VISVESVARAYA TECHNOLOGICAL UNIVERSITY
BELAGAVI

Scheme of Teaching and Examinations and Syllabus

M.TechCHEMICAL ENGINEERING (HCE)

(Effective from Academic year 2020 - 21)

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI

Scheme of Teaching and Examinations – 2020 - 21

M.Tech CHEMICAL ENGINEERING (HCE)

Choice Based Credit System (CBCS) and Outcome Based Education(OBE)

I SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours per Week			Examination				Credits
Sl. No	Course	Course Code	Course Title	Theory	Practical	Skill Development Activities (SDA)	Duration in hours	CIE Marks	SEE Mark	Total Marks	Credits
1	HSCE	20HCE11	MATHEMATICAL METHODS IN CHEMICAL ENGINEERING	03	--	02	03	40	60	100	4
2	PCC	20HCE12	Chemical Process Dynamics and Control	03	--	02	03	40	60	100	4
3	PCC	20HCE13	Advanced chemical thermodynamics	03	--	02	03	40	60	100	4
4	PCC	20HCE14	Transport Phenomena	03	--	02	03	40	60	100	4
5	PCC	20HCE15	Process Equipment Design	03	--	02	03	40	60	100	4
6	PCC	20HCEL16	Chemical EngineeringLaboratory-I	--	04	--	03	40	60	100	2
7	PCC	20RMI17	Research Methodology and IPR	02	--	--	03	40	60	100	2
			TOTAL	**17**	**04**	**10**	**21**	**280**	**420**	**700**	**24**

Note: PCC: Professional core.

Skill development activities:

Students and course instructor/s to involve either individually or in groups to interact together to enhance the learning and application skills. The students should interact with industry (small, medium and large), understand their problems or foresee what can be undertaken for study in the form of research/ testing / projects, and for creative and innovative methods to solve the identified problem. The students shall

(1) Gain confidence in modelling of systems and algorithms.

(2) Work on different software/s (tools) to Simulate, analyse and authenticate the output to interpret and conclude. Operate the simulated system under changed parameter conditions to study the system with respect to thermal study, transient and steady state operations, etc.

(3) Handle advanced instruments to enhance technical talent.

(4) Involve in case studies and field visits/ field work.

(5) Accustom with the use of standards/codes etc., to narrow the gap between academia and industry.

All activities should enhance student's abilities to employment and/or self-employment opportunities, management skills, Statistical analysis, fiscal expertise, etc.

Internship: All the students have to undergo mandatory internship of 6 weeks during the vacation of I and II semesters and /or II and III semesters. A University examination shall be conducted during III semester and the prescribed credit shall be counted for the same semester. Internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take-up/complete the internship shall be declared as fail in internship course and have to complete the same during the subsequent University examination after satisfying the internship requirements.

Note: (i) Four credit courses are designed for 50 hours Teaching – Learning process.

(ii) Three credit courses are designed for 40 hours Teaching – Learning process.

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M.TechCHEMICAL ENGINEERING (HCE)

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II SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week			Examination				Credits
				Theory	Practical/ seminar	Skill Development Activities (SDA)	Duration in hours	CIE Marks	SEE Marks	Total Marks	
1	PCC	20HCE21	Applied Mathematics in Chemical Engineering	03	--	02	03	40	60	100	4
2	PCC	20HCE22	Bioinstrumentation and Biosensors	03	--	02	03	40	60	100	4
3	PCC	20HCE23	Catalytic Reaction Engineering	03	--	02	03	40	60	100	4
4	PEC	20HCE24X	Professional elective 1	04	--	--	03	40	60	100	4
5	PEC	20HCE25X	Professional elective 2	04	--	--	03	40	60	100	4
6	PCC	20HCEL26	Chemical Engineering Laboratory-II	--	04	--	03	40	60	100	2
7	PCC	20HCE27	Technical Seminar	--	02	--	--	100	--	100	2
TOTAL				**17**	**06**	**06**	**18**	**340**	**360**	**700**	**24**

Note: PCC: Professional core, PEC: Professional Elective.

Professional Elective 1		**Professional Elective 2**	
Course Code under 20HCE24X	**Course title**	**Course Code under 20HCE25X**	**Course title**
20HCE241	Waste Management Techniques	20HCE251	Fuel cell Technology
20HCE242	Paints, Adhesives and Coatings	20HCE252	Air Pollution Control and Equipment
20HCE243	Multiphase Flow	20HCE253	Advanced Nanotechnology
20HCE244	Process Intensification	20HCE254	Process Integration Techniques

Note:

1. Technical Seminar: CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide, if any, and a senior faculty of the department. Participation in the seminar by all postgraduate students of the same and other semesters of the programme shall be mandatory.

The CIE marks awarded for Technical Seminar, shall be based on the evaluation of Seminar Report, Presentation skill and Question and Answer session in the ratio 50:25:25.

2. Internship: All the students shall have to undergo mandatory internship of 6 weeks during the vacation of I and II semesters and /or II and III semesters. A University examination shall be conducted during III semester and the prescribed credit shall be counted in the same semester. Internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take-up/complete the internship shall be declared as fail in internship course and have to complete the same during the subsequent University examination after satisfying the internship requirements.

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M.Tech CHEMICAL ENGINEERING (HCE)
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III SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week			Examination				Credits
				Theory	Practical/ Mini –Project/ Internship	Skill Development activities (SDA)	Duration in hours	CIE Marks	SEE Marks	Total Marks	
1	PCC	20HCE31	Modern Separation Processes	03	--	02	03	40	60	100	4
2	PEC	20HCE32X	Professional elective 3	03	--	--	03	40	60	100	3
3	PEC	20HCE33X	Professional elective 4	03	--	--	03	40	60	100	3
4	Project	20HCE34	Project Work phase -1	--	02	--	--	100	--	100	2
5	PCC	20HCE35	Mini-Project	--	02	--	--	100	--	100	2
6	Internship	20HCEI36	Internship	(Completed during the intervening vacation of I and II semesters and /or II and III semesters.)			03	40	60	100	6
TOTAL				**09**	**04**	**02**	**12**	**360**	**240**	**600**	**20**

Note: PCC: Professional core, PEC: Professional Elective.

Professional elective 3		**Professional elective 4**	
Course Code under 20XXX32X	**Course title**	**Course Code under 20XXX33X**	**Course title**
20HCE321	Fermentation Engineering	20HCE331	Chemical Process Optimization
20HCE322	Total Quality Management	20HCE332	Gasification Technology
20HCE323	Process Modeling and Simulation	20HCE333	Computational Fluid Dynamics
20HCE324	Pharmaceutical Technology	20HCE334	Food Processing & Engineering

Note:

1. Project Phase-1: Students in consultation with the guide/co-guide if any, shall pursue literature survey and complete the preliminary requirements of selected Project work. Each student shall prepare relevant introductory project document, and present a seminar.

CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide if any, and a senior faculty of the department. The CIE marks awarded for project work phase -1, shall be based on the evaluation of Project Report, Project Presentation skill and Question and Answer session in the ratio 50:25:25.

SEE (University examination) shall be as per the University norms.

2. Internship: Those, who have not pursued /completed the internship shall be declared as fail in internship course and have to complete the same during subsequent University examinations after satisfying the internship requirements. Internship SEE (University examination) shall be as per the University norms.

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IV SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week		Examination				Credits
				Theory	Practical/ Field work	Duration in hours	CIE Marks	SEE Marks Viva voce	Total Marks	
1	Project	20HCE41	Project work phase -2	--	04	03	40	60	100	20
			TOTAL	--	**04**	**03**	**40**	**60**	**100**	**20**

Note:

1. Project Phase-2:

CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide, if any, and a Senior faculty of the department. The CIE marks awarded for project work phase -2, shall be based on the evaluation of Project Report subjected to plagiarism check, Project Presentation skill and Question and Answer session in the ratio 50:25:25.

SEE shall be at the end of IV semester. Project work evaluation and Viva-Voce examination (SEE), after satisfying the plagiarism check, shall be as per the University norms.

MATHEMATICAL METHODS IN CHEMICAL ENGINEERING			
Course Code	20HCE11	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	60
Credits	04	Exam Hours	03

Course Learning Objectives: This course will facilitate the students:

- To understand advanced linear algebra and numerical/statistical methods used in chemical engineering practice.
- To learn mathematical/optimization techniques required to get an insight in various chemical engineering process.

Module-1

Linear Algebra

Introduction to vector spaces and sub-spaces, definitions, illustrative example. Linearly independent and dependent vectors- Basis-definition and problems. Linear transformations-definitions.Matrix form of linear transformations-Illustrative examples (Text Book:1)

Module-2

Orthogonality and least squares: Inner product, orthogonal sets, orthogonal projections, orthogonal bases. Gram-Schmidt orthogonalization process. QR factorizations of a metrics, least square problems, applications to linear models (least square lines and least square fitting of other curves).
(Text Book:1) (RBT Levels: **L2 & L3)**

Module-3

Solving system of linear equations: Gauss elimination, Gauss Jordan method, Iterative method: Gauss-Siedel iterative method. Optimization based solution of linear algebraic equations, examples of well conditioned and ill-conditioned linear systems.
(RBT Levels: **L1 & L2)**(Text Book:2&3)

Module-4

Roots of Equations by Numerical Methods: Newton- Raphson method, Horner's Method. Muller's method , Bairstow's (or Lin's method) , Graeffe's roots squaring method.
(RBT Levels: **L1 & L2)**(Text Book:2&3)

Module-5

Engineering Applications On:

i) Steady- state analysis of a system of reactors(Article No:12.1 P.No:309, Ref.1)
ii) Least cost design of a tank, (Article No:16.1, P.No:399, Ref.1)
iii) Integration to determine the total quantity of heat, (Article No:24.1 P.No:643, Ref.1)

(RBT Levels: **L1 & L3)**

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

1. Understand the basics of vector spaces and Gram-Schmidt process.
2. Apply the knowledge of numerical methods in modeling various Physical and engineering phenomena.
3. Use the methods of solving set of linear equations by using matrix theory.
4. To apply numerical methods to compute roots of the equations and, for solving ODE's.
5. Apply the knowledge of mathematical tools in designing of a tank, transient response of a reactor.

Question Paper Pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have **ten**full questions carrying equal marks.
- Each full question consisting of **20** marks.
- There will be **two** full questions (with a **maximum** of **four** sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer **five** full questions, selecting **one** full question from each module.
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Text Books:

1. David C.Lay, Steven R.Lay and J.J.McDonald: Linear Algebra and its Applications,
   a. 5th Edition, Pearson Education Ltd., 2015.
2. Gourdin A.and Boumhrat M. "Applied Numerical Methods", Prentice-Hall India,2000.
3. M K Jain, S.R.K Iyengar, R K. Jain, Numerical methods for Scientific and Engg Computation, New Age International, 2003.

Reference books:

1. Steven C Chapra and Raymond P Canale, "Numerical Methods for Engineers," 7th Ed., McGraw-Hill Edition, 2015.
2. B.S. Grewal: Higher Engineering Mathematics, Khanna Publishers, 44th Ed., 2017.
3. G.Strang, "Introduction to Linear Algebra", 4th Edition, Wellesley-Cambridge Press,2009.

CHEMICAL PROCESS DYNAMICS AND CONTROL			
Course Code	20HCE12	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Review of Process Dynamics: First order systems – thermometer, level tank, CSTR, Second order system – U tube manometer, mass vibrator. Control aspects of chemical unit, basic control system, negative and positive feedback control systems.

Module-2

Mechanism of Pneumatic Controllers and its dynamic behavior and Control valve: Mechanism of various controllers like, On-Off, P, PI, PD and PID. dynamicbehavior of controllers using servo and regulating problems. Pneumatic control valve, dynamic behavior of pneumatic control valve.

Module-3

Stability Analysis and Design of Control systems Using Frequency Response: Concept and Criterion of stability , Routh test, frequency response analysis – Bode diagrams – First order and second order systems. Bode diagram for P, PI, PD and PID Controllers.

Module-4

Analysis of Control Systems: Ziegler-Nichols method, Nyquest Diagram and Root Locus Diagram.

Module-5

Analysis of Advanced Control Systems: MIMO Control system, Ratio control, Adaptive control, Cascade control- cascade control of HE, Jacketed CSTR, Furnace, Distillation, Reaction curve method.

Course outcomes:

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

- Identify various types of controllers used in industry
- Develop control systems based on process parameters
- Analyze stability of an control system

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

(1)Coughnour D R, Process system analysis and control, 2nd Edition, McGraw Hill Book Company, ISBN: 0070132127 New York, 1991

(2)George Stephanopoules, Chemical process control, An Introduction to Theory and Practice,Prentice Hall India Pvt. Ltd., ISBN-10: 0131286293,New Delhi, 1998

(3) Luyben, Process Modelling, Simulation and Control for chemical Engineers, 2nd Edition, McGraw Hill Book Company, New York, 1990

Reference Books

(1)R.P. Vyas, Process control and Instrumentation, 6th Edition, Denett& Co., India, 2011.

(2)Smith C A and Corripio A B, Principles and practice of automotive process control, John Wiley, New York, 1976.

ADVANCED CHEMICAL THERMODYNAMICS			
Course Code	20HCE13	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Review of First & Second Law of Thermodynamics: First Law of Thermodynamics: General statement of First law of thermodynamics, First law of cyclic process and non – flow processes, Heat capacity. Derivation for closed system & steady state flow process-flow calorimeter & heat capacity
Second Law of Thermodynamics: General statements of the Second law, concept of Entropy, The Carnot Principle, Calculation of entropy changes, Clausius Inequality, Entropy and irreversibility, Third law of thermodynamics.

Module-2

Applications Solution Thermodynamics:Partial Molar Properties: Ideal & non ideal solutions, fugacity and it's coefficient, Determination of fugacity coefficient, Gibbs Duhem equation, azeotropic separation techniques–VLE

Module-3

Vapor Liquid Equilibrium Correlations:Correlation Techniques: Van Laar, Margules, Wilson,, NRTL and other types of correlation Equation , applications of -High pressure VLE and Partially miscible systems.

Module-4

Chemical Reaction Equilibria:-Industrial chemical reaction equilibria-homogeneous and heterogeneous systems, Effect of pressure and temperature – Complex reactions – liquid phase and vapour phase reactions.

Module-5

Third Law of Thermodynamics: Verification of third law, Applications and evaluation of Statistical Thermodynamics, Energy levels, Boltzmann Distribution Law and Partition functions.

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

- Apply basic knowledge of first, second and third law of thermodynamics
- Analyse the molar properties of solution mixture, phase equilibrium and chemical equilibrium
- Evaluate the thermodynamic consistency of chemical data and equilibrium composition of given system

Question paper pattern:
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

(1) Jefferson W. Tester, Michael Model, "Thermodynamics and Its Applications", 3rd Edition, Prentice Hall, India, 1997, ISBN 13: 9780139153563.

(2)Textbook of Chemical Engineering Thermodynamics, Narayanan, K.V., 8th Edition,Prentice Hall of India Private Limited, New Delhi, 2001, ISBN: 978-81-203-4747-2

Reference Books
(1) Chemical Engineering Thermodynamics, Sikdar D. C., Khanna Publisher, New Delhi, 2015, ISBN No.878-81-7409-254-0
(2)J.M. Smith and Van Ness H.C, Introduction to Chemical Engineering Thermodynamics"-McGraw Hills, New work, 1996, ISBN-13: 978-0071247085

TRANSPORT PHENOMENA			
Course Code	20HCE14	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Newtonian fluids, Non Newtonian Fluids, Analogies between Momentum, Heat and Mass Transport, Rheological behavior of fluids, Differential balance equations for heat , mass and momentum

Module-2

Steady state Shell momentum balances, Boundary conditions applicable to momentum transport problems (flow over flat plate, flow through circular tube and annulus).

Module-3

Friction factor(qualitative treatment only) Introduction to velocity distributions in Turbulent flow (Fluctuations and Time smooth Quantities) and Equation of Change for Isothermal system(Equation of Continuity and Motion), Formation of bubbles and drops and their size distribution, Solid-fluid systems - forces acting on stagnant and moving solids.

Module-4

Heat Transfer coefficient, Free and Forced convection, film type and drop wise condensation and equations for heat transfer coefficients for both, Heat transfer in boiling liquids.
The spectrum of electromagnetic radiation, absorption and emission at solid surfaces, Planck's distribution law, Wein's displacement law and Stefan- Boltzmann law, Lambart's cosine law, heat exchange by radiation between two black surface elements.

Module-5

Introduction to Mass Transport: Fick's law of diffusion, mass transfer co-efficient, Shell mass balance techniques (Diffusion with homogeneous and heterogeneous chemical reaction).

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

- Comprehend basics of transport operations and its applications
- Apply the mathematical techniques to solve simple mass, momentum and heat transport problems in a simplified way
- Comprehend basic principle of radiation mode of heat transfer

Question paper pattern:
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

(1).Bird R.B., W.E. Stewart and E.N. Lightfoot, Transport Phenomena, John Wiley and Sons, Academic Press, 2007 ISBN-o-470011539-4

(2)Welty, J.R., C.E. Wicks and R.E. Wilson, Fundamental of Momentum, Heat and Mass Transfer, 4th Edn., John Wiley & Sons, New York, 2014 ISBN 978-1-118-80887-0.

Reference Books

(1) Sissom L.E. and D.R.Pitts, Elements of Transport Phenomena, McGraw Hill Book Company, New York, 1972

(2)Brodkey R.S. and H.C.Hershey, Transport Phenomena - A Unifed Approach, McGraw Hill Book Company, 1988 ISBN- 0-07-100152-2

PROCESS EQUIPMENT DESIGN			
Course Code	20HCE15	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Detailed Engineering & Process and Mechanical aspects and sketches with sectional front view full top and side view of Double pipe heat exchanger

Module-2

Detailed Engineering & Process and Mechanical aspects and sketches with sectional front view full top and side view of shell and tube heat exchanger

Module-3

Detailed Engineering & Process and Mechanical aspects and sketches with sectional front view full top and side view of horizontal and vertical condensor

Module-4

Detailed Engineering & Process and Mechanical aspects and sketches with sectional front view full top and side view of evaporator

Module-5

Detailed Engineering & Process and Mechanical aspects and sketches with sectional front view full top and side view of bubble cap distillation column and Absorption column

Course outcomes:

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

- Design DPHE, STHE, condenser & evaporators
- Process Design Bubble cap distillation column for binary and multi-component systems
- Process Design of Absorption column for given equilibrium conditions

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have TWO questions
- Each full question consisting of 100 marks. Students have to answer anyone full question
- There will be two full questions (with a maximum of four sub questions) from each module.
- Use of Chemical Engineers handbook-Perry & Green and IS codebooks IS 2g25 and4503 are permitted in the final examination and Internal tests.

Textbook/ Textbooks

(1).Kern. D. Q. Process Heat Transfer, McGraw Hill Book Company, 2008

(2) B.I. Bhatt &Thakore, Introduction to Process Design Equipment, Tata McGraw Hill Book Company, New Delhi, 2007

(3) V. V. Mahajani and S. B. Umaeji, 4th Edition, Joshes' Process Equipment design MacMillan Publications India Ltd, New Delhi, 2009

Reference Books

(1) Coulson and Richardson, Chemical Engineering Design, Vol.6, Butter-Worth Heinemann Ltd., New York, 2005

(2)Don W. Green & Robert H. Perry, Perry's Chemical Engineering Hand Book, 8th Edition, McGraw Hill Book Company, 2008

CHEMICAL ENGINEERING LABORATORY - I			
Course Code	20HCEL16	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	0:4:0	SEE Marks	60
Credits	02	Exam Hours	03

Sl. NO	Experiments
1	Tank system Response
2	Response of a second order system
3	Control valve Characteristics of and controller response
4	Plate type heat exchanger
5	Shell and tube heat exchanger
6	Heat transfer to boiling liquids
7	Friction in Pipe Fittings
8	Centrifugal Pump
9	Atomic Absorption spectrophotometer
10	Ultraviolet spectrophotometer

Course outcomes:

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

- Analyze the role of various control actions
- Analyze the dynamic behavior of a first order and second order system
- Determine heat transfer coefficients for a given fluid using heat transfer equipment

RESEARCH METHODOLOGY AND IPR			
Course Code	20RMI17	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	1:0:2	SEE Marks	60
Credits	02	Exam Hours	03

Module-1

Research Methodology: Introduction, Meaning of Research, Objectives of Research, Motivation in Research, Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Research and Scientific Method, Importance of Knowing How Research is Done, Research Process, Criteria of Good Research, and Problems Encountered by Researchers in India.

Defining the Research Problem: Research Problem, Selecting the Problem, Necessity of Defining the Problem, Technique Involved in Defining a Problem, An Illustration. ■

Module-2

Reviewing the literature: Place of the literature review in research, Bringing clarity and focus to your research problem, Improving research methodology, Broadening knowledge base in research area, Enabling contextual findings, How to review the literature, searching the existing literature, reviewing the selected literature, Developing a theoretical framework, Developing a conceptual framework, Writing about the literature reviewed.

Research Design: Meaning of Research Design, Need for Research Design, Features of a Good Design, Important Concepts Relating to Research Design, Different Research Designs, Basic Principles of Experimental Designs, Important Experimental Designs. ■

Module-3

Design of Sampling: Introduction, Sample Design, Sampling and Non-sampling Errors, Sample Survey versus Census Survey, Types of Sampling Designs.

Measurement and Scaling: Qualitative and Quantitative Data, Classifications of Measurement Scales, Goodness of Measurement Scales, Sources of Error in Measurement Tools, Scaling, Scale Classification Bases, Scaling Technics, Multidimensional Scaling, Deciding the Scale.

Data Collection: Experimental and Surveys, Collection of Primary Data, Collection of Secondary Data, Selection of Appropriate Method for Data Collection, Case Study Method. ■

Module-4

Testing of Hypotheses: Hypothesis, Basic Concepts Concerning Testing of Hypotheses, Testing of Hypothesis, Test Statistics and Critical Region, Critical Value and Decision Rule, Procedure for Hypothesis Testing, Hypothesis Testing for Mean, Proportion, Variance, for Difference of Two Mean, for Difference of Two Proportions, for Difference of Two Variances, P-Value approach, Power of Test, Limitations of the Tests of Hypothesis.

Chi-square Test: Test of Difference of more than Two Proportions, Test of Independence of Attributes, Test of Goodness of Fit, Cautions in Using Chi Square Tests. ■

Module-5

Interpretation and Report Writing: Meaning of Interpretation, Technique of Interpretation, Precaution in Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports, Oral Presentation, Mechanics of Writing a Research Report, Precautions for Writing Research Reports.

Intellectual Property: The Concept, Intellectual Property System in India, Development of TRIPS Complied Regime in India, Patents Act, 1970, Trade Mark Act, 1999,The Designs Act, 2000, The Geographical Indications of Goods (Registration and Protection) Act1999, Copyright Act,1957,The Protection of Plant Varieties and Farmers' Rights Act, 2001,The Semi-Conductor Integrated Circuits Layout Design Act, 2000, Trade Secrets, Utility Models, IPR and Biodiversity, The Convention on Biological Diversity (CBD) 1992, Competing Rationales for Protection of IPRs, Leading International Instruments Concerning IPR, World Intellectual Property Organisation (WIPO),WIPO and WTO, Paris Convention for the Protection of Industrial Property, National Treatment, Right of Priority, Common Rules, Patents, Marks, Industrial Designs, Trade Names, Indications of Source, Unfair Competition, Patent Cooperation Treaty (PCT), Advantages of PCT Filing, Berne Convention for the Protection of Literary and Artistic Works, Basic Principles, Duration of Protection, Trade Related Aspects of Intellectual Property Rights(TRIPS) Agreement, Covered under TRIPS Agreement, Features of the Agreement, Protection of Intellectual Property under TRIPS, Copyright and Related Rights, Trademarks, Geographical indications, Industrial Designs, Patents, Patentable Subject Matter, Rights Conferred, Exceptions, Term of protection, Conditions on Patent Applicants, Process Patents, Other Use without Authorization of the Right Holder, Layout-Designs of Integrated Circuits, Protection of Undisclosed Information, Enforcement of Intellectual Property Rights, UNSECO.■

Course outcomes:

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

- Discuss research methodology and the technique of defining a research problem
- Explain the functions of the literature review in research, carrying out a literature search, developing theoretical and conceptual frameworks and writing a review.
- Explain various research designs, sampling designs, measurement and scaling techniques and also different methods of data collections.
- Explain several parametric tests of hypotheses, Chi-square test, art of interpretation and writing research reports
- Discuss various forms of the intellectual property, its relevance and business impact in the changing global business environment and leading International Instruments concerning IPR.■

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbooks

(1) Research Methodology: Methods and Techniques, C.R. Kothari, Gaurav Garg,New Age International,4th Edition, 2018.

(2) Research Methodology a step-by-step guide for beginners. (For the topic Reviewing the literature under module 2), RanjitKumar,SAGE Publications,3rd Edition, 2011.

(3) Study Material (For the topic Intellectual Property under module 5), Professional Programme Intellectual Property Rights, Law and Practice, The Institute of Company Secretaries of India, Statutory Body Under an Act of Parliament, September 2013.
Reference Books
(1) Research Methods: the concise knowledge base, Trochim, Atomic Dog Publishing, 2005.
(2) Conducting Research Literature Reviews: From the Internet to Paper, Fink A, Sage Publications, 2009.

*** END OF I SEMESTER ***

APPLIED MATHEMATICS IN CHEMICAL ENGINEERING			
Course Code	20HCE21	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Probability and sampling theory: Definitions, Conditional probability,Probability Distributions-Bernoulli, Binomial, Poisson, uniform, exponential, normal and gamma. Random samples, central limit theorem, X2, t and F distributions. Estimation-point estimation, unbiasedness and consistency. Hypothesis testing-types of errors, significance level, Test concerning single mean, single variance and two means and two variance. Goodness of fit test.

Module-2

Design and analysis of experiments: Treatment and interpretation on engineering data: Curve fitting, Non-linear least square regression. Interpolation: Newton's Forward/Backward interpolation formula, Lagrange's interpolation formula and experiments their application.

Module-3

Numerical solution of linear & nonlinear algebraic equations: Linear systems of equations, solutions by Creamer's Rule, Matrix methods, Gaussian, Gauss-Jordan, Jacobean, Gauss-Seidel and Relation methods. Formulation of linear and non-linear first and second order ordinary differential equations, higher order linear, differential equations for systems involving momentum, heat and mass transfer with and without chemical reactions and their analytical solutions.

Module-4

Numerical solution of ordinary differential equations: Ordinary differential equations: Runge-Kutta, Euler's and Milne's predictor corrector methods. Solution of boundary value problems.

Module-5

Partial differential equations: Solutions of elliptic, parabolic, and hyperbolic types of equations by Finite differences method

Course outcomes:

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

- Solve problems related to probability theory
- Apply numerical methods to solve ordinary differential equations
- Apply finite difference method to solve parabolic, hyperbolic and elliptic types of equations
- Apply matrix methods to solve problem involving linear equations.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

(1) Sheldon M. Ross, Introduction to Probability and Statistics for Engineers and Scientists,John Wiley& Sons, New York, 1989. ISBN-13: 978-0123704832

(2) Jain M.K., Numerical Solution of differential equations, Wiley Eastern Publishers, NewDelhi, 1987, ISBN No. 0-85226-432-1

Reference Books

(1) H.S. Mickley, T. K. Sherwood and C.E. Reid, “Applied Mathematics in Chemical Engineering”, 2nd Edn., Tata McGraw Hill, New Delhi, 1978. ISBN 0-471-30377-1 1.

(2) Smith G.D., Numerical Solution of partial differential equations, Oxford UniversityPress, London, 1978, ISBN-13: 978-0198596509 York, 2005.

BIOINSTRUMENTATION AND BIOSENSORS			
Course Code	20HCE22	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Basic concept of biomedical instrumentation: Generalized medical Instrumentation System, Medical Measurement constraints, Classification of Biomedical Instruments, Generalized static and dynamic characteristics, Design criteria.

Module-2

Analytical instruments in Biomedical Engineering: Chromatography, Electrophoresis oximeter, spectrophotometer, colorimeter, blood gas analyzer, blood cell counter. , Applications to biomedical systems.

Module-3

Introduction: Overview of Biosensors, Fundamental elements of biosensor devices, advantages and limitations, components of biological elements and their immobilization techniques. Desired characteristics of biosensors: reliability, simplicity, cost, and related parameters.

Module-4

Transducers in biosensor: Choice of Transduction Parameter, types of transducer- resistive, conductive, inductive, Photoelectric, piezoelectric and mechano-electronics. Biochip – introduction - Gene chip, Cantilever based chemical sensors - AFM, FAB.

Module-5

Potentiometric sensors &amperometric sensors: Define Electric Potential, Measuring electrode potential -glass electrode, Ion-selective electrodes - Measurement Considerations - Potentiometric solid-state sensors .The working of Potentiostat - Amperometric Oxygen Sensor Semiconductor Gas Sensors.

Course outcomes:

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

- Apply the principles of analytical techniques to detect biomolecules
- Apply the principles of analytical techniques to predict the behaviour of biomolecules
- Apply the Chemical Engineering principles to design and develop bio sensors.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

(1) Fundamentals Of Bioanalytical Techniques And Instrumentation, Sabari Goshal, Srivastava A K, PHI Learning, ISBN: 978 – 81- 203 – 3855 - 5

(2) Instrumental Methods of Analysis in Biotechnology, Dinesh Kumar Chatanta, Prahlad Singh Mehra, IK Internation Publishing House Pvt Ltd, 2012, ISBN 978–93–81141–38-0

Reference Books

(1) Principles And Techniques Of Biochemistry And Molecular Biology, Keith Wilson And John Walker, Seventh Edition, Cambridge University Press 2010, ISBN 978-0-521-51635-8

(2) Bioanalytical Techniques, AbhilashaShourie and Shilpa S Chapadgaonkar, The Energy and Resources Institute, 2015, ISBN: 978 – 81 – 7993 – 529 - 3

CATALYTIC REACTION ENGINEERING			
Course Code	20HCE23	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Industrial Catalysis: Classification on catalyst- homogeneous ,heterogeneous, Biocatalysts, Typical industrial catalytic processes, preparation of catalysts- laboratory techniques, Industrial methods, Transition models, dual functional catalysts, zeolites, Enzymes, Solid Supportive materials, Catalyst activation.

Catalyst Characterization: Surface area measurements, BET Theory, pore size distribution, Porosity-Chemisorption techniques, Static and dynamic methods, Crystallography and surface analysis techniques, XRD, XPS,ESCA, ESR, NMR, Raman and Molecular spectroscopies, Surface acidity and toxicity, activity, life time, Bulk density, Thermal stability Kinetics of Heterogeneous Reactions(catalytic): Catalytic Reactions, Rate controlling steps, Langmuir - Hinshelwood model, Riedel – Eiley Mechanism.

Module-2

Catalyst Deactivation: Poisons, Sintering of catalysts, pore mouth plugging and uniform poisoning models, Kinetics of deactivation, Catalyst regeneration.

Module-3

Heterogeneous Reactions (non catalytic): Introduction, non catalytic fluid fluid reactions. Non catalytic fluid solid reactions & models for such reactions to determine time of conversion.

Module-4

Non ideal reactor analysis: Mixing concepts, Residence Time Distribution, Response measurements, Segregated flow model, Dispersion model, Series of stirred tanks model, Recycle reactor model, Analysis of non-ideal reactors, Two parameter model for CSTR.

Module-5

External Diffusion Effects in Heterogeneous Reactions: surface kinetics& pore diffusion effects, Evaluation of effectiveness factor, Design of reactors for heterogeneous Catalytic & Non catalytic Reactions: Design of reactors for non-catalytic fluid-fluid and fluid- solid reactions.

Course outcomes:

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

- Explain the application of catalysts for industrial purposes
- Explain the kinetics of catalyst deactivation and various techniques used in catalyst characterization
- Explain design concepts of heterogeneous reaction systems.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

(1) Octave Levenspiel, Chemical Reaction Engineering, 3rd Edition, Johnwiley and sons, New York, 1999 ISBN 978-0-471-25424-9

(2) Emmett, P.H., Catalysis Vols. I & II,Reinfold Publishing Corpoartion, New York, 1954.

(3) Fogler H.S, Elements of Chemical Reaction Engineering, Prentice Hall, New York, 1986 4th edition ISBN 10:0130473944,13:007-6092027737.

Reference Books
(1) Smith J.M, Chemical Engineering Kinetics, 3rd Edition, McGraw- Hill Book Company, New York, 2014 ISBN 10:9332902631,13: 9789332902633.
(2) Bischoff and Froment, Chemical Reactor Design and Analysis, Addision Wesley, New York, 3rd edition 2011 ISBN 978-0-470-56541-4.
(3) Uzi Mann, Principles of chemical Reactor analysis, John wiley and sons, New York, 2009 ISBN 978-0-471-26180-3.

WASTE MANAGEMENT TECHNIQUES			
Course Code	20HCE241	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	0:4:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Introduction to Waste water: Ecosystem, characteristics, standards, effects of waste water on health, ecosystem, and materials.
Physical Treatment Methods: Introduction to Screening, flow equalization, flocculation, Grit removal, sedimentation, flotation.
Chemical Treatment Methods: Introduction to coagulation, precipitation, oxidation, Neutralization, chlorination. Detailed study on phosphorous and heavy metals removal.

Module-2

Biological Treatment: Introduction to Bacterial life cycle, cell culturing, types of biological processes. Anaerobic Process: Construction and working of UASBR, Rotating biological contactors. Algal ponds, Hyacinth and Duckweed, fish ponds.

Module-3

Aerobic process. Theory of aeration, factor affecting oxygen transfer, Mixing requirements, types of aerators. Nitrification & Denitrification. Detailed study on Activated sludge process & Trickling filter.

Module-4

Solid waste Management: sources, characteristics, present techniques of solid waste management, integrated solid waste management, Measures and methods to assess solid waste quantities. Functional elements, Generation of solid waste, Onsite handling. Collection SCS, HCS, and separation processes, source reduction, 3R's.

Module-5

Solid Waste Transformation: Thermal conversion techniques Pyrolysis, Gasification, waste to energy, composting.
Disposal: Site selection, landfill and engineering landfill, Leachate and gas collection. Industrial Regulations pertaining to waste water and solid waste.

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

- Differentiate conventional and nonconventional treatment processes for the waste water and solid wastes
- Apply design principles for construction of wastewater treatment processes
- Analyze and apply suitable techniques for solid waste collection and disposal.

Question paper pattern:
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

(1) Arecivala S.J. and S.R.Asolekar, Wastewater Treatment for Pollution Control and Reuse, 3rd Edition, ISBN 13-978-0-07-062099-5Tata McGraw Hill Pvt. Ltd., New Delhi, 2009.

(2) George Tchobanoglous et al, Integrated Solid Waste Management, 2nd Edition, ISBN 10.0070632375 McGraw Hill Book Company, New York, 1993.

Reference Books

(1) Metcalf and Eddy, Wastewater Engineering -Treatment, Disposal & Reuse, ISBN 0070418780 Tata McGraw Hill, Book Company, New Delhi, 1991.

(2) C S Rao Environmental Pollution Control and Engineering, ISBN 0470217634 New age international Pvt. Ltd New Delhi, 2009.

PAINTS, ADHESIVES AND COATINGS			
Course Code	20HCE242	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	0:4:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Industrial Paint resins: Synthesis, properties, formulations and applications of paints and coatings of the following resins to be discussed. Alkyds and polyesters, phenol formaldehyde, polyurethanes, epoxy resin.

Industrial paint Resins: acrylic resins, chlorinated rubber, silicone resin.

Pigments and Pigment Dispersion: Manufacturing and properties of organic and inorganic pigments. Factors affecting dispersions, preparation of pigment dispersion, grinding equipment.

Module-2

Painting Processes:

(a)Surface preparation: mechanical cleaning, solvent cleaning, alkali cleaning and acid pickling. Chemical conversion treatment.

(b) Paint application: mechanism of film formation (i) Applying processes: brushing, dip coating and flow coating, curtain coating, roller coating and spray painting. (ii) Fixation (iii) Curing: Physical, chemical and oxidative

(c) Factors affecting coating properties. Testing, Evaluation and Application of Paints: Mechanical, optical, flammability and environmental properties, Applications such as Appliance finishes, automotive finishes, coil coating, can coating, marine coating and aircraft coating.

Module-3

Introduction to Adhesives: Advantages and disadvantages of adhesive bonding, theories of adhesive action, requirements of good bond, mechanism of bond failure, classification of adhesives.

Adhesive Bonding Process and Types of Adhesives: Design of joints, surface preparation (for metals, plastics, elastomers and others), General composition of adhesives, measuring and mixing, applying formulation.

Module-4

Adhesive Polymers- Structural adhesives: Epoxies, PF, UF, MF.

Non structural adhesives: Natural rubber (NR), poly ester based (unsaturated polyester), silicone, acrylics (reactive, aerobic, anaerobic and cyano acrylics), polyurethane, poly vinyl acetate and ethylene vinyl acetate copolymer.

Properties and Selection of Adhesives: Environmental properties of adhesives: Effect on temperature, humidity, weathering, chemicals and solvents, vacuum and radiation (a) Factors affecting on selection, (b) Adhesives for metals, (c) Adhesives for plastics,(d) Adhesives for Elastomers, (e) Adhesives for wood and (f) Adhesives for glass.

Module-5

Testing, Quality Control and Application of Adhesives: Tensile test, T-peel test, lap shear test, cleavage test, fatigue test, impact test, creep test, environmental tests and methods of quality control. Application of adhesives in electrical and electronic industry, wood industry, bio adhesive in drug delivery, dentistry and automobile industry.

Course outcomes:

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

- Explain ingredients in paints and their characteristics,
- Explain various methods used in application and testing paints
- Explain role of adhesives, ingredients, mechanism of bonding and its failure
- Basic principles of adhesives, types of adhesives, basic bonding process and quality test methods necessary in testing adhesives for various applications

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

(1) R. Lambourne and T. A. Strivens, Paint and Surface coatings, Woodhead Publishing Ltd., ISBN 1884207731, 9781884207730 Cambridge, 1987.

(2) Wicks Z. W. Jr. Et al. Organic coatings- Sicence and Technology, 3rd Edition, Wiley and Sons , ISBN 0471698067, 9780471698067 New York, 2007.

Reference Books

(1) Pizzi A. and Mittal K. L., Handbook of Adhesive Technology, Taylor &Francis, ISBN 0203912225, 1996.

MULTIPHASE FLOW			
Course Code	20HCE243	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	0:4:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Multiphase Flow Scope and Significance of multiphase flows – Dimensionless numbers in multiphase flow – Flow pattern and Flow regimes: Fluid-Solid System, Fluid-Fluid Systems, Solid-Fluid-Fluid systems.

Module-2

Flow Classification Two phase Co-current flow of Gas-Liquid, Gas-Solid and Liquid-Liquid, Upward and Downward flow in vertical pipes -- Suspensions of Solid and their transport in Horizontal pipes -- Drag Reduction Phenomena, Laminar, Turbulent and Creeping Flow regimes.

Module-3

Mixing Power Correlations Theories of intensity and scale of turbulence – Calculation of circulation velocities and power consumption in agitated vessels for Newtonian and Non-Newtonian Fluids – Blending and Mixing of phases – Power requirement for aeration to suspend to an immiscible liquid or solids in slurry reactors, prediction of optimum speed of impeller Rotor and design criteria for scale up.

Module-4

Quantification of Flow system Prediction of holdup, pressure drop and bubble size in pipe flow - Lockhart - Martinelli Parameters, Bubble column and its design aspects; Flow through packed bed and fluidized bed, Minimum carryover velocity – Holdup Ratios, Pressure drop and transport velocities and their prediction – Solid Fluid Conveying and Settling.

Module-5

Flow in Three Phase Systems Gas Solid and Liquid composites in slurries in Horizontal pipes, Flow through porous media of composite mixtures, Prediction of holdup, pressure drop and throughput velocities in three phase system – Design of multiphase contactors involving Solids, Liquids and Gases.

Course outcomes:

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

- Explain flow regimes encountered in flow of two phase systems and flow maps
- Predict pressure drop and power required for agitation of two phase systems
- Comprehend behavior of packed bed and bubble column systems under different operating regimes.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

(1) Gover. G. W. and Aziz K., The Flow of Complex Mixture in Pipes, Richardson Tex: Society of Petroleum Engineers 2008, ISBN 0882755471.

(2) Wallis, G. B., One Dimensional Two Phase Flow Mc Graw Hill Book Co., ISBN 0070679728, New York, 1969.

(3) John G Collier and John R Thome, Convective Boiling and Condensation, Oxodfor University Press, 3rd Edition, ISBN 9780198562962, 2002

Reference Books

(1) Brodkey, R. S., The Phenomena of Fluid motions, Addision-Weselely ISBN 0486686051, New York, 1967.

(2) Hestroni, G., (Ed.,) Hand Book of Multiphase Sysems, Hemisphere Pulbishing, Washington, ISBN 9780070284609, 1982.

PROCESS INTENSIFICATION			
Course Code	20HCE244	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	0:4:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

History, philosophy and principles of process intensification (PI): Introduction, philosophy and opportunities of PI, Types of PI equipment-Equipment and methods.

Module-2

High gravity in chemical processing: Historical development, Fundamentals, mechanical design, applications, scale-up and commercial use, future, The spinning disc reactor.

Module-3

Multifunctional heat exchanger: Introduction, Compact heat exchanger technology, single-phase flow, heat transfer and mass transfer, applications.

Module-4

Micro-reaction technology: Micro-technology, effect of miniaturization, micro fabrication, implementation.

Module-5

Structured catalysis and reactors: Introduction, overview of structured reactors, Gas phase reactions, multiphase reactions.

Course outcomes:

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

- Explain the need for process intensification and its role in chemical engineering
- Principles beyond new techniques and their application in various process operations
- Principles and significance of multi heat exchanger, micro reactors
- Explain structured reactors and their design for multiphase reactions.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

(1) Reengineering the chemical processing plant, Andrej Stankiewiez, Jaco A., Moulin, Marcel Dekker Inc., ISBN 978-082474302, New York, Basel

Reference Books

(1) Microreactors, Ehrfel W., Hessel V., Lowre H., Weinheim: ISBN 978-3-11-036707-2, Wiley-VCH, 2000.

(2) Conceptual design of chemical processes, J. M. Douglas, McGraw Hill Book Company, ISBN 0071001956, New York, 1988

FUEL CELL TECHNOLOGY			
Course Code	20HCE251	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	0:4:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Overview of fuel cells: Introduction to fuel cells and their characteristics – Classification Low and high temperature fuel cells.

Module-2

Fuel cell thermodynamics: Heat, work potentials, prediction of reversible voltage, fuel cell efficiency.

Module-3

Fuel cell reaction kinetics: Electrode kinetics, over voltages, Tafel equation, charge transfer reaction, exchange currents, electro-catalyses - design, activation kinetics, Fuel cell charge a n d mass transport - flow field, transport in electrode and electrolyte.

Module-4

Fuel cell characterization: In-situ and ex-situ characterization, techniques, i-V curve, frequency response analyses; Fuel cell.

Module-5

Balance of plant: Hydrogen production from renewable sources and storage; safety issues, cost expectation and life cycle analysis of fuel cells.

Course outcomes:

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

- Explain fuel cell, its role and its working principle
- Select suitable materials for electrode, catalyst and membrane for the fuel cell
- Estimate mass transfer process such as pressure drop and velocity distribution in single cell as well as stacked cell arrangement.
- Design fuel cell by stack making process for real field applications.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

(1) O 'Hayre, R. P., S. Cha, W. Colella, F. B. Prinz, Fuel Cell Fundamentals, Wiley & Sons, ISBN 1119114209 New York, 2006.

(2) Bard, A. J. , L. R., Faulkner, Electrochemical Methods, Wiley, ISBN 0471043729 New York, 2004.

Reference Books

(1) Basu, S. (Ed) Fuel Cell Science and Technology, Springer, ISBN 935214080X New York, 2007.

(2) Liu, H., Principles of fuel cells, Taylor & Francis, ISBN-13: 9781591690221, New York, 2006.

AIR POLLUTION CONTROL AND EQUIPMENT			
Course Code	20HCE252	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	0:4:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Introduction: Definition and concentrations, classification and properties of air pollutants, emission sources-natural and anthropogenic sources, effects of air pollution on flora and fauna, human health and materials. Photochemical smog. Air Pollution Laws and Standards.

Module-2

Meteorological aspects of air pollution: Dispersion- Temperature lapse rates and stability, wind velocity and turbulence, plume behavior, dispersion of air pollutants, solutions to atmospheric dispersion equation, the Gaussian plume model, effective stack height.

Module-3

Air Pollution Sampling and Measurements: Types of pollution sampling and measurements, ambient air sampling, Collection of gaseous air pollutants, collection of particulate pollutants, stack sampling, analysis of air pollutants like sulphur dioxide, nitrogen oxide, carbon monoxide, oxidants and ozone, hydrocarbon, particulate matter.

Module-4

Air Pollution Control Methods and Design of Equipments: Control methods, source correction methods, cleaning of gaseous effluents, Particulate Emission Control: Gravitational settling chambers, cyclone separators, bag house filters, electrostatic precipitators, wet scrubbers, Selection of particulate collector.

Module-5

Control of Gaseous Emissions: Absorption by liquids, adsorption by solids, combustion. Air pollution control in specific industries: control of sulphur dioxide, nitrogen dioxides, carbon monoxides and hydrocarbon emissions. Acid rain, green house effects, important air pollution episodes.

Course outcomes:

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

- Differentiate various air pollutants their formation, sources and effects on living and non-living things
- Explain methods of air pollution sampling and its measurement
- Explain salient features important laws enacted to protect environment
- Apply the principles in design of design of air pollution control equipment

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

(1) C S Rao, Environmental Pollution Control Engineering, New Age International Publishers, ISBN 0470217634, 9780470217634 New Delhi, 2010.

(2) Mudakavi J.R, Principles and Practices of Air Pollution Control and Analysis, I.K. International Publishing Home Pvt. Ltd., ISBN 978-93-80026-38-1 New Delhi, 2010.

Reference Books

(1) Martin Crawford, Pollution control theory, McGraw Hill Book Company, ISBN 0070134901, 9780070134904 New York, 1976.

(2) Joe Ledbetter, Air Pollution Part A&B, Marcel Dekker, ISBN 0824714067, 9780824714062 New York, 1972.

(3) Cheremissinoff N, Air Pollution Control Design Hand Book, Part I and II, Marcel Dekker, ISBN 0824764447, 978082476444 New York, 1977.

ADVANCED NANOTECHNOLOGY			
Course Code	20HCE253	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	0:4:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

The science of miniaturization Moore's Laws (1,2,&3) and technology' Roadmap–clean rooms Processing Methods: Cleaning – Oxidation – Lithography – Etching- – CVD - Diffusion – Ion implantation – metallization – state of the art CMOS architectures Photolithography Overview – Critical Dimension – Overall Resolution – Line-Width – Lithographic Sensitivity and Intrinsic Resist Sensitivity (Photochemical Quantum Efficiency) – Resist Profiles – Contrast and Experimental Determination of Lithographic Sensitivity – Resolution in Photolithography – Photolithography Resolution Enhancement Technology.

Module-2

Physico-chemical methods of nanostructured material synthesis Chemical Methods: Metal Nanocrystals by Reduction - Solvothermal Synthesis- Photochemical Synthesis - Sonochemical Routes- Chemical Vapor Deposition (CVD) – Metal Oxide - Chemical Vapor Deposition (MOCVD).Physical Methods:Ball Milling – Electrodeposition - Spray Pyrolysis - Flame Pyrolysis - DC/RF Magnetron Sputtering - Molecular Beam Epitaxy (MBE).

Module-3

Characterization of nanophase materials: Fundamentals of the techniques – experimental approaches and data interpretation – applications/limitations of Xray characterization: – X-ray sources – wide angle, extended x-ray absorption technique – Electron microscopy: SEM/TEM – high resolution imaging – defects in nanomaterials – Spectroscopy: – electron energy-loss mechanisms – electron filtered imaging – prospects of scanning probe microscopes – optical spectroscopy of metal/semiconductor nanoparticles.

Module-4

Carbon nanotubes: Carbon materials – Allotropes of carbon – Structure of carbon nanotubes – Types of CNTs – Electronic properties of CNTs – Band structure of Graphene – Band structure of SWNT from graphene – Electron transport properties of SWNTs – Scattering in SWNTs – Carrier mobility in SWNTs.

Module-5

Application of Nanotechnology: Nanotechnology in electrical and electronics industry : Advantages of nano electrical and electronic devices –Sensors, Actuators, Optical switches, Bio-MEMS ,Nanotechnology in biomedical and pharmaceutical industry Nanosensors in Diagnosis– Neuro-electronic Interfaces – Protein Engineering – Drug delivery – Therapeutic applications - Nanotechnology in chemical industry Nanocatalyts Molecular Encapsulation and its applications Nanoporous zeolites – Self-assembled Nanoreactors - Organic electroluminescent displays Nanotechnology in Food industry - Packaging, Food processing - Food safety and biosecurity – Contaminant detection – Smart packaging.

Course outcomes:

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

- Comprehend basics of Nanomaterials and Nanotechnology and synthesis of nanomaterials
- Comprehend basics and synthesis of carbon nanomaterials
- Comprehend characterization methods for nanomaterials

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

(1) Introduction to nanotechnology, Charles P. Poole Jr and Frank J. Owens, Wiley India Pvt Ltd, 1st edition, 2003.
(2) Nano:The essentials: Understanding nanoscience and nanotecnology, T. Pradeep, Tata McGraw-Hill Publishing company limited, New Delhi, 2008.
Reference Books
(1) Rao C. N., A. Muller, A. K. Cheetham, "Nanomaterials Chemistry", Wiley- VCH ,2007.
(2) Gustaaf V. Tendeloo, Dirk van Dyck, Stephen J. Pennycook, Handbook of Nanoscopy Wiley publication, 2012

PROCESS INTEGRATION TECHNIQUES			
Course Code	20HCE254	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	0:4:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

The nature of Chemical Process Design and Integration: Formulation,Hierarchy, approaches.Thermodynamic properties and phase equilibria: Equations of state,Fugacity, VLE, LLE, Calculation of enthalpy, entropy, simple problems.

Module-2

Energy targets: Composite curves, Temperature interval diagram, process constraints, Grand composite curve, simple Problems.

Module-3

Network design: Pinch design method. Minimum no of heat exchangers, breaking of heat loop, Stream splitting, No of heat exchanger units, heat exchange area targets Simple problems.

Module-4

Mass exchangers, types, cost optimization of mass exchangers, Mass integration strategies, Mass exchange Pinch diagram, Composition interval diagram, simple problems.

Module-5

Application of process integration concepts in minimum water usage, pinch technology for wastewater treatment applications, simple problems.

Course outcomes:

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

- Explain various principles underlying process integration
- Apply techniques of energy integration, and solve simple problems on heat exchange networks.
- Apply techniques of mass integration to solve simple industrial problems.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

(1) Robin Smith, Chemical Process Design & Integration, Wiley, 2005. ISBN 10: 0471486817,13: 978-0471-486812.

(2) Process Integration - Mahmoud. M., El – Hawalgi, Vol. 7, Academic Press, 2006, ISBN 9780123705327..

Reference Books

(1) Linnhoff B, A User Guide on Process Integration for Efficient Use of Energy, UMIST.

(2) Kemp, I C, Pinch Analysis and Process Integration - A user guide on process integration for efficient use of energy, 2nd Edition, Butterworth, Heinneman, New York, 2006 ISBN 10: 0750682604,13: 978-0750682602.

CHEMICAL ENGINEERING LABORATORY-II			
Course Code	20HCEL26	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	0:4:0	SEE Marks	60
Credits	02	Exam Hours	03

Sl. NO	Experiments
1	RTD studies in Packed bed reactor
2	RTD studies in CSTR –Two parameter model
3	RTD studies in Tubular Reactor
4	Steam distillation
5	Liquid- Liquid equilibria and extraction
6	Adsorption studies
7	Batch sedimentation
8	Screen effectiveness
9	Simulation studies of PFR
10	Simulation studies of heat exchanger

Course outcomes:

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

- Apply statistical tools to analyze RTD data to various reacting systems
- Analyze mass transfer operations
- Analyse and characterize particle size during screening
- Analyse behavior of Reactor/heat exchanger using simulation software.

TECHNICAL SEMINAR			
Course Code	20HCE27	CIE Marks	100
Number of contact Hours/week	0:0:2	SEE Marks	--
Credits	02	Exam Hours	--

Course objectives:

The objective of the seminar is to inculcate self-learning, face audience confidently, enhance communication skill, involve in group discussion and present and exchange ideas.

Each student, under the guidance of a Faculty, is required to

- Choose, preferably through peer reviewed journals, a recent topic of his/her interest relevant to the Course of Specialization.
- Carryout literature survey, organize the Course topics in a systematic order.
- Prepare the report with own sentences.
- Type the matter to acquaint with the use of Micro-soft equation and drawing tools or any such facilities.
- Present the seminar topic orally and/or through power point slides.
- Answer the queries and involve in debate/discussion.
- Submit two copies of the typed report with a list of references.

The participants shall take part in discussion to foster friendly and stimulating environment in which the students are motivated to reach high standards and become self-confident.

The CIE marks for the seminar shall be awarded (based on the relevance of the topic, presentation skill, participation in the question and answer session and quality of report) by the committee constituted for the purpose by the Head of the Department. The committee shall consist of three faculties from the department with the senior most acting as the Chairperson.

Marks distribution for CIE of the course 20HCE27 seminar:

Seminar Report: 30 marks

Presentation skill:50 marks

Question and Answer:20 marks

*** END OF II SEMESTER***

MODERN SEPARATION PROCESSES			
Course Code	20HCE31	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

Introduction: Review of conventional processes, recent advances in separation techniques based on size, surface properties, ionic properties and other special characteristics of substances, Process concept, Theory and equipment used in cross flow filtration, cross flow electro filtration, dual functional filter, Surface based solid -liquid separations involving a second liquid, Sirofloc filter.

Module-2

Membrane Separations: Introduction to membranes, types and choice of membranes, Plate and frame, tubular, spiral wound and hollow fiber membrane and their relative merits, Commercial, pilot plant and laboratory membrane permeators involving dialysis, reverse osmosis, Nano filtration, ultra filtration, Micro filtration and Donnan dialysis, Economics of membrane operations, Ceramic membranes.

Module-3

Supercritical Fluid Extraction: Concept, modeling, design aspects and applications Separation by Adsorption Techniques: Mechanism, Types and choice of adsorbents, Normal adsorption techniques, PSA TSA operation. Types of equipments and commercial processes. Recent advances and process economics.

Module-4

Ionic Separations: Controlling factors, Applications, Types of equipment employed for electrophoresis, Dielectrophoresis, Ion exchange, and electro dialysis. Chromatography: Affinity chromatography and immuno chromatography Commercial Processes.

Module-5

Miscellaneous separation Techniques: Separations involving Lyophilization, Pervaporation and permeation techniques for solids, liquids and gases. Industrial viability and examples, Zone melting, Adductive crystallization, Oil spill Management, Industrial effluent treatment by modern techniques.

Course outcomes:

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

- Explain the various Chemical Engineering Separation processes
- Identify appropriate separation technique for an intended process
- Analyze the separation system for multi-component mixtures
- Develop design for a separation system for a given process condition.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

(1) King, C.J, Separation Processes, 2nd Edition,Tata McGraw Hill Publishing Co., Ltd., New Delhi, copy Right 2013.

(2) Seader, J. D and Ernest J. Henley, Separation Process Principles, 3rd edition, John Wiley and Sons, ISBN : 978-0-470-48183-7 Inc., New York, November 2010, ©2011

(3) Herbert M. Schoen, New Chemical Engineering Separation Techniques, Interscience Publishers, New York, 1962.

Reference Books

(1) Robert H. Perry, Don W. Green Perry's Chemical Engineering Hand book, 8th edition, Mc Graw Hills, New York ,1999.

(2) Schoem, H.M, New Chemical Engineering Separation Techniques, Inter science Publishers, 1972.

FERMENTATION ENGINEERING			
Course Code	20HCE321	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Module-1

Introduction to fermentation Process: Interaction between chemical engineering, Microbiology and Biochemistry. Introduction and scope of microbial processes. Microbial biomass, Microbial enzymes, Microbial metabolites, Recombinant products, Batch culture, continuous culture. Sources of industrial cultures and maintenance. Production of Industrial Alcohol, proteases, celluloses, amylase, lipase.

Module-2

Microbial growth kinetics: Batch culture, continuous culture, multistage systems, fed batch culture, comparison between batch and continuous culture in industrial processes. Media formulation and process optimization.

Module-3

Improvement of industrially important micro-organisms: Isolation, preservation and improvement of industrial micro-organism, development of media for industrial fermentation. Development of inoculate for yeast and bacterial processes.

Module-4

Sterilization: Introduction, medium sterilization, sterilization of feed, fermenter, esign of batch and continuous sterilization processes.

Module-5

Design of Fermenter: Basic functions of fermenter for microbial or animal cell culture, Aseptic operation and containment, construction materials, Aeration and agitation, stirrer glands and bearings, baffles, fermentation vessels – Waldhof type fermenter, tower fermenter, cylindro – conical vessels, air-lift fermenters, packed tower, rotating disc fermenters.

Course outcomes:

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

- Analyze the growth kinetics of the micro-organisms and develop reactors for production of microbial products.
- Isolate the micro-organisms from different sources and interpret their applications for sustainable development.
- Design fermenters for industrial applications of various fermentation processes.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

(1) Bailly, J.E. and Ollis D.F. Bio Chemical Engineering Fundamentals (1986) McGraw-Hill Education, ISBN 13: 9780070032125.

Reference Books

(1) Introduction to Biochemical Engineering, DubasiGovardhana Rao, Tata McGraw-Hill Education, 2010

(2) Stanbury, P.E. and Whitaker A., Principles of Fermentation Technology, 3rd edition Butterworth-Heinemann, 1995, ISBN: 9780080999531.

TOTAL QUALITY MANAGEMENT			
Course Code	20HCE322	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Module-1

Introduction – Need for quality – Evolution of quality – Definition of quality – Dimensions of manufacturing and service quality – Basic concepts of TQM – Definition of TQM – TQM Framework – Contributions of Deming, Juran and Crosby – Barriers to TQM.

Module-2

TQM PRINCIPLES Leadership – Strategic quality planning, Quality statements – Customer focus – Customer orientation, Customer satisfaction, Customer complaints, Customer retention -Employee involvement – Motivation, Empowerment, Team and Teamwork, Recognition and Reward, Performance appraisal – Continuous process improvement – PDSA cycle,5s, Kaizen – Supplier partnership – Partnering, Supplier selection, Supplier Rating.

Module-3

TQM TOOLS & TECHNIQUES I The seven traditional tools of quality – New management tools – Six-sigma: Concepts,methodology, applications to manufacturing, service sector including IT – Bench marking – Reason to bench mark, Bench marking process – FMEA – Stages, Types.

Module-4

TQM TOOLS & TECHNIQUES II Quality circles – Quality Function Deployment (QFD) Taguchi quality loss function –TPM – Concepts, improvement needs – Cost of Quality – Performance measures.

Module-5

QUALITY SYSTEM Need for ISO 9000- ISO 9000-2000 Quality System – Elements, Documentation, Quality auditing- QS 9000 – ISO 14000 – Concepts, Requirements and Benefits – Case studies of TQM implementation in manufacturing and service sectors.

Course outcomes:

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

- Develop an understanding on quality management philosophies and frameworks.
- Demonstrate the importance of customer and various problem-solving skills.
- Develop in-depth knowledge on various tools and techniques of quality management.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

(1) Dale H.Besterfield et al, Total Quality Management, Third edition, Pearson Education(First Indian Reprints 2004)..

(2) Shridhara Bhat K, Total Quality Management – Text and Cases, Himalaya PublishingHouse, First Edition 2002.

PROCESS MODELING AND SIMULATION			
Course Code	20HCE323	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Module-1

Introduction to process modelling: a systematic approach to model building, classification of models,types of mathematical equations , Conservation principles, thermodynamic principles of process systems.

Module-2

Numerical methods: Iterative convergence methods, numerical integration of ordinary differential equations, numerical solutions of partial differential equations

Module-3

Steady state and unsteady state lumped parameter models: Boiling of multi component mixture, condensation of vapor mixture, flash drum, boiler with hold up, tank models

Module-4

Steady state distributed parameter models: Co-current and counter-current DPHE, PFR with axial dispersion, tubular permeation process, pipe line flasher, packed bed tubular reactor

Module-5

Un steady state distributed parameter models: Thermal conduction through a rod, unsteady state steam heated heat exchanger, unsteady state counter current DPHE, reactor with axial dispersion, binary distillation column, chlorination of benzene, Parameter estimation. Introduction to finite element and finite volume methods.

Course outcomes:

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

- Apply the concept of mathematical modeling to understand the chemical process
- Apply numerical methods to solve the model equations
- Model any process unit and simulate its performance using simulation methods.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Reference Books

(1) Luyben, Process Modeling, Simulation and Control for Chemical Engineers, International Student Edition, 1981 2nd edition ISBN 0070391599.

(2) Franks R.E., Modeling and Simulation in Chemical Engineering, John Wiley, 1972 ISBN 978-0-471-275350.

(3) Gaikwad R.W, and Dr. Dhirendra, Process Modelling and Simulation, 2nd Edition, Denetted&Co., 2006.

(4) Ramirez W.F., Computational Methods In Process Simulation, Butterworth, 2nd edition1997 ISBN 0-7506-3541X.

PHARMACEUTICAL TECHNOLOGY			
Course Code	20HCE324	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Module-1

Electrophilic Substitution Reaction: Preparation of Cyclo Alkane, Bayer's strain theory and orbital picture of angle stream. Electrophilic Substitution Reaction Mechanism & Application: Dehydrogenation ofalkylhalides. 1-2 elimination kinetics: E2 and E1 mechanisms. Isotope effect. Dehydration of alcohols. Ease of dehydration.

Module-2

Nucleophilic Addition Reaction: Mechanism. Important chemicals. Oxidation-Reduction reactions.

Module-3

Rheology of Fluids in Mixing and Blending.

Module-4

Preparation: Test for purity and medical uses of Chlorobutal, Dimercopral, Glyceroltrinitrate. Urea, ethylene diamine dihydrate, vanillin paraldehyde.

Module-5

Preparation: Test for purity and medical uses of lactic acid, citric acid, salicylic acid, saccharin Sodium, Ethyl borate, dimethyl phthalate, aspirin.

Course outcomes:

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

- Know about Electrophilic Substitution Reaction and Nucleophilic Addition Reaction and its mechanism.
- Analyze Rheology of Fluids in Mixing and Blending.
- Conduct test for purity of many chemical component and know its medicinal uses.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

(1) Organic Chemistry, T.R. Morisson and R. Boyd, 6th Edition, Prentice Hall of India Pvt.Ltd., New Delhi, 1992. ISBN-13: 978-0136436690.

(2) Organic Chemistry Fundamentals, I. L. Finar, 2nd Edition, ELBS, Pergemon Press, 1965, ISBN-13: 978-0582442214

Reference Books

(1) Fundamental of Organic Chemistry, John E McMurry, 7th Edition, Cornell University, 2011, David R. Klen,. ISBN-13: 9781439049716

(2) A text book of Organic Chemistry, R. K. Gupta. Arihant, ISBN:13-9789352031184, 2010.

CHEMICAL PROCESS OPTIMIZATION			
Course Code	20HCE331	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Module-1

Introduction: Introduction to optimization, Functions of single and multiple variables - optimality criteria, direct and indirect search methods. Formulation of problems and basic concepts.

Module-2

Linearization: Fundamental theorem of linear programming, Degenerate solutions, Simplex methods, Cycling, Duality, Complementary slackness conditions. Transformation methods based on linearization. Quadratic and Geometric Programming: problems.

Module-3

Optimal Control Problems: Euler-Lagrange optimality criteria, Pontryagin's maximum principle, optimal control problems. Numerical methods.

Module-4

Introduction to Artificial Intelligence in optimization. Introduction to Genetic algorithm (qualitative treatment only).

Module-5

Optimization in Chemical Engineering: Importance of Engineering economics, various optimization softwares (qualitative treatment only), use of optimization techniques for process design and integration (take some typical examples).

Course outcomes:

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

- Solve simple chemical engineering problems using optimization techniques.
- Use various optimization tools available for simple systems.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

(1) T.F. Edgar and D.M. Himmelblau," Optimization Techniques for Chemical Engineers",McGraw-Hill, New York, 1985.

Reference Books

(1) K. Deo, "Optimization Techniques", Wiley Eastern, 1995.

(2) Robin Smith, Chemical Process Design & Integration, Wiley, 2005 ISBN 10: 0471486817,13: 978-0471-486812.

GASIFICATION TECHNOLOGY			
Course Code	20HCE332	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Module-1

Biomass and its properties: Types and Sources of Biomass, Physical and Thermal Properties of Biomass, Proximate and Ultimate analysis, stoichiometric considerations, Equivalence Ratio, Thermochemical conversion processes, Types of gasifiers, gas yield and its composition.

Module-2

Theory of gasification Gasification reactions, Gasification processes - Drying, Devolatilization/Pyrolysis, combustion and gasification/reduction, Pyrolysis types and product yield, torrefaction, catalytic gasification.

Module-3

Gasification Kinetics Kinetic models for gasification - Drying, Devolatilization/Pyrolysis, combustion and gasification/reduction, Chemical equilibrium, char reactivity, Effect of feed properties on gasification, Estimating Equilibrium Gas Composition.

Module-4

Design of Gasifiers Energy and Mass Balance, Heat transfer in gasifiers, Gasifier Efficiency, sizing of downdraft biomass gasifier, design optimization.

Module-5

Gas Cleaning Technologies Tar formation, composition, reduction of tar by operating conditions, reduction by design, Particulate removal technologies, Environmental emissions.

Course outcomes:

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

- Explain various gasification Processes
- Select appropriate kinetics and analysis techniques for intended processes
- Analyze the environmental impact of process
- Design gasifier for the effective production.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

(1) John Rezaiyan and Nicholas P. Cheremisinoff, Gasification Technologies - A Primer for Engineers and Scientists, ISBN 1420028146 Taylor and Francis, 2005

Reference Books

(1) PrabirBasu, Biomass Gasification and Pyrolysis, ISBN 0123965438 Elsevier Publishing, 2010.

(2) ChristoperHigman and MaarenvanderBurgt, Gasification, ISBN 0080477992 Elsevier Publishing, 2003.

COMPUTATIONAL FLUID DYNAMICS			
Course Code	20HCE333	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Module-1

Introduction to Governing equations – Impact and applications of CFD in diverse fields – Governing equations of fluid dynamics – Continuity – Momentum and Energy – Generic integral form of governing equations – Initial and boundary conditions – Governing equations for boundary layers – Classification of partial differential equations – Hyperbolic – Parabolic – Elliptic and Mixed types – Applications and relevance.

Module-2

Basic aspects of discretization – Finite difference – Finite volume and Finite Element method - Comparison of discretization by the three methods. Introduction to Finite Differences – Transient One dimensional and two dimensional conduction – Explicit – Implicit – Crank Nicolson, ADI Scheme- Stability Criterion Difference equations – Numerical errors – Grid independence test – optimum step size.

Module-3

Grid generation – General transformation of the equations – Form of the governing equations suitable for CFD – Boundary fitted co-ordinate systems – Elliptic grid generation – Adaptive grids- Modern developments in grid generation.

Module-4

Convection Diffusion Steady one dimensional convection and diffusion – Central difference, upwind, quick, exponential, false diffusion, hybrid and power law scheme. Transient one dimensional het conduction equation.

Module-5

Calculation of Flow Field Representation of the pressure – Gradient term and continuity equation – Staggered grid – Momentum equations – Pressure and velocity corrections – Pressure correction equation - Numerical procedure for SIMPLE algorithm – Boundary conditions for the pressure correction method – Stream function – Vorticity method – Discussion of case studies.

Course outcomes:

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

- Exhibit knowledge about importance of CFD, governing equations and their discretization
- Demonstrate methods of grid generation and application of numerical methods for solution of fluid flow equations
- Explain the types of errors and stability criteria to be verified during simulations.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

(1) J. D. Andersor Jr., (2000) Computational Fluid Dynamics – The basic with applications, ISBN 0-07-001685-2 Mc Graw Hill ISE.

(2) K A Hoffman (2001) Computational Fluid Dynamics for Engineering VolI-III, 2nd Ed., Engineering Eductaion system, ISBN 13:-978-0962373107 Austin, Texas

Reference Books

(1) K. Muralidhar, T. Sundarajan (2011), (Computational Fluid Flow and Heat transfer, 2nd Ed., ISBN 978-81-7319-522-8 Narosa Publishing House, New Delhi.

(2) S. V. Patankar, (1999) Numerical Heat Transfer and Fluid Flow, Hemisphere, ISBN 0-07-048740-5, New York.

FOOD PROCESSING & ENGINEERING			
Course Code	20HCE334	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Module-1

Introduction: General aspects of food industry, world food demand and Indian scenario, constituents of food, quality and nutritive aspects, need for food additives and preservatives and their applications. Stabilizers and thickeners, other additives. Food safety, food contamination and adulteration. Food laws and standards.

Module-2

Food processing methods: general processing methods for various food products - soft and alcoholic beverages, dairy products, meat, poultry and fish products. Treatment and disposal of food processing wastes.

Module-3

Separation processes in food processing: Electro-dialysis Systems, Membrane Systems, Reverse-Osmosis and Ultra filtration Systems, Drying Processes, Dehydration System, Sedimentation, Centrifugation and Mixing.

Module-4

Food preservation methods: Preservation by heat and cold, dehydration, concentration, drying irradiation, microwave heating, sterilization and pasteurization, fermentation and pickling.

Module-5

Packaging: Introduction, Food Protection, Product Containment, Product Communication, Product Convenience, Mass Transfer in Packaging Materials. Innovations in Food Packaging, Product Shelf-life.Food canning technology-fundamentals. Heat sterilization of canned food, containers - metal, glass and flexible packaging. Canning procedures for fruits, vegetables, meats, poultry and marine products.

Course outcomes:

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

- Explain the role and importance of food industries in the global scenario
- Explain characteristics of food, ingredients and their role in enhancement of food quality and standard
- Exhibit the understanding of principle and working of food processing equipment in storing, processing, and packaging.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

(1) B. Srilakshmi, Food Science, 4thEdition ISBN 8122420222 New Age International, New Delhi, 2007.

(2) Rick Parker, Introduction to Food Science – Texas Science Series, Delmar/ Thomson Learning, ISBN 0766813142, 2003.

(3) G.Subbulakshmi and Shobha A. Udupi, Food Processing and Preservation, ISBN 8122412831 New Age International, New Delhi, 2001.

(4) SinoshSkariyachan, Abhilash M, Introduction to Food Biotechnology, ISBN-10: 8123922078, CBS publishers and distributors Pvt. Ltd, New Delhi.

Reference Books

(1) N. ShakuntalaManay and M. Shadaksharamurthy, Foods: Facts and Principles, ISBN 8122422152, New Age Publishers, New Delhi, 2005.

(2) Norman N. Potter and Joseph H. Hotchkin, Food Science, ISBN 9780834212657 Avi Publishing Co, 1968.

PROJECT WORK PHASE – 1			
Course Code	20HCE34	CIE Marks	100
Number of contact Hours/Week	2	SEE Marks	--
Credits	02	Exam Hours	--

Course objectives:

- Support independent learning.
- Guide to select and utilize adequate information from varied resources maintaining ethics.
- Guide to organize the work in the appropriate manner and present information (acknowledging the sources) clearly.
- Develop interactive, communication, organisation, time management, and presentation skills.
- Impart flexibility and adaptability.
- Inspire independent and team working.
- Expand intellectual capacity, credibility, judgement, intuition.
- Adhere to punctuality, setting and meeting deadlines.
- Instil responsibilities to oneself and others.
- Train students to present the topic of project work in a seminar without any fear, face audience confidently, enhance communication skill, involve in group discussion to present and exchange ideas.

Project Phase-1 Students in consultation with the guide/s shall carry out literature survey/ visit industries to finalize the topic of the Project. Subsequently, the students shall collect the material required for the selected project, prepare synopsis and narrate the methodology to carry out the project work.

Seminar: Each student, under the guidance of a Faculty, is required to

- Present the seminar on the selected project orally and/or through power point slides.
- Answer the queries and involve in debate/discussion.
- Submit two copies of the typed report with a list of references.

The participants shall take part in discussion to foster friendly and stimulating environment in which the students are motivated to reach high standards and become self-confident.

Course outcomes:

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

- Demonstrate a sound technical knowledge of their selected project topic.
- Undertake problem identification, formulation, and solution.
- Design engineering solutions to complex problems utilising a systems approach.
- Communicate with engineers and the community at large in written an oral forms.
- Demonstrate the knowledge, skills and attitudes of a professional engineer.

Continuous Internal Evaluation

CIE marks for the project report (50 marks), seminar (30 marks) and question and answer (20 marks) shall be awarded (based on the quality of report and presentation skill, participation in the question and answer session by the student) by the committee constituted for the purpose by the Head of the Department. The committee shall consist of three faculty from the department with the senior most acting as the Chairperson.

MINI PROJECT			
Course Code	20HCE35	CIE Marks	40
Number of contact Hours/Week	2	SEE Marks	60
Credits	02	Exam Hours/Batch	03

Course objectives:

- To support independent learning and innovative attitude.
- To guide to select and utilize adequate information from varied resources upholding ethics.
- To guide to organize the work in the appropriate manner and present information (acknowledging the sources) clearly.
- To develop interactive, communication, organisation, time management, and presentation skills.
- To impart flexibility and adaptability.
- To inspire independent and team working.
- To expand intellectual capacity, credibility, judgement, intuition.
- To adhere to punctuality, setting and meeting deadlines.
- To instil responsibilities to oneself and others.
- To train students to present the topic of project work in a seminar without any fear, face audience confidently, enhance communication skill, involve in group discussion to present and exchange ideas.

Mini-Project: Each student of the project batch shall involve in carrying out the project work jointly in constant consultation with internal guide, co-guide, and external guide and prepare the project report as per the norms avoiding plagiarism.

Course outcomes:

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

- Present the mini-project and be able to defend it.
- Make links across different areas of knowledge and to generate, develop and evaluate ideas and information so as to apply these skills to the project task.
- Habituated to critical thinking and use problem solving skills.
- Communicate effectively and to present ideas clearly and coherently in both the written and oral forms.
- Work in a team to achieve common goal.
- Learn on their own, reflect on their learning and take appropriate actions to improve it.

CIE procedure for Mini - Project:

The CIE marks awarded for Mini - Project, shall be based on the evaluation of Mini - Project Report, Project Presentation skill and Question and Answer session in the ratio 50:25:25.The marks awarded for Mini - Project report shall be the same for all the batch mates.

Semester End Examination

SEE marks for the mini-project shall be awarded based on the evaluation of Mini-Project Report, Presentation skill and Question and Answer session in the ratio 50:25:25 by the examiners appointed by the University.

INTERNSHIP / PROFESSIONAL PRACTICE			
Course Code	20HCEI36	CIE Marks	40
Number of contact Hours/Week	2	SEE Marks	60
Credits	06	Exam Hours	03

Course objectives:

Internship/Professional practice provide students the opportunity of hands-on experience that include personal training, time and stress management, interactive skills, presentations, budgeting, marketing, liability and risk management, paperwork, equipment ordering, maintenance, responding to emergencies etc. The objective are further,

To put theory into practice.

To expand thinking and broaden the knowledge and skills acquired through course work in the field.

To relate to, interact with, and learn from current professionals in the field.

To gain a greater understanding of the duties and responsibilities of a professional.

To understand and adhere to professional standards in the field.

To gain insight to professional communication including meetings, memos, reading, writing, public speaking, research, client interaction, input of ideas, and confidentiality.

To identify personal strengths and weaknesses.

To develop the initiative and motivation to be a self-starter and work independently. ■

Internship/Professional practice: Students under the guidance of internal guide/s and external guide shall take part in all the activities regularly to acquire as much knowledge as possible without causing any inconvenience at the place of internship.

Seminar: Each student, is required to

- Present the seminar on the internship orally and/or through power point slides.
- Answer the queries and involve in debate/discussion.
- Submit the report duly certified by the external guide.
- The participants shall take part in discussion to foster friendly and stimulating environment in which the students are motivated to reach high standards and become self-confident. ■

Course outcomes:

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

- Gain practical experience within industry in which the internship is done.
- Acquire knowledge of the industry in which the internship is done.
- Apply knowledge and skills learned to classroom work.
- Develop a greater understanding about career options while more clearly defining personal career goals.
- Experience the activities and functions of professionals.
- Develop and refine oral and written communication skills.
- Identify areas for future knowledge and skill development.
- Expand intellectual capacity, credibility, judgment, intuition.
- Acquire the knowledge of administration, marketing, finance and economics. ■

Continuous Internal Evaluation

CIE marks for the Internship/Professional practice report (20 marks), seminar (10 marks) and question and answer session (10 marks) shall be awarded (based on the quality of report and presentation skill, participation in the question and answer session by the student) by the committee constituted for the purpose by the Head of the Department. The committee shall consist of three faculty from the department with the senior most acting as the Chairperson. ■

Semester End Examination

SEE marks for the internship report (30 marks), seminar (20 marks) and question and answer session (10 marks) shall be awarded (based on the quality of report and presentation skill, participation in the question and answer session) by the examiners appointed by the University. ■

PROJECT WORK PHASE -2			
Course Code	20HCE41	CIE Marks	40
Number of contact Hours/Week	4	SEE Marks	60
Credits	20	Exam Hours	03

Course objectives:

- To support independent learning.
- To guide to select and utilize adequate information from varied resources maintaining ethics.
- To guide to organize the work in the appropriate manner and present information (acknowledging the sources) clearly.
- To develop interactive, communication, organisation, time management, and presentation skills.
- To impart flexibility and adaptability.
- To inspire independent and team working.
- To expand intellectual capacity, credibility, judgement, intuition.
- To adhere to punctuality, setting and meeting deadlines.
- To instil responsibilities to oneself and others.
- To train students to present the topic of project work in a seminar without any fear, face audience confidently, enhance communication skill, involve in group discussion to present and exchange ideas. ■

Project Work Phase - II: Each student of the project batch shall involve in carrying out the project work jointly in constant consultation with internal guide, co-guide, and external guide and prepare the project report as per the norms avoiding plagiarism. ■

Course outcomes:

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

- Present the project and be able to defend it.
- Make links across different areas of knowledge and to generate, develop and evaluate ideas and information so as to apply these skills to the project task.
- Habituated to critical thinking and use problem solving skills
- Communicate effectively and to present ideas clearly and coherently in both the written and oral forms.
- Work in a team to achieve common goal.
- Learn on their own, reflect on their learning and take appropriate actions to improve it. ■

Continuous Internal Evaluation:

Project Report: 20 marks. The basis for awarding the marks shall be the involvement of the student in the project and in the preparation of project report. To be awarded by the internal guide in consultation with external guide if any.

Project Presentation: 10 marks.

The Project Presentation marks of the Project Work Phase -II shall be awarded by the committee constituted for the purpose by the Head of the Department. The committee shall consist of three faculty from the department with the senior most acting as the Chairperson.

Question and Answer: 10 marks.

The student shall be evaluated based on the ability in the Question and Answer session for 10 marks.

Semester End Examination

SEE marks for the project report (30 marks), seminar (20 marks) and question and answer session (10 marks) shall be awarded (based on the quality of report and presentation skill, participation in the question and answer session) by the examiners appointed by the University. ■