IPS ACADEMY INDORE

INSTITUTE OF ENGINEERING &SCIENCE

(AN AUTONOMUS INSTITUTE BY UGC)

DEPARTMENT OF CHEMICAL ENGINEERING

SYLLABYS FOR POST GRADUATE PROGRAM

M. Tech. II Semester

Chemical Engineering

IPS Academy, Indore, Institute of Engineering & Science

(A UGC Autonomous Institute, Affiliated to RGPV, Bhopal)

Scheme Based on AICTE Flexible Curricula

II Semester — **Master of Technology (M. Tech.) [Chemical Engineering]**

S. No.	Subject Code	Category	Subject Name	Maximum Marks Allotted					Total Marks	Contact Hours per week			Total Credits
				Theory			Practical						
				End Sem.	Mid Sem. Exam.	Quiz/ Assignment	End Sem.	Term work Lab Work & Sessional		L	T	P	
1.	PSCC-MTCH201	PSCC	Advance Heat Transfer	60	25	15	-	-	100	3	1	0	4
2.	PSCC-MTCH202	PSCC	Advanced Process Dynamics & Control	60	25	15	-	-	100	3	1	0	4
3.	PSEC-MTCH201	PSEC	Program Specific Elective Course-III	60	25	15	-	-	100	3	0	0	3
4.	OEC-MTCH201	OEC	Open Elective Course	60	25	15	-	-	100	3	0	0	3
5.	LC-MTCH201	LC	Advance Heat Transfer Lab	-	-	-	60	40	100	0	0	4	2
6.	LC-MTCH202	LC	Advanced Process Dynamics & Control Lab	-	-	-	60	40	100	0	0	4	2
7.	MLC-MTCH201	MLC	Research Methodology & IPR	60	25	15	-	-	100	2	0	0	2
8.	AUC-MTCH201	AUC	Audit Course-II	-	-	-	-	-	100	2	0	0	0
			Total	**300**	**125**	**75**	**120**	**80**	**800**	**16**	**02**	**08**	**20**

Program Specific Elective Course-III	**Open Elective Course**	**Audit Course-II**
Introduction to Micro-fluidics and Micro-reactors	Energy Conservation & Audit	Soft Skills and Interpersonal Communication
Multiphase Reactor Engineering	Industrial Safety & Hazard Management	Communication Skills
Design of Piping Systems	Waste to Energy	Disaster Management
Advanced Nanotechnology	Composite Materials	Life Science

Course Code	Semester	Course Title	Load	Credit
PSCC-MTCH201	II	Advance Heat Transfer	L-3, T-1, P-0	4

Course objective- Basic principles of heat transfer and their application. Subject areas include steady-state analyses for conduction, free and forced convection, boiling, condensation and thermal radiation

Course content-

MODULE 1: Introduction: Basic design procedure of heat transfer equipment, overall heat transfer coefficient, shell and tube heat exchangers Critical thickness of insulation, , log mean temperature difference.

MODULE 2: Heat Exchangers: General design considerations of shell and tubes of heat exchangers, thermo -physical properties, design of double pipe heat exchangers, tube-side heat transfer coefficient and pressure drop, shell-side heat transfer coefficient.

MODULE 3: Laminar flow over flat plate Momentum equations of hydrodynamic boundary layer over a flat plate, Laminar and turbulent flow over a flat plate, turbulent flow in tube, cylinder and sphere. Free convection Momentum and energy equations for laminar free convection heat transfer on a flat plate. Equations for velocity and temperature in vertical and horizontal planes

MODULE 4: Radiation heat transfer concepts. Angle factor calculation. Network method of analysis of radiation exchange. Radiation calculation through gas and vapors.

MODULE 5: Design of compact heat exchanges, Heat transfer due to boiling liquefied metal heat transfer. Heat exchanger effectiveness and number of transfer unit.

Text/Reference Book-

1. Sinnott R.K. and Towler G. 5th Ed. 2009, Chemical Engineering Design, Butterworth-Heinemann
2. McCabe W.L., Smith J.C. and Harriott P. 6th Ed.2001, Unit Operations of Chemical Engineering, New York, McGraw Hill.
3. Holman J.P. 9th Ed, 2001, Heat Transfer, New York, McGraw Hill.
4. Incropera F.P. and Dewitt D.P. 5th Ed. 2002, “Fundamentals of Heat and Mass Transfer. John Wiley.

Course Code	Semester	Course Title	Load	Credit
PSCC-MTCH202	II	Advance Process Dynamics & Control	L-3, T-1, P-0	4

Course objective- Making the students aware of the sophisticated automated process plants and safety concerns and prepared for successful participation in industrial automation and safe process design and confident to handle various software /simulators (MATLAB and SIMULINK).

Course content-

MODULE 1: The notion of a system, stability, Dead time compensator, Inverted response compensator.

MODULE 2: Classical feedback control and controller design, loop shaping, Feed-forward and Ratio controller, and Cascade Controller.

MODULE 3: Internal model control (IMC), IMC based PID design, direct synthesis controller. Elements of linear system theory (system description canonical transformation state controllability and observability).

MODULE 4: State estimator, State feedback controller, Pole placement and observer-based controller. MIMO systems: Extent of interaction and pairing of controlled and manipulated variable using RGA and SVD analysis.

MODULE 5: Practical procedure of MIMO system (closed loop) design. Design of model predictive Controller (MPC).

Text/Reference Book-

1. H. K. Versteeg and Malalasekera, An Introduction to Computational Fluid Dynamics: The Finite Volume Method, Longman Scientific & Technical, 1995.
2. K. Muralidhar, and T. Sundararajan,Computational Fluid Flow and Heat Transfer, Narosa Publishing House, 1995.

Course Code	Semester	Course Title	Load	Credit
PSEC-MTCH201(A)	II	Program Specific Elective Course-III Introduction to Micro-Fluidics and Micro Reactors	L-3, T-0, P-0	3

Course objective-To study the fundamentals of micro-scale flows and micro fabrication. design of microfluidic components and few applications of microfluidic systems.

Course content-

MODULE 1: Origin, Definition, Benefits, Challenges, Commercial activities, Physics of miniaturization, Scaling laws.

MODULE 2: Intermolecular forces, States of matter, Continuum assumption, Governing equations, Constitutive relations. Gas and liquid flows, Boundary conditions, Slip theory, Transition to turbulence, Low Re flows, Entrance effects. Exact solutions, Couette flow, Poiseuille flow, Stokes drag on a sphere, Time-dependent flows, Two-phase flows, Thermal transfer in microchannels. Hydraulic resistance and Circuit analysis, Straight channel of different cross-sections, Channels in series and parallel.

MODULE 3: Surface tension and interfacial energy, Young-Laplace equation, Contact angle, Capillary length and capillary rise, Interfacial boundary conditions, Marangoni effect.

MODULE 4: Materials, Clean room, Silicon crystallography, Miller indices. Oxidation, photolithography- mask, spin coating, exposure and development, Etching, Bulk and Surface micromachining, Wafer bonding. Polymer microfabrication, PMMA/COC/PDMS substrates, micro molding, hot embossing, fluidic interconnections.

MODULE 5: Micropumps, Check-valve pumps, Valve-less pumps, Peristaltic pumps, Rotary pumps, Centrifugal pumps, Ultrasonic pump, EHD pump, MHD pumps. Microvalves, Pneumatic valves, Thermo pneumatic valves, Thermo mechanical valves, Piezoelectric valves, Electrostatic valves, Electromagnetic valves, Capillary force valves. Micro flow sensors, Differential pressure flow sensors, Drag force flow sensors, Lift force flow sensors, Coriolis flow sensors, Thermal flow sensors. Micro mixers, Physics of mixing, Pe-Re diagram of micromixers, Parallel lamination, Sequential lamination, Taylor-Aris dispersion. Droplet generators, Kinetics of a droplet, Dynamics of a droplet, In-channel dispensers, T-junction and Cross-junction, Droplet formation, breakup and transport. Microparticle separator, principles of separation and sorting of micro particles, design and applications. Microreactors, Design considerations, Liquid-phase reactors, PCR, Design consideration for PCR reactors.

Text/Reference Book-

1. Patrick Tabeling, 2012, Introduction to Microfluidics Oxford University Press.
2. Nam-Trung Nguyen, Steven T. Wereley and Seyed Ali Mousavi Shaegh, 2019 Fundamentals and Applications of Microfluidic Third edition, Artech House.
3. Brian J. Kirby, 2010 Micro- and Nanoscale Fluid Mechanics: Transport in Microfluidic Devices, Cambridge University Press.

Course Code	Semester	Course Title	Load	Credit
PSEC-MTCH201	II	Program Specific Elective Course-III Multiphase Reactor Engineering	L-3, T-0, P-0	3

Course objective-Students should be able to calculate size and operating conditions required for a given multiphase reactor.

Course content-

MODULE 1: Introduction of multiphase reactor**,** Flow past immersed bodies: Drag and drag coefficients, flow through beds of solids, motion of particles through fluids, fluidization, types of fluidization and applications.

MODULE 2: Interaction of fluids: Mixing of a single fluid; degree of segregation, early and late mixing of fluids, Gas-liquid flow phenomenon.

MODULE 3: Types of Multiphase-Reactors: Various types of multiphase reactors. Gas-liquid-solid reactors eg. Packed bed, packed bubble column, trickle bed reactor, three phase fluidized bed reactor, slurry bubble column, stirred tank reactor Characteristics of above-mentioned reactors.

MODULE 4: RTD in Multiphase flow systems: Non-Ideal Flow: Residence time distribution of fluid in vessel, E, F & C Curve, Mean and variance, conversion in a reactor using RTD data.

MODULE 5: Models for multiphase reactors: Models for non-ideal flow, dispersion model, N tanks in series model.

Text/Reference Book-

1. Fogler H.S.2014, Elements of Chemical Reaction Engineering,4th Ed., Prentice Hall of India.
2. Levenspiel O. 2008, Chemical Reaction Engineering, 3rd Ed., Wiley-India.

Course Code	Semester	Course Title	Load	Credit
PSEC-MTCH201	II	Program Specific Elective Course-III Design of Piping Systems	L-3, T-0, P-0	3

Course objective-To provide advanced concepts of types of fluids its application in different types of piping network, calculation of power losses in piping network in vertical and horizontal system.

Course content-

MODULE 1: Classification of pipes and tubes IS & BS codes for pipes used in chemical process industries and utilities.

MODULE 2: Pipes for Newtonian and non-Newtonian fluids, sudden expansion and contraction effects, Pipe surface roughness effects, Pipe bends, Shearing characteristics.

MODULE 3: Pressure drop for flow of Newtonian and non-Newtonian fluids through pipes, resistance to flow and pressure drop, effect of Reynolds and apparent Reynolds number. V Pipes of circular and non-circular cross section-velocity distribution, average velocity and volumetric rate of flow. Flow through curved pipes (Variable cross sections), effect of pipe-fittings on pressure losses.

MODULE 4: Non-Newtonian fluid flow through process pipes, Shear stress, Shear rates behavior, apparent viscosity and its shear dependence, Power law index, Yield Stress in fluids, Time dependent behavior, Thixotropic and rheopectic behavior, mechanical analogues, velocity pressure relationships for fluids, line.

MODULE 5: Pipe line design and power losses in compressible fluid flow, Multiphase flow, gas-liquid, solid - fluid, flows in vertical and horizontal pipelines, Lockhart Martinelli relations, Flow pattern regimes.

Suggested Readings

1. Coulson JM and Richardson J.F; Chemical Engineering - Vol I, Butterworth, Oxford
2. Govier, G.W. and Aziz K; Flow of Complex Mixtures in pipe; Krieger Pub, Florida.
3. Dean W.M., Analysis of Transport Phenomena, 2nd Ed, Oxford University Press.
4. Green DW and Malony, Perrys; Chemical Engineers Handbook; TMH.

Course Code	Semester	Course Title	Load	Credit
PSEC-MTCH201	II	Program Specific Elective Course-III Advance Nanotechnology	L-3, T-0, P-0	3

Course objective- To introduce the fundamental concepts of nanoscience and nanomaterials, their synthesis, characterization techniques, size-dependent properties, and applications in chemical engineering, energy, catalysis, and biomedical fields.

MODULE 1: Basic concepts of nanoscience, scientific revolution - Feynman's vision for nanoscience, nanotechnology, and nanomaterials, classification of nanomaterials, dimensions, confinement, surface to volume ratio, energy at bulk and nano scale, nature nanophenomena, size dependent variation in mechanical, physical, chemical, electronics, reaction, catalytic properties.

MODULE 2: Preparation and types of nano materials, physical- chemical and mechanical methods of preparation top down approach, chemical vapor deposition, high energy balling mechano chemical reactions, mechanical alloying, nanostructure through lithography. bottom up approach: polyol route, colloidal precipitation, sol-gel process, chemical precipitation sonochemical, microbial routes, biosynthesis, electrospining method, special nanostructures, quantum dots, magnetic, metal, carbon nanomaterials, nanocomposites.

MODULE 3: Characterization techniques of nanomaterials, electrical, optical, mechanical and magnetic properties of nanomaterials, electrical conductivity and permittivity, magnetic permeability, Structural characterization: X-ray diffraction, electron microscopy, FTIR, XPS. Surface characterization: scanning, electron microscopy, atomic force microscopy. Characterization of porous structures, characterization of quasi-static and dynamic elastic properties

MODULE 4: Applications of nanomaterials for research in chemical engineering nanomaterials for solar cells, energy, drug delivery, nanoscale catalysts for and automobile industries, rechargeable batteries etc.

Text Books

1. Nanomaterials for medical diagnosis and therapy, Challa Kumar, Wiley-VCH, 2007.
2. K.K.Jain, Nano Biotechnology, Horizon's Biosciences, 2006
3. Springer Handbook of Nanotechnology, Edited by Bharat Bhushan, Springer-Verlag (2004)
4. Nanostructures & Nanomaterials: Synthesis, Properties &Applications, G. Cao, Imperial College Press, 2004.
5. Fundamentals of Nanotechnology, Hornyak, G. Louis, Tibbals, H. F., Dutta, Joydeep, CRC Press, 2009

Course Code	Semester	Course Title	Load	Credit
OEC-MTCH201(A)	II	Open Elective Course Energy Conservation and Audit	L-3, T-0, P-0	3

Course objective-To understand the structure and functioning of energy management systems and to aware students on the auditing of energy management systems.

Course content-

MODULE 1: Identify the demand supply gap of energy in Indian scenario, energy management concept and objectives, energy conservation principle, energy conservation methods, energy conservation building codes, energy labeling and energy standards.

MODULE 2: Energy policy; energy conservation act; energy resources allocation and efficient energy use for energy conservation; energy audit instruments and their use.

MODULE 3: Energy efficient technologies in thermal systems: boilers and turbines; cogeneration and combined cycles; steam system and condensate systems and insulation; heat exchangers; furnaces; waste heat recovery and reuse.

MODULE 4: Management systems approach for energy management in organizations; energy management systems and requirements of ISO 50001.

MODULE 5: Auditing and certification of energy management systems: energy audit and its benefits, energy flow diagram, methodology of preliminary energy audit and detailed energy audit, energy audit report.

Text/Reference Book-

1. Thumann and W.J. (2003) Younger: Handbook of energy audits, Fairmont Press, Georgia, USA.
2. Sivaganaraju, S. (2012), Electric Energy Generation, Utilisation and Conservation, Pearson, New Delhi.
3. Partab H., Art and Science of utilization of Electrical Energ, Dhanapat Rai and Sons, New Delhi.
4. ISO 50001: 2011 -Energy management systems —Requirements with guidance for use.

Course Code	Semester	Course Title	Load	Credit
OEC-MTCH201(B)	II	Open Elective Course Industrial Safety & Hazard Management	L-3, T-0, P-0	3

Course objective: To provide comprehensive knowledge of safety and hazards aspects in industries and the management of hazards.

Course content-

MODULE 1: Introduction to industrial safety and hazards: importance of industrial safety, types of hazard: chemical hazard, thermal hazard, electrical hazard, mechanical hazard, vibrational hazard, biological hazard, radioactive hazard, safety and health standards, Indian standards and codes for safety and health.

MODULE 2: Relief systems: Preventive and protective management from fires and explosion-inerting, static electricity passivation, ventilation, and sprinkling, proofing, relief systems – relief valves, flares, scrubbers.

MODULE 3: Toxicology: hazards identification-toxicity, fire, static electricity, noise and dust concentration; material safety data sheet, hazards indices- Dow and Mond indices, hazard operability (HAZOP) and hazard analysis (HAZAN).

MODULE 4: Leaks and leakages: spill and leakage of liquids, vapors, gases and their mixture from storage tanks and equipment; estimation of leakage/spill rate through hole, pipes and vessel burst; isothermal and adiabatic flows of gases, spillage and leakage of flashing liquids, pool evaporation and boiling; release of toxics and dispersion. naturally buoyant and dense gas dispersion models; effects of momentum and buoyancy; mitigation measures for leaks and releases.

MODULE 5: Case studies: Flixborough, Bhopal, Texas, ONGC offshore, HPCL Vizag and Jaipur IOC oil-storage depot incident; Oil, natural gas, chlorine and ammonia storage and transportation hazards.

Text/Reference Book-

1. Crowl D.A. and Louvar J.F. 2nd Ed,2001, Chemical Process Safety: Fundamentals with Applications, Prentice Hall.
2. Mannan S. Vol.I, 3rd Ed. 2004, Lee’s Loss Prevention in the Process Industries, Butterworth Heinemann.
3. Mannan S. Vol.II, 3rd Ed. 2005, Lee’s Loss Prevention in the Process Industries, Butterworth Heinemann.

Course Code	Semester	Course Title	Load	Credit
OEC-MTCH201(C)	II	Open Elective Course Waste to Energy	L-3, T-0, P-0	3

Course objective-To deal with the various types of wastes available and technological options of their exploitation for obtaining useful energy.

Course content-

MODULE 1: Introduction: Introduction to energy from waste, characterization and classification of wastes, availability of agro-based, forest, industrial, municipal solid waste in India, proximate and ultimate analyses, heating value determination of solid liquid and gaseous fuels.

MODULE 2: Waste to energy options I: Incineration, pyrolysis, gasification, hydrogen production, storage and utilization, anaerobic digestion, composting: gas generation and collection in landfills.

MODULE 3: Waste to energy options II: Industrial liquid effluents and their energy potential, anaerobic reactor configuration for fuel gas production, separation of methane and compression.

MODULE 4: Densification: Densification of agro and forest wastes, technological options, combustion characteristics of densified fuels, usage in boilers, brick kilns and lime kilns.

MODULE 5: Biodiesel: Biodiesel production from waste/discarded oils, Case studies: Two industrial case studies where waste materials are used to supplement energy needs.

Text/Reference Book-

1. EL-Halwagi, M.M.1984, Biogas Technology- Transfer and Diffusion, Elsevier Applied Science.
2. Hall, D.O. and Overeed, R.P.1987, Biomass - Renewable Energy, John Willy and Sons.
3. Harker, J.H. and Backhusrt, J.R.1981, Fuel and Energy, Academic Press Inc.
4. Rogoff, M.J. and Screve, F.2011, Waste-to-Energy: Technologies and Project Implementation, Elsevier Store.
5. Young G.C.2010, Municipal Solid Waste to Energy Conversion processes, John Wiley and Sons.

Course Code	Semester	Course Title	Load	Credit
OEC-MTCH201(D)	II	Open Elective Course Composite Materials	L-3, T-0, P-0	3

Course objective-This subject offers the knowledge and understanding of the engineering behavior of composite materials.

Course content-

MODULE 1: Introduction to composite materials: definitions of composite material, fiber, matrix. types of fibers and raw fiber properties, types of matrix, prepegs, fillers and other additives.

MODULE 2: Advantages and applications: advantages of composite materials and structures. applications and use of composite materials in present world. basics of composites: mechanical behavior of composite materials. lamina, laminate: the basic building block of a composite material.

MODULE 3: Various types of composites: classification based on matrix material: organic matrix composites, polymer matrix composites (PMC), carbon matrix composites or carbon-carbon composites, metal matrix composites (MMC).

MODULE 4: Ceramic matrix composites (CMC); classification based on reinforcements: fiber reinforced composites, fiber reinforced polymer (FRP) composites, laminar composites, particulate composites, comparison with metals, advantages and limitations of composite.

MODULE 5: Testing of composites: mechanical testing of composites, tensile testing, compressive testing, intra-laminar shear testing, inter-laminar shear testing, fracture testing etc.

Text/Reference Book-

1. K.K. Chawla, 1988, Composite Materials – Science & Engineering, New York, Springer- Veslag.
2. L.J. Broutman and R.M. Krock, 1967, Modern Composite Materials, Addison-Wesley.
3. Robert M. Jones, 2015, Mechanics of Composite Materials, CRC Press Taylor & Francis.
4. David A Colling & Thomas Vasilos, vol. 2, 1995, Industrial Materials: Polymers, Ceramics and Composites, N. Jersey Prentice Hall.

Course Code	Semester	Course Title	Load	Credit
LC-MTCH201	II	Advance Heat Transfer Lab	L-0, T-0, P-4	2

Course Objective To develop practical understanding of heat transfer mechanisms—conduction, convection, radiation, phase change, and transient heat transfer—and to enable students to evaluate thermal properties, heat transfer coefficients and performance of heat transfer equipment through experiments.

List of experiments-

1. Determine the thermal conductivity of metal rod.
2. Calculate overall heat transfer coefficient & effectiveness for plate type heat exchanger.
3. Observe pool boiling phenomena and to determine the critical heat flux at different bulk temperature.
4. Determine heat transfer coefficients in drop and film condensation phenomenon.
5. Study Stefen-Boltzman constant.
6. Study forced convection by air.
7. Determine the overall heat transfer coefficient and the economy of open pan evaporator when evaporating saturation brine.
8. Study Unsteady state heat transfer by the lumped capacitance.

Course Code	Semester	Course Title	Load	Credit
LC-MTCH201	II	Advanced Process Dynamics & Control Lab	L-0, T-0, P-4	2

Course Objective

To develop practical skills in modeling, simulation, optimization, and control of chemical processes using computational tools such as MATLAB, SCILAB, and SIMULINK.

List of experiments-

1. Solving linear and non-linear algebraic using MATLAB/SCILAB.
2. Differential and partial differential equations using MATLAB/SCILAB.
3. Process Identification using MATLAB/SCILAB.
4. Optimization using MATLAB/SCILAB.
5. Open loop/closed loop process simulation using MATLAB/SCILAB.
6. Use of SIMULINK for process simulation (open loop and closed loop)
7. Use of control toolbox, and MPC toolbox

Course Code	Semester	Course Title	Load	Credit
MLC-MTCH201	II	Research Methodology & IPR	L-2, T-0, P-0	2

Course content-

MODULE 1: Meaning of research problem, Sources of research problem, CriteriaCharacteristics of a good research problem, Errors in selecting a researchproblem, Scope and objectives of research problem.Approaches of investigation of solutions for research problem, data collection,analysis, interpretation, Necessary instrumentations, Effective literature studies approaches, analysis, Plagiarism, Research ethics.

MODULE 2: Effective technical writing, how to write report, Paper, Developing a Research Proposal, Format of research proposal, a presentation andassessment by a review committee.

MODULE 3: Nature of Intellectual Property: Patents, Designs, Trade and Copyright, Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

MODULE 4: Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System. New developments in IPR of Biological Systems, Computer Software etc.Traditional knowledge Case Studies, IPR and IITs.

Text/Reference Book-

1. Stuart Melville and Wayne Goddard, “Research methodology: an introduction for science & engineering students.
2. Wayne Goddard and Stuart Melville, Research Methodology: An Introduction.
3. Ranjit Kumar, 2nd Edition, Research Methodology: A Step by Step Guide for beginners.
4. Halbert, Resisting Intellectual Property, Taylor & Francis Ltd , 2007.
5. Mayall, Industrial Design, McGraw Hill, 1992.
6. Niebel, Product Design, McGraw Hill, 1974.
7. Asimov, Introduction to Design, Prentice Hall, 1962.
8. Robert P. Merges, Peter S. Menell, Mark A. Lemley, Intellectual Property in New Technological Age”, 2016.
9. T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008

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