<table>
<thead>
<tr>
<th>Subject Code</th>
<th>Name of the Subject</th>
<th>Teaching hours/week</th>
<th>Duration of Exam in Hours</th>
<th>Marks for Total Marks</th>
<th>Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>14HCE11</td>
<td>PLANT WIDE CONTROL OF CHEMICAL PROCESSES</td>
<td>4 2 3</td>
<td>50 100</td>
<td>150</td>
<td>4</td>
</tr>
<tr>
<td>14HCE12</td>
<td>ADVANCED THERMODYNAMICS</td>
<td>4 2 3</td>
<td>50 100</td>
<td>150</td>
<td>4</td>
</tr>
<tr>
<td>14HCE13</td>
<td>TRANSPORT PHENOMENA</td>
<td>4 2 3</td>
<td>50 100</td>
<td>150</td>
<td>4</td>
</tr>
<tr>
<td>14HCE14</td>
<td>CHEMICAL EQUIPMENT DESIGN</td>
<td>4 2 3</td>
<td>50 100</td>
<td>150</td>
<td>4</td>
</tr>
<tr>
<td>14HCE15X</td>
<td>ELECTIVE - I</td>
<td>4 2</td>
<td>50 100</td>
<td>150</td>
<td>4</td>
</tr>
<tr>
<td>14HCE16</td>
<td>LAB COMPONENT</td>
<td>-- 3</td>
<td>25 50</td>
<td>75</td>
<td>2</td>
</tr>
<tr>
<td>14HCE17</td>
<td>SEMINAR</td>
<td>-- 3</td>
<td>--</td>
<td>25</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>20 13 15</td>
<td>300 550</td>
<td>850 23</td>
<td></td>
</tr>
</tbody>
</table>

**ELECTIVE – I:**
- 14HCE151 AIR POLLUTION CONTROL AND DESIGN OF EQUIPMENT
- 14HCE152 COMPUTATIONAL FLUID DYNAMICS
- 14HCE153 MODERN SEPARATION TECHNIQUES
- 14HCE154 FUEL CELL TECHNOLOGY
## VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
### SCHEME OF TEACHING AND EXAMINATION FOR
#### M.TECH. CHEMICAL ENGG.

**II Semester**

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>Name of the Subject</th>
<th>Teaching hours/week</th>
<th>Duration of Exam in Hours</th>
<th>Marks for</th>
<th>Total Marks</th>
<th>CREDITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>14HCE21</td>
<td>APPLIED MATHEMATICS IN CHEMICAL ENGINEERING</td>
<td>4</td>
<td>3</td>
<td>50</td>
<td>150</td>
<td>4</td>
</tr>
<tr>
<td>14HCE22</td>
<td>RESEARCH METHODOLOGY AND INDUSTRIAL SAFETY</td>
<td>4</td>
<td>3</td>
<td>50</td>
<td>150</td>
<td>4</td>
</tr>
<tr>
<td>14HCE23</td>
<td>CATALYTIC REACTION ENGINEERING</td>
<td>4</td>
<td>3</td>
<td>50</td>
<td>150</td>
<td>4</td>
</tr>
<tr>
<td>14HCE24</td>
<td>WASTE MANAGEMENT TECHNIQUES</td>
<td>4</td>
<td>3</td>
<td>50</td>
<td>150</td>
<td>4</td>
</tr>
<tr>
<td>14HCE25X</td>
<td>ELECTIVE-II</td>
<td>4</td>
<td>3</td>
<td>50</td>
<td>150</td>
<td>4</td>
</tr>
<tr>
<td>14HCE26</td>
<td>LAB COMPONENT</td>
<td>3</td>
<td>3</td>
<td>25</td>
<td>75</td>
<td>2</td>
</tr>
<tr>
<td>14HCE27</td>
<td>SEMINAR</td>
<td>--</td>
<td>--</td>
<td>25</td>
<td>--</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td><strong>PROJECT WORK PHASE-I COMMENCEMENT (2-3 WEEKS DURATION)</strong></td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>20</td>
<td>13</td>
<td>15</td>
<td>850</td>
<td>23</td>
</tr>
</tbody>
</table>

**Elective – II:** 14HCE251- ENZYME ENGINEERING, 14HCE252- Interfacial Engineering, 14HCE253- GASIFICATION TECHNOLOGY, 14HCE254- FOOD PROCESSING AND ENGINEERING

**Between the II Semester and III Semester, after availing a vocation of 2 weeks.**
### M.TECH. CHEMICAL ENGG.

#### III Semester: INTERNSHIP  

**CREDIT BASED**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Subject</th>
<th>No. of Hrs./Week</th>
<th>Duration of Exam in Hours</th>
<th>Marks for Total Marks</th>
<th>Total Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>14HCE31</td>
<td>SEMINAR / PRESENTATION ON INTERNSHIP (AFTER 8 WEEKS FROM THE DATE OF COMMENCEMENT)</td>
<td>-</td>
<td>-</td>
<td>25</td>
<td>1</td>
</tr>
<tr>
<td>14HCE32</td>
<td>REPORT ON INTERNSHIP</td>
<td>-</td>
<td>-</td>
<td>75</td>
<td>15</td>
</tr>
<tr>
<td>14HCE33</td>
<td>INTERNSHIP EVALUATION AND VIVA-VOCE</td>
<td>-</td>
<td>-</td>
<td>50</td>
<td>4</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>-</td>
<td>-</td>
<td>25</td>
<td>20</td>
</tr>
</tbody>
</table>

**VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM**

**SCHEME OF TEACHING AND EXAMINATION FOR M.TECH. CHEMICAL ENGG.**
### IV Semester

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>Subject</th>
<th>No. of Hrs./Week</th>
<th>Duration of Exam in Hours</th>
<th>Marks for Total Marks</th>
<th>CREDITS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lecture</td>
<td>Field Work / Assignment / Tutorials</td>
<td></td>
<td>I.A.</td>
<td>Exam</td>
</tr>
<tr>
<td>14HCE41</td>
<td>BIOINSTRUMENTATION AND BIOSENSORS</td>
<td>4</td>
<td>3</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>14HCE42X</td>
<td>Elective-III</td>
<td>4</td>
<td>3</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>14HCE43</td>
<td>Evaluation of Project Work Phase-II</td>
<td>-</td>
<td>-</td>
<td>25</td>
<td>-</td>
</tr>
<tr>
<td>14HCE44</td>
<td>Evaluation of Project Work Phase-III</td>
<td>-</td>
<td>-</td>
<td>25</td>
<td>-</td>
</tr>
<tr>
<td>14HCE45</td>
<td>Evaluation of Project Work and Viva-voce</td>
<td>–</td>
<td>3</td>
<td>-</td>
<td>100+10</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>12</td>
<td>07</td>
<td>09</td>
<td>150</td>
</tr>
</tbody>
</table>

**Grand Total (I to IV Sem.) : 2400 Marks; 94 Credits**

**Elective III:** 14HCE421 FERMENTATION ENGINEERING, 14HCE-422 TOTAL QUALITY MANAGEMENT, 14 HCE423 CHEMICAL PROCESS OPTIMIZATION, 14HCE 424 PHARMACEUTICALTECHNOLOGY
### NOTE:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Project Phase – I: 6 weeks duration shall be carried out between II and III Semesters. Candidates in consultation with the guides shall carry out literature survey / visit to Industries to finalize the topic of dissertation</td>
</tr>
<tr>
<td>2.</td>
<td>Project Phase – II: 16 weeks duration. 3 days for project work in a week during III Semester. Evaluation shall be taken during the first two weeks of the IV Semester. Total Marks shall be 25.</td>
</tr>
<tr>
<td>3.</td>
<td>Project Phase – III: 24 weeks duration in IV Semester. Evaluation shall be taken up during the middle of IV Semester. At the end of the Semester Project Work Evaluation and Viva-Voce Examinations shall be conducted. Total Marks shall be 250 (Phase I Evaluation: 25 Marks, Phase –II Evaluation: 25 Marks, Project Evaluation marks by Internal Examiner( guide): 50, Project Evaluation marks by External Examiner: 50, marks for external and 100 for viva-voce). Marks of Evaluation of Project: I.A. Marks of Project Phase – II &amp; III shall be sent to the University along with Project Work report at the end of the Semester. During the final viva, students have to submit all the reports.</td>
</tr>
<tr>
<td>4.</td>
<td>The Project Valuation and Viva-Voce will be conducted by a committee consisting of the following: a) Head of the Department (Chairman) b) Guide (c) Two Examiners appointed by the university. (out of two external examiners at least one should be present).</td>
</tr>
</tbody>
</table>
M.TECH CHEMICAL ENGINEERING SYLLABUS

I Semester

PLANT WIDE CONTROL OF CHEMICAL PROCESS

Subject Code: 14HCE11
IA Marks : 50
No. of Lecture Hours/Week: 04
Exam Hours: 03
No. of Practical Hours/Week: 02
No. of Tutorial
Total No of Lecture Hours: 52
Exam Marks: 100

Review of Process Dynamics: First order systems – thermometer, level tank, CSTR, Second order system – U tube manometer, mass vibrator.

Feed Back Control: Feedback controllers, PID Controller design and tuning, Zeigler – Nichols controller tuning.

Stability: Concept and Criterion, Routh test, Root locus, frequency response analysis – Bode diagrams, Phase margin and gain margin.

Advanced control techniques: Cascade, feed forward and feed backward, ratio control, selective and adaptive control, smith predictor and internal module controller

Multi variable Controller: Features and examples of multi input and multi output processes, design of cross controller, relative gain array, Niderlinski index.

Control Structures for unit operations: Simple distillation column, heat exchanger, evaporator, and reactor

Plant wide control for improved economics: Process operation for a given throughput and for maximum throughput, concept of bottleneck constraint, application of optimizing controllers for throughput maximization on case study processes.

BOOKS RECOMMENDED:
2. George Stephanopoules, Chemical process control, An Introduction to Theory and Practice, Prentice Hall, New Delhi, 1998

ADVANCED THERMODYNAMICS

Subject code : 14HCE12
IA Marks : 50
No. of Lecture Hours / Week : 04
Exam Hours : 03
No. of Practical Hours / Week : ---
No. of Tutorial : 02 Hours/ Week
Total No. of Lecture Hours : 52
Exam Marks : 100

equation applications - High pressure VLE – Partially miscible systems. Chemical reaction equilibria - Industrial chemical reaction equilibria - homogeneous and heterogeneous systems - Effect of pressure and temperature – Complex reactions – liquid phase, vapour phase reactions.

**Third Law of Thermodynamics**: Verification of third law, Applications and evaluation.

**Statistical Thermodynamics**: Energy levels, Boltzmann Distribution Law and Partition functions.

**REFERENCE BOOKS:**


**TRANSPORT PHENOMENA**

Subject Code : 14HCE13
No. of Lecture Hours/Week : 04
No. of Practical Hours/Week : --
Total No of Lecture Hours : 52

IA Marks : 50
Exam Hours : 03
No. of TutorialHours/Week: 02
Exam Marks : 100

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

**Momentum Transport (laminar flow)**: Steady state Shell momentum balances, Boundary conditions applicable to momentum transport problems(flow over flat plate, flow through circular tube and annulus),
**Interphase and Multiphase Momentum Transfer:** 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), Macroscopic Balance for Isothermal Systems (Mass, Momentum And Mechanical Energy Balance). Formation of bubbles and drops and their size distribution, Solid-fluid systems - forces acting on stagnant and moving solids.

**Energy Transport:**

*Convection:* 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.

*Radiation:* 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.

**Mass Transport:** Fick’s law of diffusion, Diffusion with homogeneous and heterogeneous chemical reaction, convective mass transfer co-efficient, theories of ordinary diffusion in liquids

**REFERENCE BOOKS:**
5. Warren L. Mccabe, Julian C. Smith, Peter Harriott, Unit Operations of Chemical Engineering, Mcgraw-hill, 7th Edition

---

**CHEMICAL EQUIPMENT DESIGN**

**Subject Code : 14HCE14**

**IA Marks : 50**

**No. of Lecture Hours/Week : 04**

**Exam Hours : 04**

**No. of Practical Hours/Week : 02**

**No. of Tutorial Hours/Week**

**Total No of Lecture Hours : 52**

**Exam Marks : 100**

Detailed Engineering Process & Mechanical Design Aspects and sketching (The sketch shall include sectional front view, full Top/side view) of the following:

1. Double pipe Heat Exchanger.
2. Shell and Tube Exchanger.
3. Horizontal and Vertical Condensers
4. Evaporator Single Effect
5. Bubble Cap Distillation Column
6. Absorption column

**REFERENCE BOOKS:**
4. BIS 4503 – Code for shell and tube heat exchangers
5. Treybal R E, Mass transfer operations
7. Chemical engineer’s hand book by Perry

**ELECTIVE-I**

**AIR POLLUTION CONTROL AND DESIGN OF EQUIPMENT**

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>IA Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>14HCE151</td>
<td>50</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No. of Lecture Hours/Week</th>
<th>Exam Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>04</td>
<td>03</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No. of Practical Hours/Week</th>
<th>No. of Tutorial Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>--</td>
<td>02</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total No. of Lecture Hours</th>
<th>Exam Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>52</td>
<td>100</td>
</tr>
</tbody>
</table>

**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.

**Air Pollution Laws and Standards:** 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.

**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.

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

**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.

**REFERENCE BOOKS:**


**COMPUTATIONAL FLUID DYNAMICS**

- Subject code: 14HCE152
- IA Marks: 50
- No. of Lecture Hours / Week: 04
- Exam Hours: 03
- No. of Practical Hours / Week: ---
- No. of Tutorial: 02 Hours/ Week
- Total No. of Lecture Hours: 52
- Exam Marks: 100

Introduction to CFD, Flow fields. Finite difference and finite element methods. Various numerical techniques for CFD.

Conservation laws of fluid motion and boundary conditions. (Governing equations of fluid flow and heat transfer) Differential and integral forms of the transport equations. (Navier-Stokes equations) Turbulence Modeling.


About the CFD softwares for different applications and construction of geometry and Discretions using available commercial CFD solvers. (Tutorials) Creating and meshing a basic geometry. Any 5 Basic problems (eg. Basic flow studies in pipe Modeling a mixing elbow (2-D). Modeling a
three-pipe intersection (3-D). Modeling flow in a tank, Modeling a combustion chamber (3-D). (Tutorial)

Books:

MODERN SEPARATION TECHNIQUES

Subject code: 14HCE153 IA Marks: 50
No. of Lecture Hours / Week: 04 Exam Hours: 03
No. of Practical Hours / Week: --- No. of Tutorial: 02 Hours/ Week
Total No. of Lecture Hours: 52 Exam Marks: 100

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.

Membrane Separations: Types and choice of membranes, Plate and frame, tubular, spiral wound and hollow fibre 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.

Supercritical Fluid Extraction: Concept, modeling, design aspects and applications

Separation by Adsorption Techniques: Mechanism, Types and choice of adsorbents, Normal adsorption techniques, Affinity chromatography and immuno chromatography. Types of equipment and commercial processes, recent advances and process economics.

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

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.

REFERENCE BOOKS:
Fuel Cell Technology

Subject code : 14HCE154      IA Marks : 50
No. of Lecture Hours / Week : 04      Exam Hours : 03
No. of Practical Hours / Week : ---      No. of Tutorial : 02 Hours/ Week
Total No. of Lecture Hours : 52      Exam Marks : 100

Overview of fuel cells: Low and high temperature fuel cells;
Fuel cell thermodynamics: Heat, work potentials, prediction of reversible voltage, fuel cell efficiency.
Fuel cell reaction kinetics: Electrode kinetics, over voltages, Tafel equation, charge transfer reaction, exchange currents, electro-catalyses - design, activation kinetics, Fuel cell charge and mass transport - flow field, transport in electrode and electrolyte.
Fuel cell characterization: In-situ and ex-situ characterization, techniques, i-V curve, frequency response analyses; Fuel cell
Balance of plant: Hydrogen production from renewable sources and storage; safety issues, cost expectation and life cycle analysis of fuel cells.

REFERENCES


ADDITIONAL READINGS

LAB COMPONENT

Process Dynamic and Control Lab

Subject code : 14HCE16  IA Marks : 25
No. of Practical Hours / Week : 3  Exam Hours : 03
Exam Marks : 50

The following experiments are to be carried out; the data are to be analyzed based on the theoretical aspects, and recorded with comments.
1. Level control trainer – open and closed loop
2. Flow control trainer – open and closed loop
3. Temperature control trainer – open and closed loop
4. Pressure control trainer – open and closed loop
5. Control valve – Air to close
6. Control valve - air to open
7. Integral to proportional converter & Proportional to integral converter

SEMINAR-I

Sub. Code 14HCE17  IA Marks : 25

The student has to prepare, submit a seminar report and make a presentation on seminar topic allotted. The seminar shall be evaluated as internal assessment by a committee constituted by the HOD.

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


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

Reference Books
Research Methodology and Industrial Safety Analysis

Basic concept: Types of research, Significance of research, Research framework, Case study method, Experimental method, Sources of data, data collection using questionnaire and interviewing.

Research formulation: Components, selection and formulation of a research problem, objectives of formulation and criteria of a good research problem.

Research Hypothesis: Criterion for hypothesis construction, nature of hypothesis, need for having a working hypothesis, characteristics and types of hypothesis, procedure for hypothesis testing.

Sampling methods: Introduction to various sampling methods and their applications

Data analysis: sources of data, collection of data, measurement and scaling technique, and different techniques of data analysis.


Hazards in work places: Nature and type of Work places, Types of hazards, hazards due to improper house keeping, hazards due to fire in multi floor industries and buildings, guidelines and safe methods in above situations.

Workers’ exposures to hazardous chemicals, TLVs of Chemicals, Physical and Chemical properties of chemicals leading to accidents like fire explosion, ingestion and inhalation, pollution in work places due to hazardous, dust, fumes and vapors, guidelines and safety methods in chemicals handling, storage entry to confined space.

TEXT BOOK:
CATALYTIC REACTION ENGINEERING

Subject Code: 14HCE23 IA Marks: 50
No. of Lecture Hours/Week: 04 Exam Hours: 03
No. of Practical Hours/Week: 02 No. of Tutorial Hours/Week: 00
Total No of Lecture Hours: 52 Exam Marks: 100

**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,

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

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

**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

**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.

**REFERENCE BOOKS:**

WASTE MANAGEMENT TECHNIQUES

Subject Code: 14HCE24 IA Marks: 50
No. of Lecture Hours/Week: 04 Exam Hours: 03
No. of Practical Hours/Week: 02

Biological: Introduction to Bacterial life cycle, cell culturing, types of biological processes, Aerobic process. Theory of aeration, factor affecting oxygen transfer, Mixing requirements, types of aerators. nitrification & denitrification. Detailed study on Activated sludge process & Trickling filter.

Anaerobic Process: Construction and working of UASBR, Rotating biological contactors. Algal ponds, Hyacinth and Duckweed, fish ponds

Solid waste: 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.


ELECTIVE-II

ENZYME ENGINEERING

**Subject Code**: 14HCE251
**IA Marks**: 50
**No. of Lecture Hours/Week**: 04
**Exam Hours**: 03
**No. of Practical Hours/Week**: --
**No. of Tutorial Hours/Week**: 02
**Total No. of Lecture Hours**: 52
**Exam Marks**: 100
Structures and Functions of Proteins: Enzyme classification, based on structure classification of amino acids, classifications of proteins, specificities of enzyme action, biosynthesis and properties of proteins.

Kinetics: Chemical mechanisms of enzyme catalysed reactions, introduction to bioenergetics and kinetics, kinetics of multi-substrate bioreactions, investigations of active sites structures.

Chemical Nature of Enzyme Catalysis: Sigmoidal kinetics and allosteric enzymes, co-enzymes, significance of sigmoidal behaviour.

Applications: Investigation of enzymes in biological preparation, extraction and purification, enzymes as analytical reagents

Instrumental Techniques: Instrumental techniques available for using enzymatic analysis, applications in medicine, industries, and biotechnological applications

REFERENCE BOOKS:

Interfacial Engineering

Subject code : 14HCE252 IA Marks : 50
No. of Lecture Hours / Week : 04 Exam Hours : 03
No. of Practical Hours / Week : --- No. of Tutorial : 02 Hours/ Week
Total No. of Lecture Hours : 52 Exam Marks : 100

Introduction to the engineering of interfaces: Definitions of fluid-fluid and fluid-solid interfaces; Occurrence of interfaces in science and engineering; Overview of industrial applications of various interfacial phenomena; Colloidal materials; Properties of colloidal systems; Experimental characterization of colloidal dispersions.

Surface and interfacial tension: Theoretical methods for the calculation of surface and interfacial tension; Experimental techniques for the determination of equilibrium and dynamic tension; Shape of the surfaces: curvature and radius of curvature; Young-Laplace equation; Kelvin equation; Pendant and sessile drops; Adams-Bashforth equation; Characterization of fluid-solid interfaces;
Contact angle and wetting phenomena; Young-Dupré equation; Measurement of equilibrium and dynamic contact angles; Deposition of thin films; Mechanism of film nucleation.

**Introduction to intermolecular and surface forces:** van der Waals forces; Electrostatic double layer force; Disjoining pressure; DLVO theory; Non-DLVO forces. Chemical vapor deposition, molecular beam epitaxy, sputtering and atomic layer deposition techniques; Applications of fluid-solid interfaces in crystallization, development of ceramic materials, catalysts, electronic products and nanomaterials.

**Adsorption at fluid-fluid and fluid-solid interfaces:** Adsorption of surfactants; Gibbs and Langmuir monolayers; Gibbs adsorption equation; Surface equation of state; Surface pressure isotherm; Langmuir-Blodgett films and their applications; Radiotracer and neutron reflection techniques for studying adsorption at fluid-fluid interfaces; Henry, Freundlich, Langmuir, Frumkin and Davies adsorption isotherms; Brunauer-Emmett-Teller theory of adsorption; Adsorption hysteresis; Characterization of adsorption at fluid-solid interfaces by vacuum and non-vacuum techniques.

**Interfacial rheology and transport processes:** Surface shear viscosity; Surface dilatational viscosity; Boussinesq number; Interfacial tension gradient and Marangoni effect; Gibbs and Marangoni elasticity; Boussinesq-Sriven model; Interfacial turbulence; Motion of drops in a liquid; Thin liquid films; Disjoining pressure and body-force models; Stability of thin liquid film; Black films.

**Emulsions:** Preparation, characterization and applications; Ostwald ripening; Flocculation and coalescence; Microemulsions: characterization and properties; Stability of microemulsions; Foams: preparation, characterization and stability; Structure of foams.

**Interfacial reactions:** Reactions at fluid-solid interfaces; Langmuir-Hinshelwood model; External and internal transport processes; Interfacial polycondensation reactions; Fast and instantaneous reactions at fluid-fluid interfaces; Reactions at biointerfaces; Micellar catalysis; Phase transfer catalysis.

**Nanomaterials:** classification and preparation; Self-assembly; Nanoparticles; Nanowires, nanorods and nanotubes; Microporous and mesoporous materials; Lithographic techniques; Toxic effects of nanomaterials. Biological interfaces; Adsorption of proteins at interfaces; Biomembranes; Interfacial forces at biointerfaces; Adhesion and fusion phenomena; Biomaterials.

**Text books:**


**Reference books:**

**GASIFICATION TECHNOLOGY**

Subject code : 14HCE253  
IA Marks : 50

No. of Lecture Hours / Week : 04  
Exam Hours : 03

No. of Practical Hours / Week : ---  
No. of Tutorial : 02 Hours/ Week

Total No. of Lecture Hours : 52  
Exam Marks : 100

**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.

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

**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

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

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

**Reference Books:**


  John Rezaian and Nicholas P. Cheremisinoff, Gasification Technologies - A Primer for Engineers and Scientists, Taylor and Francis, 2005
Introduction - general aspects of food industry, world food demand and Indian scenario, constituents of food, quality and nutritive aspects. Food additives, standards, deteriorative factors and their control, preliminary processing methods, conversion and preservation operation.


Introduction to Food Science - Rick Parker - Thomsan Detmer-2001.
LAB COMPONENT

Subject code : 14HCE26  IA Marks : 25
No. of Practical Hours / Week : 3  Exam Hours : 03
Exam Marks : 50

Chemical Reaction Engineering Lab:
At least five of the following experiments are to be carried out, the data are to be analyzed based on the theoretical aspects, and recorded with comments.
1. Packed bed catalytic reactor
2. Effect of temperature on rate of reaction
3. Enzyme catalyzed reaction in a Batch reactor
4. Fluidized bed reactor
5. Absorption with reaction
6. Integral & differential analysis
7. Study of rusting of iron or burning of coal.

SEMINAR-II

Sub. Code 14HCE27  IA Marks : 25

The students are required to prepare a report and make a presentation on seminar topic allotted. The seminar shall be evaluated as internal assessment by a committee constituted by the HOD.

PROJECT WORK PHASE-I

Topic of project work has to be completed during II semester classes in consultations with HOD & Guide. The students are required to undergo internship (practical training), literature survey related to their project work during vacation after II semester examinations for minimum durations of at least 15 days.
M.TECH CHEMICAL ENGINEERING SYLLABUS

III Semester

SEMINAR

Subject Code : 14HCE31          IA Marks : 50
No. of Field Work Hours/Week : 03

The students are required to make a presentation on seminar topic allotted. The seminar shall be evaluated as internal assessment by a committee constituted by the HoD.

REPORT OF INTERNSHIP

Subject Code : 14HCE32          Exam Marks : 75
No. of Field Work Hours/Week : 03

The students are required to undergo internship, submit a report and make a presentation on the internship training carried out. The seminar shall be evaluated as internal assessment by a committee constituted by the HOD.

INTERNSHIP EVALUATION AND VIVA-VOCE

Subject Code : 14HCE33          IA Marks : 50
Exam Marks : 200

Each student will be assigned an experimental, design, a case study or an analytical problem, to be carried out under the supervision of an internal guide. It should be relevant to the field and preferably of current text. The project has to be assigned at the beginning of the third semester. The project work should be completed at the end of fourth semester. The project work shall be evaluated as an external examination by a committee constituted by the VTU.
M.TECH CHEMICAL ENGINEERING SYLLABUS

IV Semester

BIOINSTRUMENTATION AND BIOSENSORS

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>IA Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>14HCE41</td>
<td>50</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No. of Lecture Hours/Week</th>
<th>Exam Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>04</td>
<td>03</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No. of Practical Hours/Week</th>
<th>No. of Tutorial Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>--</td>
<td>02</td>
</tr>
</tbody>
</table>

Total No. of Lecture Hours

<table>
<thead>
<tr>
<th>Total No. of Lecture Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>52</td>
</tr>
</tbody>
</table>


INTRODUCTION TO BIOSENSORS, Biological sensing elements and transducer systems, classification of biosensors, enzyme and whole cell based biosensors, affinity biosensors, amperometric biosensors, immuno sensors, ELISA, plant cell based biosensors, pesticide biosensors, flow injection analysis based biosensors, stability of biosensors, signal amplification, stabilisation and measurement, luminescence based biosensors

REFERENCE BOOKS:


ELECTIVE IV

FERMENTATION ENGINEERING

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>IA Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>14HCE421</td>
<td>50</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No. of Lecture Hours/Week</th>
<th>Exam Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>04</td>
<td>03</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No. of Practical Hours/Week</th>
<th>No. of Tutorial Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>--</td>
<td>02</td>
</tr>
</tbody>
</table>

Total No. of Lecture Hours

<table>
<thead>
<tr>
<th>Total No. of Lecture Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>52</td>
</tr>
</tbody>
</table>
**Overview:** Fermentation industry growth prospects, general requirements of fermentation processes, basic configurations of fermenter and ancillaries, parameters to be monitored and controlled in fermentation processes.

**Microbial Kinetics:** Types of reaction, order of reaction, Michealis-Menten constant, effect of temperature on reaction rate, activated complexes, catalysed reactions, thermal death of microorganisms, enzyme inhibition.

**Fermentation Engineering:** Continuous fermentation, advantages and limitations, theory of single and two stage continuous fermentation systems application. Media formulation and preparations—complex and synthetic media, Selection of components, buffers, pH adjustment.

**Sterilization:** Media and air—Batch and Continuous In-situ sterilization in fermenter.

**Product Isolation:** selection and improvement of cultures—screening methods, culture preservation, strain improvement. Aseptic culture transfer and incubation, inoculum age/size, studies on growth kinetics in batch, continuous and fed batch cultures. Details of Industrial manufacture of important biotechnological products.

**Bio Reactor Configuration:** Ideal bioreactors, various configurations, Mechanical construction, various parts and accessories—Mass and Heat transfer: Agitation and aeration, Modes of reactor operations.

Fermentation Products: Details of the process parameters and materials for the industrial manufacture of Antibiotics, solvents, amino acids, organic acids and Biopharmaceuticals.

**Text Books:**

**Reference Books:**
3. A.H.Scragg -Bioreactors in Biotechnology – A practical approach;

**TOTAL QUALITY MANAGEMENT**

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>IA Marks</th>
<th>No. of Lecture</th>
<th>Hours/Week</th>
<th>Exam Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>14HCE422</td>
<td></td>
<td>04</td>
<td></td>
<td>03</td>
</tr>
<tr>
<td>No. of Practical</td>
<td></td>
<td>--</td>
<td></td>
<td>02</td>
</tr>
<tr>
<td>Hours/Week</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total No. of Lecture</td>
<td>52</td>
<td></td>
<td>Exam Marks</td>
<td>100</td>
</tr>
<tr>
<td>Hours</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Concepts of TQM:** Basics of total quality, Guru’s of TQM, Philosophy of TQM, customer focus, organization, quality philosophies of Deming.

**TQM Process:** Quality control tools, cost of quality, quality circles, bench marking, strategic quality planning.

**TQM Systems:** Quality policy deployment, quality function deployment, standardization, designing for quality, manufacturing for quality.

**Quality System:** Need for ISO 9000 system, advantages, clauses of ISO 9000, Implementation of ISO 9000, quality auditing, case studies, introduction to other ISO systems.

**Implementation of TQM:** KAIZEN, 5s, JIT, POKAYOE, Taguchi methods, case studies.
REFERENCE BOOKS:

1. Dale H. Besterfield, Total Quality Management, PHI, India.
2. Sharma D.D, TQM principles, Practice and Cases, Chand and Sons, New Delhi.
4. John Bank., The essence of total quality management, PHI,

CHEMICAL PROCESS OPTIMIZATION,

Subject Code : 14HCE423  IA Marks : 50
No. of Lecture : 04  Exam Hours : 03
Hours/Week
No. of Practical : --  No. of Tutorial : 02
Hours/Week
Total No. of Lecture : 52  Exam Marks : 100
Hours

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

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,


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

TEXT BOOK

REFERENCE

PHARMACEUTICAL TECHNOLOGY

Subject Code : 14HCE424     IA Marks : 50
No. of Lecture Hours/Week : 04     Exam Hours : 03
No. of Practical Hours/Week : --     No. of Tutorial Hours/Week : 02
Total No. of Lecture Hours : 52     Exam Marks : 100

Formulations: Introduction, organoleptic properties, purity, particle size, shape and surface area. Solubilization, surfactants and its importance, temperature, PH, co-solvency, solid dispersion, b-cyclodextrin drug-dispersion system. Techniques for the study of crystal properties and Polymorphism. formulation stability studies. A consideration of physico-chemical characteristics of new drug molecules with respect to different dosage forms.

Tablet Making: Compaction of powders with a particular reference to distribution and measurement of forces with in the powder mass undergoing Compression. Effect of particle size, moisture content, lubrication etc. On Strength of tablets. A brief study on formulation aspects of tablets such as Sublingual, buccal chewable and medicated lozenges.

Capsule Technology: Manufacturing equipment and machinery used in capsule technology. Formulation and evaluation of hard gelatin capsules and soft gelatin capsules.


Parenterals Technology: Manufacturing of LVP, SVP. Sterilization and sterility testing of Parenterals, GMP regulations of parenteral technology. Optimization techniques in Pharmaceutical formulation and processing: Concept of optimization, optimization parameters, classical optimization, statistical design and optimization methods.

Manufacturing Techniques: GMP Significance of pilot scale up phase to effect an orderly set up from the laboratory procedures and formulations to routine production procedures. Pilot study of some important dosage forms such as Tablets, Capsules, Injections and liquid orals and discussions on important parameters such as formula and equipment product uniformity and stability. Raw materials and process, physical layouts personnel requirements and reporting responsibilities. Input Specifications and in process and finished product specifications.


REFERENCE BOOKS: