid and Hazardous Waste Management and Treatment methods, Recycling methods for plastics, Wastewater Treatment	5

Books Recommended:

Textbooks:

1. Environmental Studies: From Crisis to Cure, R. Rajagopalan, 2012
2. Environmental Pollution Control Engineering, C.S.Rao
3. Textbook of Environmental Studies For Undergraduate Courses, Erach Bharucha

Reference Books:

1. “Design for Environment: A Guide to Sustainable Product Development”, Joseph Fiksel, McGraw-Hill Companies.
2. “A Handbook of Environmental Management”, Jon C. Lovett and David G. Ockwell, 2010
3. ”Introduction to Environment management” Mary K. Theodore Louis Theodore, 2013