Syllabus for the

M.E (Petrochemical Engineering)

(W.e.f 2008-2009)
THE SYLLABUS IS PREPARED BY:

BOS- Petroleum and Petrochemical Engineering
University of Pune

PEER REVIEW BY:

- Dr. P B Jadhav (Chairman)
- Dr Raju Mankar, Director, Laxminarayan Institute of Technology, Nagpur
- Mr. S P Singh, Process Manager, Praj India Limited, Pune
- Dr. V K Jayaraman, NCL Pune

Note:- This syllabus is subject to change without prior notice by the concerned BOS
### UNIVERSITY OF PUNE
### STRUCTURE OF M.E. (PETROCHEMICAL ENGINEERING)
### REVISED TWO-YEAR COURSE (2008)

#### SEMESTER I

<table>
<thead>
<tr>
<th>Code</th>
<th>Subject</th>
<th>Teaching Scheme</th>
<th>Examination Scheme</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>512201</td>
<td>Advances in Petroleum Refining</td>
<td>3 -</td>
<td>100</td>
<td>3</td>
</tr>
<tr>
<td>512202</td>
<td>Advanced Transport Phenomena</td>
<td>3 -</td>
<td>100</td>
<td>3</td>
</tr>
<tr>
<td>512203</td>
<td>Mathematical Methods in Petrochemical Engineering</td>
<td>3 -</td>
<td>100</td>
<td>3</td>
</tr>
<tr>
<td>512204</td>
<td>Elective I</td>
<td>3 -</td>
<td>100</td>
<td>3</td>
</tr>
<tr>
<td>512205</td>
<td>Elective II</td>
<td>3 -</td>
<td>100</td>
<td>3</td>
</tr>
<tr>
<td>512206</td>
<td>Lab Practice I</td>
<td>- 6</td>
<td>- 50</td>
<td>3</td>
</tr>
<tr>
<td>512207</td>
<td>Seminar I</td>
<td>- 4</td>
<td>- 50</td>
<td>2</td>
</tr>
</tbody>
</table>

**Total of First Term**

<table>
<thead>
<tr>
<th>L</th>
<th>P</th>
<th>TW</th>
<th>Or</th>
<th>Pr</th>
<th>Total</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>10</td>
<td>500</td>
<td>100</td>
<td>-</td>
<td>600</td>
<td>20</td>
</tr>
</tbody>
</table>

**512204 Elective I**

- a) Advanced Petrochemical Processes
- b) Petroleum Exploration, Drilling and Production
- c) Fuels, Combustion and Gasification Technology

**512205 Elective II**

- a) Novel Separation Techniques.
- b) Principles of Green Technologies
- c) Energy Engineering
## SEMESTER II

<table>
<thead>
<tr>
<th>Code</th>
<th>Subject</th>
<th>Teaching Scheme</th>
<th>Examination Scheme</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>L</td>
<td>Pr</td>
<td>P</td>
</tr>
<tr>
<td>512208</td>
<td>Applied Process Design for Petrochemical Plants</td>
<td>3</td>
<td>-</td>
<td>100</td>
</tr>
<tr>
<td>512209</td>
<td>Safety, Health and Environment in Petrochemical Plants</td>
<td>3</td>
<td>-</td>
<td>100</td>
</tr>
<tr>
<td>512210</td>
<td>Advanced Process Control</td>
<td>3</td>
<td>-</td>
<td>100</td>
</tr>
<tr>
<td>512111</td>
<td>Elective III</td>
<td>3</td>
<td>-</td>
<td>100</td>
</tr>
<tr>
<td>512112</td>
<td>Elective IV (Open)</td>
<td>3</td>
<td>-</td>
<td>100</td>
</tr>
<tr>
<td>512113</td>
<td>Lab Practice II</td>
<td>-</td>
<td>6</td>
<td>-</td>
</tr>
<tr>
<td>512114</td>
<td>Seminar II</td>
<td>-</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total of Second Term</strong></td>
<td></td>
<td>15</td>
<td>10</td>
<td>500</td>
</tr>
</tbody>
</table>

### 512211 Elective III

a) Modeling and Simulation of Petrochemical Processes  
b) Piping Design and Engineering  
c) Advanced Natural Gas Technology

### 512212 Elective IV (Open)

a) Catalysis and Catalytic Reactor Design  
b) Multiphase Reactor Design  
c) Polymerization Process Modeling  
d) Any other elective from other branches
### SEMESTER III

<table>
<thead>
<tr>
<th>Code</th>
<th>Subject</th>
<th>Teaching Scheme</th>
<th>Examination Scheme</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>Pr</td>
<td>P</td>
<td>TW</td>
<td>Orat</td>
</tr>
<tr>
<td>512215</td>
<td>Seminar III</td>
<td>- 4</td>
<td>50</td>
<td>-</td>
</tr>
<tr>
<td>512216</td>
<td>Project Stage I</td>
<td>- 18</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Total of Third Term</td>
<td>- 22</td>
<td>50</td>
<td>-</td>
</tr>
</tbody>
</table>

**Note** - The Contact Hours for the calculation of load of teacher

Seminar - 1 Hr / week / student

Project - 2 Hr / week / student

### SEMESTER IV

<table>
<thead>
<tr>
<th>Code</th>
<th>Subject</th>
<th>Teaching Scheme</th>
<th>Examination Scheme</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>Pr</td>
<td>Project</td>
<td>TW</td>
<td>Orat</td>
</tr>
<tr>
<td>512216</td>
<td>Project Stage II</td>
<td>- 18</td>
<td>200</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Total of Fourth Term</td>
<td>- 18</td>
<td>200</td>
<td>-</td>
</tr>
</tbody>
</table>
512201  Advanced Petroleum Refining

Teaching Scheme:  
Lectures: 3 Hrs/week

Examination Scheme:  
Paper: 100 Marks  
Duration: 3 Hrs.


Reference books:


M.E. (Petrochemical Engg.)

512202 Advanced Transport Phenomena

Teaching Scheme:
Lectures: 3 Hrs/Week

Examination Scheme:
Paper: 100 Marks.
Duration: 3 Hrs.

Tensor Analysis:


Simultaneous heat, mass and momentum transfer. Overview of computational fluid Dynamics (CFD). Process design based on understanding of transport phenomena.

Reference books:


M.E. (Petrochemical Engg.)

512203 Mathematical Methods in Petrochemical Engineering

Teaching Scheme:
Lectures: 3 Hrs/Week

Examination Scheme:
Paper: 100 Marks.
Duration: 3 Hrs.


Reference books:


M.E. (Petrochemical Engg.)

Elective I

512204 (a) Advanced Petrochemical Processes

Teaching Scheme:  
Lectures: 3 Hrs/Week

Examination Scheme:  
Paper: 100 Marks.  
Duration: 3 Hrs.

Production and separation of \( C_1, C_2, C_3, C_4 \) and Aromatic cuts.  
Review of conventional and new technologies starting from \( C_1, C_2, C_3, C_4 \) and Aromatic cuts. Global and Indian Scenario.

Principles of high temperature flame reactors, Design of typical high temperature flame reactors, Reaction Mechanisms in cracking reactions, Effect of process parameters on product distribution in cracking of naphtha and gas.

Principles of furnace design, Design of pipe stills and cracking furnaces, materials of construction for furnaces, chimney designs.

Reference books:


M.E. (Petrochemical Engg.)

Elective I

512204 (b) Petroleum Exploration, Drilling and Production

**Teaching Scheme:**
Lectures: 3 Hrs/Week

**Examination Scheme:**
Paper: 100 Marks.
Duration: 3 Hrs.


**Reference books:**

3. Deshpande B. G. “The World of Petroleum”
**M.E. (Petrochemical Engg.)**

**Elective I**

**512204 (c) Fuels, Combustion and Gasification Technology**

**Teaching Scheme:**
Lectures: 3 Hrs/Week

**Examination Scheme:**
Paper: 100 Marks.
Duration: 3 Hrs.


**Reference Books:**

M.E. (Petrochemical Engg.)

Elective – II

512205 (a) Novel Separation Techniques

**Teaching Scheme:**
Lectures: 3 Hrs/Week

**Examination Scheme:**
Paper: 100 Marks.
Duration: 3 Hrs.


**Reference books:**


2. Schweitzer Philip “Handbook of Separation Techniques for Chemical Engineers”, 1981


Overview of Green Chemistry, Chemistry of the Atmosphere, principles of sustainable and green chemistry, Photochemical smog, Basic principles of green technology, Concept of Atom economy, Tools of Green technology, zero waste technology. Greenhouse Effect, Climate Change, Biocatalysis, Green chemistry in battery, Biofuel, Fuel cell and electric vehicles, Solar energy and hydrogen production, Green Synthetic Methods, Catalytic methods in synthesis, Synthesis in aqueous media, Unconventional energy sources in synthesis

Reference Book:

M.E. (Petrochemical Engg.)

Elective – II

512205 (c) Energy Engineering

Teaching Scheme:
Lectures: 3 Hrs/Week

Examination Scheme:
Paper: 100 Marks.
Duration: 3 Hrs.

Energy crisis in the world and position in India, energy need of growing economy, long-term energy scenario, energy pricing, energy sector reform, energy conservation and its importance, energy conservation act.

Energy strategy, energy policy & energy planning, objective of energy management, trade off between energy management,

Types & procedure of energy audits, modern techniques and instruments for energy audit. Techniques- energy consumption, production & cumulative sum of differences (CUSUM).

Recent advancement in energy technology towards 21st century, transport of energy, ethanol as a fuel. Fusion – introduction potential, condition for fusion, magnetic confinement fusion reactor, cold fusion laser induced fusion.

Case Studies: Energy conservation in different units of refinery likes FCCU, HCU & ADU.

Reference Books:
The term work shall consist of minimum of six exercises from the list given below.

1. Kinetic studies on laboratory set-up for gas-solid catalytic reactor. (Using GC for composition analysis).
2. Design of piping system for any selected petrochemical process.
3. Design of a petrochemical process plant using standard commercial process design software.
5. Heat exchanger network synthesis HEN'S for a refining plant using any standard heat integration program based on pinch analysis.
6. Sequencing of separation columns for a petrochemical plant using synthesis tools having extensive heuristics and analysis capabilities.
7. Characterization of gaseous, liquid and solid wastes from refinery/petrochemical process plants.
8. Detailed design of a pollution control equipment.
9. Experiment designed to understand the utility of network methods in petrochemical engineering.
10. Study of material of construction for furnaces.
M. E. (Petrochemical Engg.)

512207  Seminar - I

Teaching Scheme:
Practical: 4 Hr/week

Examination Scheme:
TW: 50 Marks

Each student is required to deliver a seminar in the first semester.

Topic of the seminar should be based on current trends in advanced research emphasizing literature review. A seminar report of about 30 typed pages should be submitted under the supervision of a teacher. Available case studies may also be incorporated.
M.E. (Petrochemical Engg.)

512208 Applied Process Design for Petrochemical Plants

**Teaching Scheme:**
Lectures: 3 Hrs/Week

**Examination Scheme:**
Paper: 100 Marks.
Duration: 3 Hrs.

Formulation of plant design problem, scope and objectives; construction of flow sheet; plant location selection; construction of process description, process flow diagram, mass and energy balance; selection and sizing of major process equipment; construction materials selection; equipment layout plot plan; construction cost estimation and plant economic analysis; piping and instrumentation diagram; plant design report preparation.

**Reference Books:**

4. Sinnott, R.K., 1985, Coulson-Richardson’s Chemical Engineering Volume 6:

Hazards and risks identification. Safety, health, Identification and assessment of the hazards, Hazard operability (HAZOP) hazard analysis (HAZAN); Assessment of the risk, fault tree, event tree, scope of risk assessment; Control of hazards, Prevention of losses.

Risks incurred by flammable products; flash point, explosive limits, Ignition sources; flames, self-ignition temperature, sparks and static electricity, hydrophobic products, Preventive measures and precautions: during normal conditions, during draining and sampling; in the event of leaks; with regard to storage tanks; during loading and unloading; during repair work.

Regulations and legislation, Role of government role, risk management routines, Human factors in risk management.. Difficulties in improving safety results.

Typical safety organization. Keys for a good safety management in the field.

Reference Books:

3. C. Ray Asfahl, Industrial Safety and Health Management, Fifth Edition
4. Charles D. Reese, Occupational Health and Safety Management: A
Review of Single Input Single Output (SISO) Control; Model Based Control; Multivariable Control Strategies; Internal Model Control Preliminaries and Model Predictive Control, Model forms for Model Predictive Control: Parametric and Non-parametric Models, State Space and Transfer Function Representations and their inter relationships; Control Relevant Process Identification; Choice of Input signals and Model Forms; Parameter Estimation using Batch and Recursive Least Squares; Model Validations using Correlation Concepts; Identification of Non-parametric Representations; Model Predictive Control: Analysis of Dynamic Matrix Control (DMC) and Generalized Predictive Control (GPC) Schemes, Controller Tuning and Robustness Issues; Extensions to Constrained and Multivariable Cases.

Reference books:


M.E. (Petrochemical Engg.)

Elective – III

512211 (a) Modeling and Simulation for Petrochemical Processes

Teaching Scheme:
Lectures: 3 Hrs/Week

Examination Scheme:
Paper: 100 Marks.
Duration: 3 Hrs.


Modeling and simulation of petrochemical processes such as cracking, reforming and distillation.

Reference books:


M.E. (Petrochemical Engg.)

Elective – III

512211 (b) Piping Design and Engineering

Teaching Scheme:
Lectures: 3 Hrs/Week

Examination Scheme:
Paper: 100 Marks.
Duration: 3 Hrs.


Piping systems for petroleum products, yard piping; fire fighting, distillation and heat exchangers. Long distance pipelines.


Reference books:
M.E. (Petrochemical Engg.)

Elective – III

512211 (c) Advanced Natural Gas Technology

**Teaching Scheme:**
Lectures: 3 Hrs/Week

**Examination Scheme:**
Paper: 100 Marks.
Duration: 3 Hrs.

Development and operation of gas fields, gas from condensate and oil fields, thermodynamics and energy change.

Review of physical and chemical properties of natural gas and associate hydrocarbons.

Phase behavior studies: equations of states, multiple flashes, water hydrocarbon systems, chemical inhibition, hydrate formation, gas liquid equilibria.

*Gas handling facilities*: flow of fluids, compression of gases, applications of heat transfer and mass transfer principles in natural gas engineering systems, compressors, pumps, heat exchangers, furnaces and waste heat recovery facilities, transmission of natural gas in pipelines, LPG technology production and distribution.

*Gas processing*: purification, refrigeration and low temperature processing, liquefaction process, LNG and NGL recovery, sweetening of natural gas and sulphur recovery.

*Gas storage*: tanks, underground storage, and conservation of natural gas under coal gasification process and principles, safety. Economic consideration for development of gas fields.

**Reference books:**

M. E. (Petrochemical Engg.)

ELECTIVE IV

512212 (a) Catalysis and Catalytic Reactor Design

Teaching Scheme:  
Lectures: 3 Hrs/week

Examination Scheme:  
Paper: 100 Marks  
Duration: 3 Hrs.

Introduction: industrial reactor types, fixed bed reactor; theoretical background: heterogeneous catalyst, heterogeneous catalytic reaction kinetics, transport phenomena; design and operation of reactors: modeling of fixed bed reactors, strategy and considerations in reactor design; evaluation of fixed bed reactor performance.

Reactor design, especially fixed bed reactor. Role of catalysts in chemical industries; development of catalysts; definition of catalyst; role of catalyst in accelerating reactions; catalytic reaction mechanisms; heterogeneous catalysts; catalytic reaction kinetics; development of catalysis theory; major constituents of catalysts; catalyst manufacturing methods; catalyst characterization; catalyst deactivation.

Reference books:

Teaching Scheme: Lectures: 3 Hrs/week

Examination Scheme: Paper: 100 Marks
Duration: 3 Hrs.

Reaction kinetics for multiphase reactions, Brief idea about multiphase reactors and design considerations, Catalyst deactivation and regeneration. Review of reaction kinetics and reactor design

Industrial reactors: Trickle bed, Bubble column, segmented bed, Agitated slurry, Fluidized bed and slurry reactors, Constructional features and operation (Batch and continuous)


Intrinsic kinetics: Catalysis, Langmuir – Hinshelwood models, Catalyst pellets, Effective diffusivity, Tortuosity, Effectiveness factors, Mass transfer and reaction in packed beds, Determination of limiting step from reaction data

Reference Books:
Decker, 1987


M. E. (Petrochemical Engg.)

ELECTIVE IV

512212  (c) Polymerization Process Modeling

Teaching Scheme:
Lectures: 3 Hrs/week

Examination Scheme:
Paper: 100 Marks
Duration: 3 Hrs.

Rheology of polymer melts and polymer solutions and their characterization; Linear viscoelastic models; Co-rotational derivatives and non-linear viscoelastic models; Experimental techniques of determining the viscoelastic properties.

Distinctive features of polymerizations and Polymer reactors, polymers in bulk and in solution, classification of mechanism of polymerization,

Step growth polymerizations, Linear AB step polymerization, $A_1+B_2$ step polymerization Stoichiometry, Effect of monofunctional agents, cyclizations

Chain growth polymerizations, chemistries of free radical polymerizations, Molecular weight distributions in free radical polymerizations, Parameter estimation

Copolymerization, sequence length distributions in free radical Copolymerization, Parameter estimations and Characterizations

Nonlinear polymerization, structure property relations, critique of Gellation theory, Long chain branching

Reactor configuration, Homogenous continuous stirred tank reactors (HCSTR), Segregated continuous stirred tank reactors (SCSTR), Multistep reactors

Heterogeneous polymerization, suspension, emulsion polymerizations, Heterogeneous coordination Polymerization.
**Reference Books:**

M. E. (Petrochemical Engg.)

512213 Laboratory - II

Teaching Scheme:
Practicals: 6 Hrs/week

Examination Scheme:
TW: 50 Mark

Term work shall consist of experiments and/or computational exercise related to the subjects in the second semester. Minimum of five exercises from the list given below.

1. Numerical solution of a system of ODEs and PDEs with boundary conditions. (Student should write his own code and compare the results with those obtained using any standard mathematical software).

2. Regression and correlation of data collected in laboratory/from literature.

3. Modeling and simulation of riser reactor and/or regenerator in fluid catalytic cracking.

4. Modeling and simulation of steam reformer and/or catalytic reformer.

5. Modeling and simulation of steam cracking unit.


7. Solution of a flow problem using a standard CFD package.

8. Solution of mathematical model of a process involving simultaneous heat, mass and momentum transport.
Each student is required to deliver a seminar in second semester and submit a report of about 30 typed pages.

Topic of the seminar should be based on the chosen discipline of research for dissertation work. It should be based on literature survey related to identified problem for research.
Each student is required to deliver a seminar in the third semester on the objective; literature review, methodology and work carried out during the semester on his/ her dissertation topic.

The project is aimed at training the students in literature search and critical appraisal of the same. The project may also involve some analytical and/ or experimental work. In a few cases the project may also involve a sophisticated design work. Each student will submit a report on his/ her project. The project report is expected to show clarity of thought and expression, critical appraisal of the existing literature and analytical and/ or experimental or design skill.

Each student is required to define objective, methodology, carry out literature review, and plan of work to be carried out during the semester on his/ her dissertation topic.
The project is aimed at training the students in literature search and critical appraisal of the same. The project may also involve some analytical and/or experimental work. In a few cases the project may also involve a sophisticated design work. Each student will submit a report on his/her project. The project report is expected to show clarity of thought and expression, critical appraisal of the existing literature and analytical and/or experimental or design skill.

Each student shall submit three copies of the report containing the work carried out on his/her dissertation topic during the semester for evaluation by the examiners.

On completion of dissertation work, each student will deliver a seminar to defend his/her work.

Each student will submit three copies of the dissertation for evaluation and award. It must incorporate results of investigation on an assigned problem in Petrochemical engineering or allied discipline involving experimental and/or theoretical work.