# *Faculty of Engineering and Technology*
# *P.K.University*
# *Shivpuri (MP)*

**Evaluation Scheme & Syllabus**

**M.Tech. in Chemical Engineering**

**(I Semester)**

**(Effective from session 2025-26)**

# EVALUATION SCHEME

## M.Tech –CHEMICAL ENGINEERING (1st SEM)

**STUDY AND EVALUATION SCHEME FOR M.TECH IN CHEMICAL ENGG.**

**YEAR 1st / SEMESTER-I**

| SUBJECT CODE | SUBJECTS NAME | STUDY SCHEME Periods/Week | | | Credits | MARKS IN EVALUATION SCHEME | | | | | | Total Marks of Internal & External |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | INTERNAL ASSESSMENT | | | EXTERNAL ASSESSMENT | | | |
| | | L | T | P | | Th | Pr | Tot | Th | Pr | Tot | |
| MADVACH101 | Advanced Process Control | 3 | 1 | 0 | 4 | 30 | - | 30 | 70 | - | 70 | 100 |
| MPROCCH102 | Process, Modeling and Simulation | 3 | 0 | 0 | 3 | 30 | - | 30 | 70 | - | 70 | 100 |
| MCHEMCH103 | Chemical Reactor Analysis and Design | 3 | 1 | 0 | 4 | 30 | - | 30 | 70 | - | 70 | 100 |
| MINDUCH104 | Industrial Safety and Risk Management | 3 | 0 | 0 | 3 | 30 | - | 30 | 70 | - | 70 | 100 |
| MFUELCH105 | Fuel Cell Technology | 3 | 0 | 0 | 3 | 30 | - | 30 | 70 | - | 70 | 100 |
| MNEWSCH106 | New Separation Techniques | 3 | 0 | 0 | 3 | 30 | - | 30 | 70 | - | 70 | 100 |
| MCHEMCH107 | Chemical Engineering Lab | 0 | 0 | 2 | 1 | - | 25 | 25 | - | 25 | 25 | 50 |
| **Total** | | 18 | 2 | 2 | 21 | 180 | 25 | 205 | 420 | 25 | 445 | 650 |

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*Department of Chemical Engineering*
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*P.K. University, Shivpuri (MP*
*I Year I Semester*

## MADVACH101: ADVANCED PROCESS CONTROL

**Review of Systems**: Review of first and higher order systems, closed and open loop response. Response to step, impulse and sinusoidal disturbances. Transient response. Block diagrams.

**Stability Analysis:** Frequency response, design of control system, controller tuning and process identification. Zigler-Nichols and Cohen-Coon tuning methods, Bode and Nyquist stability criterion. Process identification.

**Special Control Techniques:** Advanced control techniques, cascade, ratio, feed forward, adaptive control, Smith predictor, internal model control.

**Multivariable Control Analysis:** Introduction to state-space methods, , Control degrees of freedom analysis and analysis, Interaction, Bristol arrays, Niederlinski index - design of controllers, Tuning of multivariable controllers.

**Sample Data Controllers:** Basic review of Z transforms, Response of discrete systems to various inputs. Open and closed loop response to step, impulse and sinusoidal inputs, closed loop response of discrete systems. Design of digital controllers. Introduction to PLC and DCS.

## TEXT BOOKS:


1. D.R. Coughanour, 'Process Systems analysis and Control', McGraw-Hill, 2nd Edition, 1991.
2. D.E. Seborg, T.F. Edger, and D.A. Millichamp, 'Process Dynamics and Control', John Wiley and Sons, 2nd Edition, 2004.


## REFERENCES:


1 B.A.Ogunnaike and W.H.Ray, "Process Dynamics, Modelling and Control", Oxford Press, 1994.

2 W.L.Luyben, 'Process Modelling Simulation and Control for Chemical Engineers', McGraw Hill, 2nd Edition, 1990.

3 B.W. Bequette, 'Process Control: Modeling, Design and Simulation', PHI, 2006.

4 S. Bhanot, 'Process Control: Principles and Applications', Oxford University Press, 2008.

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*I Year I Semester*

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## MPROCCH102: PROCESS MODELLING AND SIMULATION

**Introduction to process modeling** - A systematic approach to model building, classification of models. Conservation principles, thermodynamic principles of process systems.

**Development of steady state** and dynamic lumped and distributed parameter models based on first principles. Analysis of ill-conditioned systems. Models with stiff differential equations.

**Development of grey box models.** Empirical model building. Statistical model calibration and validation. Examples. Introduction to population balance models, multi-scale modeling.

**Solution strategies for lumped parameter models** and stiff differential equations. Solution methods for initial value and boundary value problems. Euler'smethod. R-K methods, shooting method, finite difference methods – predictor corrector methods.

**Solution strategies for distributed parameter models.** Solving parabolic, elliptic and hyperbolic partial differential equations. Introduction to finite element and finite volume methods.

**Solving the problems using *MATLAB/SCILAB.***

**TEXT BOOKS:**


1. K. M. Hangos and I. T. Cameron, "Process Modeling and Model Analysis", Academic Press, 2001.
2. W.L. Luyben, "Process Modeling, Simulation and Control for Chemical Engineers", 2nd Edn., McGraw Hill Book Co., New York, 1990.
3. Singiresu S. Rao, "Applied Numerical Methods for Engineers and Scientists" Prentice Hall, Upper Saddle River, NJ, 2001


**REFERENCES:**


1. Bruce A. Finlayson, Introduction to Chemical Engineering Computing, Wiley, 2010.
2. W. F. Ramirez, "Computational Methods for Process Simulation", 2nd ed., Butterworths, 1997.
3. Amiya K. Jana, Chemical Process Modelling and Computer Simulation, Prentice Hall of India, 2nd Edition, 2011Laurene V. Fausett, Applied Numerical Analysis using MATLAB, Second edition, Pearson, 2009

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*P.K. University, Shivpuri (MP*
*I Year I Semester*

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## MCHEMCH103: CHEMICAL REACTOR ANALYSIS AND DESIGN OBJECTIVES

**Analysis of Non catalytic fluid solid reaction:** Kinetics of non-catalytic fluid-particle reactions, various models, application to design.

**Catalyst preparation and characterization: Catalysis** - Nature of catalyses, methods of evaluation of catalysis, factors affecting the choice of catalysts, promoters, inhibitors, and supports, catalyst specifications, preparation and characterization of catalysts, surface area measurement by BET method, pore size distribution, catalyst, poison, mechanism and kinetics of catalyst, deactivation.

**Physical adsorption and chemical adsorption:** Fluid-fluid reactions different regimes, identification reaction regime, application to design. Physical absorption with chemical reaction, simultaneous absorption of two reacting cases consecutive reversible reactions between gas and liquid, irreversible reactions, estimation of effective interfacial area in absorption equipment.

**Reaction kinetics, accounting porous nature of catalyst:** Heterogeneous catalytic reactions - effectiveness factor, internal and external transport processes, non-isothermal reacting systems, uniqueness and multiplicity of steady states, stability analysis.

**Modeling of chemical reactors:** Modeling of multiphase reactors - Fixed, fluidized, trickle bed, and slurry reactors.

## TEXT BOOKS:


1. O. Levenspiel, "Chemical Reaction Engineering", 3rd Edn., Wiley Eastern, New York, 1999.
2. J .M. Smith, “Chemical Kinetics", 3rd Edn., McGraw Hill, New York, 1981.
3. H.Scott Fogler, “Elements of Chemical Reaction Engineering”,4th Edn., Prentice Hall of India Ltd.,2008.


## REFERENCES:


1. J.J. Carberry “Chemical and Catalytic Reaction Engineering", McGraw Hill, New York,1976.

2. R. Aris, "Elementary Chemical Reactor Analysis", Prentice Hall, 1969.
3.
4. G.F. Froment, K.B. Bischoff, "Chemical Reactor Analysis and Design", 2nd ed., John Wiley, New York, 1990.

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*I Year I Semester*

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## MINDUCH104: INDUSTRIAL SAFETY AND RISK MANAGEMENT

**Hazards:** Chemical hazards classification. Radiation hazards and control of exposure to radiation. Fire hazards. Types of fire and prevention methods. Mechanical hazards. Electrical hazards. Construction hazards.

**Psychology and Hygiene:** Industrial psychology. Industrial hygiene. Nature and types of work places. Housekeeping. site selection and plant layout. Industrial lighting and ventilation. Industrial noise.

**Occupational diseases and control:** Occupational diseases and prevention methods. Safe housekeeping. Instrumentation and control for safe operation. Pressure, Temperature and Level controllers. Personal protective equipments.

**Management and Risk Analysis:** Safety organization – safety committee – safety education and training. Types of safety analysis. Case studies pertaining to chemical industries.

**Legislations and economics:** Factory Act. ESI Act, Environmental Act. Workmen - compensation Act. Provisions under various acts. Economics of safety. Financial costs to individual, family, organization and society. Budgeting for safety

**TEXT BOOKS:**

1. H.H. Fawcett & W. S .Wood, “Safety and Accident Prevention in Chemical Operation",

2nd Ed, Wiley Interscience, 1982.

**REFERENCES:**

1. Guide for Safety in the Chemical laboratory Second edition 1977, Manufacturing Chemists Association. Van Nostrand Reinhold Company, New York.

2. Industrial Safety and Laws, 1993, by Indian School of Labour Education, Madras.

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*I Year I Semester*

# MFUELCH105: FUEL CELL TECHNOLOGY

**Introduction:** Basic principles, classifications, heat of reactions, enthalpy of formation of substances, Gibbs free energy of substances, Efficiency, power, heat due to entropy change and internal ohmic heating.

Nernst equation and open circuit potential, pressure and temperature effect – Stoichio metric coefficients and reactants utilization - Mass flow rate calculation

**Voltage and current in parallel and serial connection –** Over potentials and polarizations - Activation polarization - Tafel equation and exchange current density –

Ionic conductivity, catalysts, Temperature and humidification effect, electro-osmotic Drag effect.

**PEM Fuel Cell components:** Anode and Cathode materials, catalysts, membrane, Fuels for fuel cells.

**PEM Fuel cell stacks -** Rate of mass transfer of reactants and products - water management – current collections and gas removal- Bipolar plates- flow distribution – Heat and water removal from the stack.

**Fuel cell systems analyze:** Energy systems, power- Train or Drive-Train Analysis – PEMFC powered Bus- Flow Sheet and conceptual Design-Detailed Engineering Designs

**TEXT BOOKS:**

1. Fuel Cell Systems Explained, James Larminie and Andrew Dicks, 2nd Edition, John Wiley & Sons Inc., 2000.

2. PEM Fuel Cells Theory and Practice, Frano Barbir, Elsevier Academic Press,2005.

3. Fuel Cell Technology Handbook, Gregor Hoogers, SAE International, 2003.

**REFERENCES:**

1. Fuel Cell Principles and Applications, B Viswanathan and M Aulice Scibioh, Universities Press, 2006.

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*I Year I Semester*

## MNEWSCH106: NEW SEPARATION TECHNIQUES

**General Review: Mechanisms:** Separation factors and its dependence on process variables, classification and characterization, thermodynamic analysis and energy utilization, kinetics and mass transport. Theory of cascades and its application in single and multistage operation for binary and multi component separations.

**Membrane Separations:** Types and choice of membranes, their merits, commercial, pilot plant polarization of membrane processes and laboratory membrane permeators, dialysis, reverse osmosis, ultra filtration, Concentration and economics of membrane operations, Design controlling factors.

**Separation by Sorption Techniques:** Types and choice of adsorbents, chromatographic techniques, Types, Retention theory mechanism, Design controlling factors ion exchange chromatography equipment and commercial processes, recent advances and economics.

**Ionic Separations:** Controlling factors, applications, Theory mechanism and - equipments for electrophoresis, dielectrophoresis and electro dialysis - commercial applications - Design considerations.

**Thermal Separation:** Thermal diffusion: Basic rate law, phenomenological theories of thermal diffusion for gas and liquid mixtures, Equipments design and applications. Zone melting: Equilibrium diagrams, Controlling factors, Apparatus and applications.

**Other Techniques:** Adductive crystallization molecular addition compounds, Clathrate compounds and adducts, Equipments, Applications, Economics and commercial processes. Foam Separation: Surface adsorption, Nature of foams,Apparatus, Applications, & Controlling factors..

***TEXT BOOKS:***


1. H.M. Schoen, "New Chemical Engineering Separation Techniques", Wiley Inter science, New York, 1972.
2. C.J. King, "Separation Processes", Tata McGraw Hill, New Delhi, 1982.
3. B. Sivasankar, "Bioseparations – Principles and Techniques", Prentice Hall of India Pvt. Ltd, New Delhi, 2005.
4. "Membrane Separation processes", Kaushik Nath, PHI ,2008.


***REFERENCES:***


1. R.E. Lacey and S. Loeb, "Industrial Processing with Membranes," Wiley–Inter sciences,New York, 1972.
2. Ronald W.Roussel, Hand book of Separation Process Technology, John Wiley, New York,*1987.* 3.H.R.C. Pratt, "Counter-Current Separation Processes," Elsevier, Amsterdam, 1967."
2. Separation process Principles", J.D. Seader, Ernest J.Henley and D. Keith Roper , 3rdedition, John Wiley & Sons Australia, Limited, 2010.

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*I Year II Semester*

## MCHEMCH107: CHEMICAL ENGINEERING LAB

**List of Experiments**

1. Determination of organic compounds using HPLC
2. Determination of heavy metals using AAS
3. Determination of microstructure using SEM
4. Determination of pollutant concentration using UV Spectro-photometer & other.
5. The course demands development of new methodology, experimental setup, and related theoretical background.