DEPARTMENT OF CHEMICAL ENGINEERING

MS Process Engineering

Scheme of Study

Pakistan Institute of Engineering and Applied Sciences (PIEAS), Nilore, Islamabad 45650, Pakistan

Program Structure

The Department of Chemical Engineering will acquire and uphold peer-recognized leadership in research and education, at national and international level, in the fields of Chemical Engineering and Mineral Resource Engineering with special focus on national security and socio-economic needs of the country, through adherence to the institutional values of PIEAS.

The MS in Process Engineering is a two year program and consists of approximately 38 credit hours. The course work consists of 26 and research work is of 12 credit hours. Since, the majority of MS students at PIEAS are sponsored by national organizations, so the program structure is slighhlty different for the fellows and self-financed students.

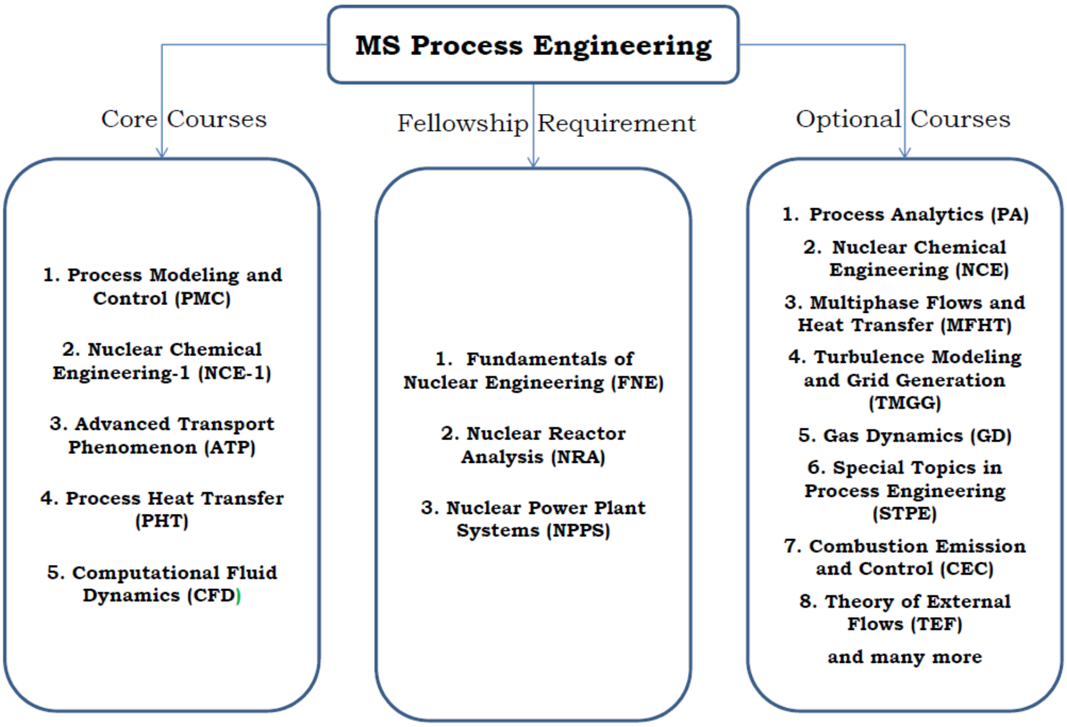
There will be seven departmental courses which will be divided into two classes i.e. core courses (compulsory) and specialized courses.

a. All registered students will be required to pass following five core courses:
   i. Process Heat Transfer (PHT)
   ii. Advanced Transport Phenomena (ATP)
   iii. Process Modelling and Control (PMC)
   iv. Computational Fluid Dynamics (CFD)
   v. Nuclear Chemical Engineering-I (NCE-1).

b. Students will be required to pass any of the two specialized courses offered in that academic year. A list of these courses will be available through registration portal. Students will have to choose these specialized courses with the consent of respective thesis project supervisor or as mandated by employer.

c. Fundamentals of Nuclear Engineering (FNE) will be offered and taught as an institutional requirement while Communication Skills (CS) will be offered and taught as degree requirement.

d. Students receiving fellowship from PAEC must also register and pass the following two courses:
   i. Nuclear Reactor Analysis (NRA)
   ii. Nuclear Power Plant Systems (NPPS).



*Communication Skills will be institutional requirement
** Non-fellow student will have to choose three optional courses.
***Fellows will have a choice of two optional courses.
**** Thesis research will have equal credits for two semesters each.

Semester Wise Layout

Note: 'C' and 'O' stand for 'Compulsory' and 'Optional', respectively

Sr. No	Code	Course Title	Credit HRs	Status	Prerequisites*
SPRING SEMESTER					
1.	CHE-512	Process Heat Transfer	3	C	Nil
2.	CHE-521	Nuclear Chemical Engineering-I	3	C	Nil
3.	CHE-610	Advanced Transport Phenomena	3	C	Nil
4.	NE-501	Fundamentals of Nuclear Engineering	3	C	Nil
5.	CMS-501	Communications Skills	1	C	Nil
SUMMER SESSION					
1.	NE-555	Nuclear Reactor Analysis	3	O	NE-501
2.	NE-510	Nuclear Power Plant Systems	3	O	Nil
FALL SEMESTER					
1.	CHE-413	Fundamentals of Radiation Protection	3+1	O	Nil
2.	CHE-614	Computational Fluid Dynamics	3	C	Nil
3.	CHEa520	Process Modeling and Control	3+1	C	Nil
4.	CHEa532	Process Analytics	3	O	IC
5.	CHE -631	Special Topics in Process Engineering – III	3	O	IC
6.	CHE-612	Multiphase Flow and Heat Transfer	3	O	Nil
7.	CHE-522	Nuclear Chemical Engineering-II	3	O	Nil
8.	CHE-535	Gas Dynamics	3	O	IC
9.	CHE-631	Principles of Safety Management Systems	3	O	Nil
10.	CHEa631	Advanced Process Optimization	3	O	Nil
11.	CHE-532	Instrumental Analytics	3	O	Nil
12.	CHE -519	Extractive Metallurgy	3	O	Nil
13.	CHE-636	Special Topics in Process Engineering– IV	4	O	IC
14.	NE-507	Radiological Engineering	3	O	Nil
15.	NE-609	Nuclear Reactor Safety	3	O	Nil
SPRING SEMESTER					
1.	CHEa697	MS Thesis Research	6	C	Nil
2.	CHEb697	MS Thesis Research	6	C	Nil

Faculty

Name	Designation	Area of Research
Dr. Atta Ullah	Associate Professor (Principal Engineer), **Head of Department**	Multiphase Flows
Dr. Mansoor Hameed Inayat	Professor / Pro-Rector (Chief Engineer)	Mass Transfer
Dr. Jamil Ahmed	Deputy Chief Engineer	Mineral Processing and Extractive Metallurgy
Dr. Muhammad Tayyeb Javed	Professor (Principal Engineer)	Chemical Engineering
Dr. Muhammad Shafiq Siraj	Assistant Professor (Principal Engineer)	Particle Engineering
Dr. Azhar ul Haq	Assistant Professor (Principal Engineer)	Mass Transfer
Dr. Muhammad Nadeem	Assistant Professor (Principal Engineer)	Direct Numerical Simulation
Dr. Adnan Hamid	Associate Professor (Principal Engineer)	CFD and colloidal dispersion
Dr. Muhammad Zaman	Assistant Professor (Principal Engineer)	Process Systems Engineering
Ms. Romana Basit	Assistant Professor (Principal Scientist)	Maths/Process Engineering
Mr. M. Zubair Rahim	Assistant Professor (Senior Engineer)	Mining/Process Engineering
Mr. Aubaidullah	Lecturer (Junior Engineer)	Process Engineering

Courses Contents

CHE-610	Advanced Transport Phenomena
Compulsory	Yes
Credits	3 (Theory: 3 ; Lab: 0)
Prerequisite	Nil
Course Format	3 hrs of lectures per week

Momentum Transport: Derivation of equation of continuity and motion; Application to laminar and turbulent flow problems both under steady state and transient conditions.

Energy Transport: Derivation of energy equation; Application to heat Transfer Problems involving conduction, forced and free convection. In forced convection the cases of laminar and turbulent flow problems both under steady state and transient conditions will be covered

Mass Transport: Derivation of species conservation equations for binary and multi-component mixtures; Application to mass transfer problems with and without chemical reactions under laminar and turbulent flow problems both under steady state and transient conditions

References:

1. Bird, R. B, Stewart, W. E, and Lightfoot, E. N, Transport Phenomenon, 2nd Ed., John Wiley, 2002
2. Welty, J. R., et al., Fundamentals of Momentum, Heat, and Mass Transfer, 5 Ed., John Wiley , 2001
3. White, F. M. Fluid Mechanics, 5th edition, McGraw Hill International, 2005

CHE-614	Computational Fluid Dynamics
Compulsory	Yes
Credits	3 (Theory: 3 ; Lab: 0)
Prerequisite	Nil
Course Format	Three hours of lectures per week

Motivation for CFD; scope and limitations. Review of continuity and transport equationsfor momentum, heat & specie. Survey of numerical methods for convection-diffusion problems: Finite Difference, Finite Volume, Finite Element, Boundary Element Methods, etc. Finite difference method applied to potential flow and conduction problems. Finite Volume method: discretization of diffusion equation, various discretization techniques for convection-diffusion terms, various types of boundary conditions their applications and numerical implementations. Introduction to turbulence and its modeling. Review of solution techniques for system of linear equations, Tri-Diagonal Matrix Algorithm. Introduction to numerical instabilities and convergence; under- and over- relaxation techniques. Case studies on a CFD code: Laminar flow case studies and their verification (Coute flow, convection heat transfer in a circular tube etc.), turbulent flow cases studies and their verifications (turbulent flow in a pipe, jet mixing etc.)

References:

1. Patankar. S. V. Numerical heat transfer and fluid flow, Hemisphere, 1980.
2. Versteeg, H. K. and W. Malalasekera, An introduction to Computational Fluid Dynamics, Addison Wesley Longman Limited, 1995
3. Anderson, J. D., Computational Fluid Dynamics: The Basics with Applications, McGraw Hill Book Co, 1995

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CHE-631	Principles of Safety Management Systems
Compulsory	Yes
Credits	3 (Theory: 3 ; Lab: 0)
Prerequisite	Nil
Course Format	Three hours of lectures per week

Introduction, elements of process safety management, toxicology, industrial hygiene and safety, workplace hazard identification and risk assessment, inherently safer design, safety oversight, physical protection and emergency preparedness, waste minimization strategies and control of pollution, HAZMAT & HAZCOM, major accidents and accident prevention and reporting, workplace-based assessment.

References:

1. Chemical Process Safety: Fundamentals with Applications (3rd Edition) (Prentice Hall International Series in the Physical and Chemical Engineering Sciences) by Daniel A. Crowl and Joseph F. Louvar (2011).
2. Guidelines on Occupational Safety and Health Management Systems, ILO-OSH 2001. International Labour Office, Geneva.
3. Methods in Chemical Process Safety, Volume 1, 1st Edition, Editor Faisal Khan, ISBN: 9780128115473, Academic Press, 7-April 2017
4. Safety Management: A comprehensive approach to developing a sustainable system (2012) by Chitram Lutchman, Rohanie Maharaj, Waddah Ghanem, March 5, 2012 by CRC Press ISBN 9781439862612
5. Inherently safer chemical processes: a life cycle approach, Robert E. Bollinger, Daniel A. Crowl, Center for Chemical Process Safety of the American Institute of Chemical Engineers, 15-Feb-1997Kern D. Q., Process Heat Transfer, McGraw Hill, 1960

CHEa631	**Advanced Process Optimization**
Compulsory	Yes
Credits	3 (Theory: 3 ; Lab: 0)
Prerequisite	Nil
Course Format	Three hours of lectures per week

Optimization problem formulation; general optimization formulation, developing models for optimization, applications of optimization, economic evaluation, efficiency improvement (energy and exergy analysis), sensitivity and uncertainty analysis.

Optimization theory; basic concepts of optimization, unconstraint and constraint optimization problems, linear and nonlinear programming, mixed integer programming, stochastic programming, parameter estimation.

Applications of optimization: Heat transfer and energy conversations systems, Separation processes, Fluid flow systems, Nuclear power plant, parameter estimation (reaction kinetics, phase equilibria), optimal design under uncertainty: selection of optimal processing pathways (biofuel), optimal design for flexible operation (power plant with emission capture) under uncertain economic factors

Case studies: optimization of refrigeration system, optimization of secondary loop of PWR, optimal design of heat exchanger, parameter estimation for EoS (cubic, cubic plus association, SAFT) etc.

Solution of these problems will be implemented in Aspen, GAMS and MATLAB softwares

References:

1. Thomas F. Edgar, David. M. Himmelblau, Optimization of chemical processes, 2nd ed., McGraw-Hill Chemical Engineering Series, 2001
2. Gade P. Rangaiah & Adrian B. Petriciolet, Multi-Objective Optimization in Chemical Engineering: Developments and Applications, John Wiley & Sons, 2013
3. Maria I. Rodrigues, Antonio F. Iemma, Experimental design and process optimization, CRC Press, Taylor and Francis, 2015
4. P. Englezos, N. Kalogerakis, Applied parameter estimation for chemical engineers, CRC Press, 2001
5. John R. Birge, François Louveaux, Introduction to Stochastic Programming, 2nd, Springer Series in Operations Research, 2011
6. Research papers

CHE-631	**Special Topics in Process Engineering - III**
Compulsory	No
Credits	3 (Theory: 3 ; Lab: 0)
Prerequisite	Instructor’s Consent
Course Format	Three hours of lectures per week

To be notified at the time of commencement.

CHE-636	Special Topics in Process Engineering - IV
Compulsory	No
Credits	4 (Theory: 3 ; Lab: 0)
Prerequisite	Instructor's Consent
Course Format	Three hours of lectures per week

To be notified at the time of commencement.

CHE-632	Radioactive Waste Management
Compulsory	No
Credits	3 (Theory: 3 ; Lab: 0)
Prerequisite	CHE-413
Course Format	Three hours of lectures per week

Major sources of nuclear waste; Waste classification; Waste management steps; Waste pre-treatment techniques; Waste treatment processes; Waste conditioning processes; Waste disposal options with special reference to cementation and vitrification; Safety assessment (Mathematical modelling); Waste from decommis-sioning; DRS management; Pakistan perspective

References:

1. Benedict, M, Pigford, T. H, Levi, H. W, Nuclear Chemical Engineering, McGraw Hill, 1981.
2. Proceedings of the Management of Radioactive Wastes from the Nuclear Fuel Cycle, IAEA, Vienna, 1976.
3. Mawsor, G.A., Management of Radioactive Waste, Van Nostrand, 1965.
4. TRS IAEA

CHE-633	Computational Gas Dynamics
Compulsory	No
Credits	3 (Theory: 3 ; Lab: 0)
Prerequisite	CHE-535, CHE-539
Course Format	Three hours of lectures per week

Governing equations of gas dynamics, Riemann problem, Riemann solvers, conservation and other basic principles, Properties of Euler Equation, CFL condition, Linear Stability, Nonlinear Stability, Basic numerical methods for scalar conservation laws, Basic numerical methods for nonlinear systems, Flux vector splitting methods, High order and TVD methods for scalar equations, High order and TVD methods for nonlinear.

References

1. C. B. Laney, "Computational Gasdynamics" Cambridge University Press, 1998
2. E. F. Toro, " Riemann Solvers and Numerical Methods for Fluid Dynamics" Springer, 1999
3. K. A. Hoffmann and S. T. Chiang, " Computational Fluid Dynamics" Vol I and II, EES, 2000

CHE-635	Computer Aided Engineering Applications
Compulsory	No
Credits	3 (Theory: 3 ; Lab: 0)
Prerequisite	Nil
Course Format	Three hours of lectures per week

Introduction to FEM; Types of Grids and methods of grid generation, pre-processing of data using CAD tools, post processing of simulation data, Introduction to various Computer Aided Engineering Codes, benchmarking of codes, Industrial cases studies.

References:

1. Hinton, E. and Owen, D. R. J., Finite Element Programming, Academic Press, 1977.

CHE-612	**Multiphase Flow & Heat Transfer**
Compulsory	No
Credits	3 (Theory: 3 ; Lab: 0)
Prerequisite	CHE-614
Course Format	Three hours of lectures per week

Fundamentals of two flow (Local instant formulation, constitutive equations, interfacial balance and boundary conditions, application of local instant formulation e.g. drag force on a spherical particle, Kelvin-Helmholtz instability, Rayleigh-Taylor instability, Purpose, classification and methods of averaging, Time averaging and time averaged balance equations, Field equations for two-fluid model and constitutive closure laws, Drift-flux modeling, Eulerian multifluid and two fluid modeling for fluid-particle type systems, Basic theory of kinetic granular flow (including derivation of Boltzmann transport equation), Lagrangian (discrete phase model) for fluid-particle type systems, Phase change heat transfer
Multifield models, Thermal non-equilibrium flows, Applications of single-phase CFD to two-phase systems, Application of multifluid models, Interface-tracking methods, Description of various approaches for multiphase fluid models, Volume-of-Fluid, Level Sets, em-bedded interface methods etc, Turbulence modelling in two-phase flows, Multiphase phenomena in Nuclear Systems, Computational Multi-fluid Dynamics (CMFD)

References:

1. Crowe, C., Sommerfield, M., Tsuji, Y., Multiphase Flows with Droplets and Particles, CRC Press, 1998.
2. Whally, P.B., Two-phase flow and heat transfer, (1996)
3. Tong, L. S., Tang, Y. S., Boiling Heat Transfer and Two-Phase Flow, Taylor & Francis, 2nd edition (1997).
4. Mamoru Ishii and Takashi Hibiki, Thermo-fluid dynamics of two-phase flow, Springer, 2nd ed. 2011 edition (December 2, 2010)
5. Brennen, C. E., Fundamentals of Multiphase Flow, Cambridge University Press, 2005.

CHE-613	**Combustion Emission & Control**
Compulsory	No
Credits	3 (Theory: 3 ; Lab: 0)
Prerequisite	Nil
Course Format	Three hours of lectures per week

Fundamental Concepts in Combustion, Primary and Secondary Fuels and Fuel Testing, Energy Conversion with Combustion, Combustion technology of gas, oil and coal, Operation of combustion plant, Pollutants formation in combustion systems, Production and emission of nitrogen oxide and sulphur oxide gases from combustion engines, Emission from coal fired power plants, Combustion calculations, staged combustion, Recent Development in control technologies, Chemical kinetics of reactions; multi-component reacting systems and their equations; coupling of chemical and thermal analysis of reacting systems; Constant pressure fixed mass reactor model; Constant volume fixed mass reactor model; perfectly stirred reactor model; Plug flow reactor model; Application to combustion system modelling; Combustion and chemical kinetic modellingsoftwares; Introduction to chemical kinetic codes for plug flow reactors, perfectly stirred reactors, shock tubes and premixed flames.

References:

1. Glassman, Combustion, Academic Press, 1994
2. E. N. Goodger, Combustion Calculation, MacMillan, 1977.
3. R. A. Strehlow, Combustion Fundamentals, McGraw Hill, 1988.
4. S. Brame and J. G. King, FUELS, Solid, Liquid and Gaseous by, St Martin's Press, NewYork.1973
5. Marion L. Smith and Karl W. Stinson, Fuels and Combustion, McGrawHill Book Company. 1959
6. Smith, J. M, Chemical Engineering Kinetics, McGraw Hill, 1985.

CHE-615	Advanced Topics in Mineral Processing
Compulsory	No
Credits	3 (Theory: 3 ; Lab: 0)
Prerequisite	CHE-514
Course Format	Three hours of lectures per week

Feed characterization: float-sink separation, release analysis, tree procedure. Vector representation for samples: Mayer curves and release curves. Physics and chemistry of surfaces.Measurement of surface properties.Onstream and laboratory analyses and measurements.Laboratory and pilot testing. Flow sheet design.Equipment selection and plant layout.Materials handling, storage and blending.Rejects and tailings disposal. Sampling: sampling theory, sources of error in sampling, design of sampling plants. Process optimisation and control. Process simulation.

References:

1. Kelly, Errol G. and Spottiswood, David J., Introduction to Mineral Processing. John Wiley & Sons. 1989
2. Wills, B.A., Mineral Processing Technology, Pergamon Press. 1985
3. SME Mineral Processing Handbook. American Institute of Mining, Metallurgy and Petroleum Engineers Inc., 1985

CHE-616	Advanced Topics in Environmental Engineering
Compulsory	No
Credits	3 (Theory: 3 ; Lab: 0)
Prerequisite	CHE-412
Course Format	Three hours of lectures per week

Environmental behaviour of noxious Industrial effluents, Atmospheric Chemistry, Photochemical and Sulphurous smog, Acid rains, Global warming, Ozone layer depletion, Particulate emission from industries, Adverse effects of pollutants and pollution economics Control of particulate emission, Design and working of particulate emission control equipment i.e. Gravity settlers, Cyclonic separators, Electrostatic precipitators, Fabric filters, Industrial scrubbers, Gaseous Effluent Treatment Processes, Environmental Assessment and Audits.

References

1. Gerard Kiely, Environmental Engineering, McGrawHill, International Edition 1998,
2. C. Stern, Air pollution, Academic press, 1977.
3. Industrial pollution control, Van Nostrand Reinhold Company, 1981
4. J. Glynn. Henrry and Gary W. Heinke, Environmental Science and Engineering, Prentice Hall, 1996.
5. Noel De. Neverse, Air Pollution Control, McGraw Hill Inc., 1995.
6. Gary W. Canter, Environmental Impact Assessment, McGraw Hill Inc., 1996.

CHE-617	Advanced Process Control
Compulsory	No
Credits	3 (Theory: 3 ; Lab: 0)
Prerequisite	CHE-517, CHE-518
Course Format	Three hours of lectures per week

Introduction; Frequency Response Review; Classical Feedback Control Synthesis; Multivariable Control Review; Multivariable Control Formulation; Linear System Theory; SISO Performance Limitations; SISO Performance Limitations; SISO Performance Limitations; MIMO Performance Limitations; MIMO Performance Limitations; Uncertainty; Frequency Domain Uncertainty; SISO Robust Stability & Robust Perfor-mance; Robust Stability; Structured Singular Value; Robust Performance; MIMO/LQG Control Design; H-2 and H-∞ Control Design; Control Variable Selection; Hierarchical Control; Plant-wide Control; Model Reduction.

References:

1. Smith, C. A, Corripio, A. B, Principles and Practice of Automatic Process Control, John Wiley, 1985.
2. Seborg, D. E, Edgar, T. F, and Mellichamp, D. A, Process Dynamics and Control, John Wiley, 1989

CHE-618	Turbulence Modeling& Grid Generation
Compulsory	No
Credits	3 (Theory: 3 ; Lab: 0)
Prerequisite	CHE-610 / IC
Course Format	Three hours of lectures per week

Turbulence Modelling: Turbulent flows; laminar/turbulent transition, turbulent boundary layers, separated flows, Nature of turbulence, Statistical description, Length scales, turbulent transport

Reynolds-averaged Navier-Stokes equations, turbulent closure, Reynolds stress, Kinetic energy balances, turbulence models; Application in CFD; Large eddy simulation. Measurement and model evaluation

Grid Generation: Introduction; geometry modelling and surface grids; algebraic mesh generation; structured meshes from partial differential equations; automatic generation of unstructured meshes; multiblock mesh generation; unstructured grids by the default triangulation; mesh adaptation on unstructured grids; unstructured grids for viscous flows.

References:

1. Bradshaw, P, Cebeci, T, Whitelaw, J. H, Engineering calculation methods for turbulent flows, Academ-ic Press, 1981. Thompson, M., Grid Generation, John Wiley, 1988.

CHE-619	Meteorology & Atmospheric Dispersion
Compulsory	No
Credits	3 (Theory: 3 ; Lab: 0)
Prerequisite	CHE-412
Course Format	Three hours of lectures per week

Introduction to Meteorology, Temperature, Moisture and Atmospheric Stability, Forms of condensation and Precipitation, Air pressure and winds, Circulation of the Atmosphere, Air Masses, Weather Pattern, Thunderstorms, Tornadoes and Hurricanes, Weather Analysis and forecasting, El-nino and La-nina processes, Moonsoons and Weather of South Asia, World Climates.

Meteorological factors affecting pollution dispersion; Steady state solution of the diffusion equation; Gaussian plume model for point, line and area sources; Calculation of plume rise; Trajectory analysis and long range transport; Emission inventories; Dispersion of pollutants released to water bodies and soil; Pollutants dispersion modeling in atmosphere and surface waters.

References:

1. Frederick K. Lutgens and Edward J. Tarbuck, The Atmosphere, Prentice Hall, 1995.
2. David R. Patrick (Editor), Toxic Air Pollution Handbook, Van Nostrand Reinhold, New York, 1994
3. IAEA, Hydrological Dispersion of radioactive Materials, IAEA Safety Series No. 50-SG-S6, Vienna, 1985.
4. C. Stern, Air pollution, Academic press, 1977.

CHE-697	MS Thesis Research
Compulsory	Yes
Credits	1, 2, 3, 9
Prerequisite	Nil
Course Format	Minimum 3, 6, 9, 27 hrs of research work per week

CHE-512	Process Heat Transfer
Compulsory	Yes
Credits	3 (Theory: 3 ; Lab: 0)
Prerequisite	Nil
Course Format	Three hours of lectures per week

Design and analysis of heat exchangers, covering double pipe, shell and tube and compact heat exchangers. Design and analysis of boilers; fired tube and water tube types. Design and analysis of condensers Radiation heat transfer and furnace design Heat Transfer in Nuclear Reactors

References:

1. Kern D. Q., Process Heat Transfer, McGraw Hill, 1960
2. Ludwig E., Applied Process Design for Chemical & Petrochemical Plants 3rd Edition, Gulf Publishing, 2001
3. El Wakil, M. M, Nuclear Heat Transport, International Text Book, 1971

CHEa520	**Process Modeling and Control**
Compulsory	Yes
Credits	4 (Theory: 3 ; Lab: 1)
Prerequisite	Nil
Course Format	3 hrs of lectures per week 48 hrs of lab-work in the semester

Mathematical Modeling , Dynamic Behavior of Linear Low Order Systems, Dynamic Behavior of Linear Higher Order Systems, Inverse Response Systems, Time-Delay Systems, Frequency-Response Analysis, Stability, Process Identification: Empirical Process Modeling, Feedback Control Systems, Conventional Feedback, Controller Design, Controller Design for Processes with Difficult Dynamics, Model-Based Control, Review of Partial Differential Equations, Physical behaviors of Partial Differential Equations, Mathematical Tools e.g. Tensors, combination of variables, Mathematical Modeling in MATLAB, SIMULINK

References:

1. Murthy, D. N. P, Mathematical Modeling, Pergamon Press, 1990
2. Smith, C. A, Corripio, A. B, Principles and Practice of Automatic Process Control, John Wiley, 1985
3. Murray R. Spiegel Vector Analysis and an Introduction to TENSOR Analysis, 1974
4. John D. Anderson, JR. Computational Fluid Dynamics The Basics with Applications.1995

CMS-501	**Communication Skills**
Compulsory	Yes
Credits	1 (Theory: 1 ; Lab: 0)
Prerequisite	Nil
Course Format	1 hr of lecture per week

Introduction to Communication, Interpersonal skills, Non-verbal communication, Presentation skills, Groups and meetings , Technical Writing Skills, Writing Reports, letters, emails

References:

1. Fujishin, R., Creating Communication, Rowman & Littlefield Publishers, 2009
2. Worth, R., Communication Skills, Career Skills Library, 2004
3. Gurak, L. J., Stretegies for Technical Communication in the Worksplace, Pearson, 2013

CHE-521	**Nuclear Chemical Engineering-I**
Compulsory	Yes
Credits	3 (Theory: 3 ; Lab: 0)
Prerequisite	Nil
Course Format	Three hours of lectures per week

Stable isotopes: Uses, Separation Methods, and Separation Principles; Separation of Isotopes of Hydrogen and other Light Elements; Water Distillation; Hydrogen Distillation; Electrolytic Plant; Exchange-Reaction Plants; Electromagnetic Separation, Chemical Engineering Aspects of Nuclear Power; Nuclear Reactions; Fuel Cycles for Nuclear Reactor; Solvent extraction of Metal; Uranium, Thorium, Zirconium and Hafnium

References:

1. Nuclear Chemical Engineering by M. Benedict, T.H. Pigford and H.W. Levi, McGraw-Hill Book Company, 2009
2. Isotope Separation by StelioVillani, American Nuclear Society,1976

NE-501	Fundamentals of Nuclear Engineering
Compulsory	No
Credits	3 (Theory: 3 ; Lab: 0)
Prerequisite	Nil
Course Format	Three hours of lectures per week

Nuclear cross-sections. Reaction rates; Nuclear fission and chain reaction; Criticality conditions; Neutron slowing-down; Thermal Neutron Spectra, Neutron Diffusion in nonmultiplying media; The one-speed diffusion model of a nuclear reactor, Conversion and breeding, Reactor components and their characteristics; Design features of research, production, and power reactors, Introduction to fast and fusion reactor systems; Core and feed materials and its preparations; Uranium enrichment; Fabrication of fuel; Reprocessing of irradiated fuel; Process waste disposal. Reactor fuel requirements; Burn up studies of nuclear fuels; Fuel cycle performance of commercially available reactors; In-core fuel management and fuel management strategies

References:

1. Murray, R. L.; Nuclear Energy, An introduction to the concepts, systems, and Applications of Nuclear Processes, 6th Ed., Elsevier, 2009.
2. Lamarsh, J.R and Anthony J. Baratta, 3rd Ed., Introduction to Nuclear Engineering, Prentice Hall. 2001.
3. Shultis, J.K. and Faw, R. E. ; Fundamentals of Nuclear Science and Technology, Marcel Dekker Inc, 2002.
4. Glasstone, S. and Sesonske, A., Nuclear Reactor Engineering, 4th Ed., Springer, 1994.
5. Rahman, I.U. and P.S. Sheikh, Introduction to Nuclear Engineering, Krieger, 1981.
6. Graves, H.W., Jr., Nuclear Fuel Management, John Wiley, 1979.

CHE-512	Process Heat Transfer
Compulsory	Yes
Credits	3 (Theory: 3 ; Lab: 0)
Prerequisite	Nil
Course Format	Three hours of lectures per week

Design and analysis of heat exchangers, covering double pipe, shell and tube and compact heat exchangers. Design and analysis of boilers; fired tube and water tube types. Design and analysis of condensers Radiation heat transfer and furnace design Heat Transfer in Nuclear Reactors

References:

1. Kern D. Q., Process Heat Transfer, McGraw Hill, 1960
2. Ludwig E., Applied Process Design for Chemical & Petrochemical Plants 3rd Edition, Gulf Publishing, 2001
3. El Wakil, M. M, Nuclear Heat Transport, International Text Book, 1971

NE-555	Nuclear Reactor Analysis
Compulsory	Yes (PIEAS Fellows only)
Credits	3 (Theory: 3 ; Lab: 0)
Prerequisite	NE-501
Course Format	Three hours of lectures per week

The neutron transport equation; Introduction to numerical solution methods for the transport equation; The diffusion approximation; The Multigroup diffusion model; Numerical solution of the multigroup diffusion equation; Criticality calculations for bare and reflected homogeneous systems; Effects of heterogeneity reactor parameters; Use of computational codes for criticality calculation; The point reactor kinetics model; Temperature and void coefficient of reactivity, Fuel depletion; Fission product poisoning, Control rods.

References:

1. Stacey, W.M, Nuclear Reactor Physics, John Willey and Sons, Inc, 2001.
2. Duderstadt, J.J. and L.J. Hamilton, Nuclear Reactor Analysis, John Wiley, 1976.
3. Ott, K.O. and W.A. Bazella, Introductory Nuclear Reactor Statics, American Nuclear Society, 1983.

4. Henry, AF., Nuclear Reactor Analysis, The M LT. Press, 1975.

NE-510	Nuclear Power Plant Systems
Compulsory	Yes (PIEAS Fellows only)
Credits	3 (Theory: 3 ; Lab: 0)
Prerequisite	NE-501
Course Format	Three hours of lectures per week

Layout of nuclear power plants; Containment buildings; Primary containment vessels; Structure of reactor core; and mechanical stress in various structures. Description and analysis of power plant systems and components including steam generator, steam dryer and separator, pressurizer, reheater, heat exchanger, condenser, demineralizer, pumps ,turbine, generator, cooling tower; Auxiliary cooling systems. Fuel handling mechanisms; Control and mechanisms; Radwaste systems; Electrical Systems; Reactor grid interface and load following. Basic considerations in nuclear plant design; Components of nuclear power cost; Economic comparison of nuclear and fossil fueled plants; Dual and multipurpose nuclear plants; Future trends in nuclear power cost.

References:

1. M. Yastrebenetsky, V. Kharchenko, Nuclear Power Plant Instrumentation and Control Systems for Safety and Security, February 2014.
2. Rust, J. H., Nuclear Power Plant Engineering, Haralson, 1979.
3. El-Wakil, M.M., Nuclear Energy Conversion, International Text Book, 1982
4. Pedersen, E.S., Nuclear Power, Ann Arbor Science, 1978.
5. El-Wakil, M.M., Power Plant Technology, McGraw-Hill, 1984.
6. Lish, K.C., Nuclear Power Plant Systems & Equipment, Industrial Press Inc., 1972.

EE-503	Numerical Methods
Compulsory	No
Credits	3 (Theory: 3 ; Lab: 0)
Prerequisite	CHE-538
Course Format	Three hours of lectures per week

Solution of non-linear equations; Simultaneous solution of a system of linear equations, direct and iterative techniques, relaxation methods; Eigenvalues / Eigenvectors, Interpolation; Numerical Integration/ Differentiation; Solution of ODEs, initial and boundary value problems; Classification and solution of 2nd order PDEs, Parabolic, Elliptic and Hyperbolic equations; Finite Element Methods

References:

1. Burden, R.L., J.D. Faires, and A.C. Reynold, Numerical Analysis, 5th Ed., Prindle, Webster Schmidts, 1993.
2. Faires J.D., and R.L. Burden, Numerical Methods, Prindle, Webster Schmidts, 1993.
3. Yakowitz, S. and F. Szidarovszky, An Introduction to Numerical Computations, Macmillan, 1986.
4. Bajpai A.C., et.al., Numerical Methods for Engineers and Scientists, John Wiley, 1978.
5. Gerald, C.F., and P.O. Wheately, Applied Numerical Analysis, Addison-Wesley, 1989.
6. Brebbia, C.A., and A.J. Ferrante, Computational Methods for the Solution of Engineering Problems, Pentech, 1986.

NE-529	Project Management
Compulsory	No
Credits	3 (Theory: 3 ; Lab: 0)
Prerequisite	Nil
Course Format	Three hours of lectures per week

Management Principles; Project management versus line management; interdisciplinary and multidisciplinary skills of a project manager; balance between cost, time and project scope quality; economic analysis; siting and environmental considerations; regulatory control and licensing; safety analysis reports; turnkey contracts versus owner controlled management; bid specification; technical bid evaluation; quality assurance and quality control; project inspection; schedule control; maintaining cost, schedule and project functional integrity; revision of estimates; plant acceptance testing; staffing for operations and maintenance.

References:

1. Hajek, V. G., Management of engineering projects, McGraw Hill, 1984.

CHE-511	Mathematical Modeling of Physical Systems
Compulsory	No
Credits	3 (Theory: 3 ; Lab: 0)
Prerequisite	CHE-538
Course Format	Three hours of lectures per week

Use of models in process engineering: Model as a working description of a system; Level of detail; types and functions of models: Mechanistic, empirical, stochastic, procedural and qualitative.

Strategy for model building: relationship between engineering and mathematical approximations; Example of dynamic delay of air heater; conceptual models; formulation of functional mechanistic models based on the conservation equations; coordinate free methods based on vector / matrix rotation; models for complex and irregular geometries; Case study examples for heat exchanger and tubular reactor. Definition of system parameters consistent with the model; averaging and model reduction techniques; numerical procedures based on weighted residuals.

References:

1. Murthy, D. N. P, Mathematical Modelling, Pergamon Press, 1990
2. Thomas, P., Simulation of Industrial Processes for Control Engineers, Butterworth Heinemann Pub, 1999

CHE-513	Transport Phenomena – I
Compulsory	No
Credits	4 (Theory: 3 ; Lab: 1)
Prerequisite	Nil
Course Format	3 hrs of lectures per week 42 hrs of lab-work in the semester

Momentum Transport: Derivation of equation of continuity and motion; Application to laminar flow prob-lems.

Energy Transport: Derivation of energy equation; Application to heat Transfer Problems involving conduction, forced and free convection.

Mass Transport: Derivation of species conservation equations for binary and multi-component mixtures; Ap-plication to mass transfer problems with and without chemical reactions.

References:

1. Bird, R. B, Stewart, W. E, and Lightfoot, E. N, Transport Phenomenon, John Wiley, 2000
2. Bennett C.O., Myers J.E. “Momentum, Heat & Mass Transfer” 3rd Ed. 1983. McGraw Hill Book
3. Company.
4. Brodkey Robert S., Hershey Harry C. “Transport Phenomena –A unified Approach”, 1988,
5. McGraw Hill International Editions.

CHE-514	Mineral Processing
Compulsory	No
Credits	4 (Theory: 3 ; Lab: 1)
Prerequisite	Nil
Course Format	3 hrs of lectures per week 42 hrs of lab-work in the semester

Introduction to Mineralogy; Sampling methods; Mineral liberation and fractionation methods; Mineral de-terminative schemes; Theory and application of image analysis for mineral size and composition determina-tion. Objectives of mineral processing. Mine-mill interface. Properties of minerals and ores. Sampling and evaluation. Comminution: fracture, liberation, size criteria, energy-size relationships. Crushing and grinding. Screening and classifying. Concentration processes: density and other physical processes. Interfacial phenomena. Flotation. Liquid-solid separation: flocculation, thickening, filtration. Washability curves. Partition curves. Material balances. Performance prediction.

References:

1. Jones, Meurig P., Applied Mineralogy: A Quantitative Approach. John Wiley & Sons, 1987
2. Kelly, Errol G. and Spottiswood, David J., Introduction to Mineral Processing. John Wiley & Sons, 1989
3. Wills, B.A., Mineral Processing Technology, Pergamon Press. 1985

CHE-515	**Environmental Pollution Assessment & Control**
Compulsory	No
Credits	3 (Theory: 3 ; Lab: 0)
Prerequisite	Nil
Course Format	Three hours of lectures per week

Analytical techniques used in environmental pollution monitoring; Sampling, sample preparation and stor-age; Chemical methods of analysis of common pollutants; Instrumental methods of monitoring/analysis of exhaust gases from automobiles, stacks and chimneys; Performance and structure of analytical techniques; Environmental quality testing for NEQS; Pollution control laws, regulations and policies; River and Marine Pollution, Pollution in Agriculture,; Prediction and assessment of impact of pollution and noise environment; Environmental management systems.

References:

1. Gary D. Christian, Analytical Chemistry, John Wiley and sons, 1984.
2. Roy M. Harrison (Editor) Pollution, causes, effects and control, The Royal Society of Chemistry, 1996.
3. Noel De. Neverse, Air Pollution Control, McGraw Hill Inc., 1995
4. Lain L. ,Malcom S. Cresser, Environmental Chemical analysis, International Text book Company, 1983.
5. J. Glynn. henrry and Gary W. Heinke, Environmental Science and Engineering, Prentice hall, 1996.

CHE-516	**Process Mass and Momentum Transfer**
Compulsory	No
Credits	4 (Theory: 3 ; Lab: 1)
Prerequisite	Nil
Course Format	3 hrs of lectures per week 48 hrs of lab-work in the semester

Design of absorption with and without chemical reaction; binary and multi-component distillation, cooling towers, knockout drums, heat exchangers and liquid extraction columns; Study of water treatment plants with particular emphasis on ion exchange columns and reverse osmosis process; Industrial applications of compressor and pumps including design calculations; Study of process flow, piping, instrumentation and layout diagrams; Brief study of process control.

References:

1. Traybal, V. G., Mass transfer operations, McGraw Hill, 1984
2. Ludwig, E.E., Applied Process Design for Chemical and Petrochemical Plants, 2nd Ed., Vol. 1 – 3, Gulf Pub. Co., 1977

CHE-517	**Applied Mathematics – II**
Compulsory	No
Credits	3 (Theory: 3 ; Lab: 0)
Prerequisite	CHE-538
Course Format	Three hours of lectures per week

Complex numbers; Analytic functions; Cauchy-Riemann equation; Cauchy integral formula; Residue theo-rem; Contour integration; Introduction to the calculus of variations; Euler-Jacobi equations. Orthogonal func-tions; Fourier series and its convergence; Dirichlet's conditions; Complex Fourier series; Fourier transform theorems; Discrete data systems; z-transform theorems; Limitation of the z-transform method, Solution of difference equations by the z-transform method.

References:

1. Churchill, R. V, and J. W. Brown, Complex Variables and Applications, McGraw Hill, 1984
2. C, R. V, and J. W. Brown, Fourier Series and boundary value problems, McGraw Hill, 1978

CHE-518	Process Dynamics and Control
Compulsory	No
Credits	4 (Theory: 3 ; Lab: 1)
Prerequisite	CHE-538, CHE-511
Course Format	3 hrs of lectures per week 42 hrs of lab-work in the semester

Introduction to Process Control; Process Dynamics and Laplace Transform; First Order Systems; Second Order Systems; Inverse Response and Time Delay; Frequency Domain; Linearization and Nonlinear Systems; Stability; Process Identification; Feedback Control Systems; Conventional Design; Inverse Response and Time Delay; Feed forward, Inverse Response, and Time Delay; Model-based Control; Digital Control Sampling; Z Transforms and Digital Block Diagrams; Digital Controller Design; Model Predictive Control; Multivariable Control; RGA and Modal Analysis; SVD and Decoupling; Multivariable Examples.

References:

1. Smith, C. A, Corripio, A. B, Principles and Practice of Automatic Process Control, John Wiley, 1985.
2. Marlin, T.E., Process Control, 2nd Ed., McGraw Hill Book Co., 2000.
3. Ogunnaike, B. A., et al., Process Dynamics, Modeling, and Control, Oxford University Press, 1997.

CHE-519	Extractive Metallurgy
Compulsory	No
Credits	3 (Theory: 3 ; Lab: 0)
Prerequisite	CHE-514
Course Format	Three hours of lectures per week

Thermodynamics and reaction kinetics of extractive metallurgical processes; Thermodynamic stability diagrams.Pyrometallurgy: Roasting, agglomeration, calcination; oxidation-reduction reactions; smelting and converting; refining. Hydrometallurgy: Leaching under atmospheric and elevated pressures; microbial leaching; purification of leach liquors (ion exchange and solvent extraction); cementation and gaseous precipitation; kinetics of hydrometallurgical processes. Electrometallurgy: Electrowinning and electrorefining of metals from aqueous and fused salt systems.

References:

1. Rosenquis, T., Principles of Extractive Metallurgy. McGraw Hill. 1983
2. Jackson, E., Hydrometallurgical Extraction and Reclamation. Jackson/ Ellis Horwood Ltd. 1986

CHE-523	Mineral Resource Exploitation
Compulsory	Yes
Credits	4 (Theory: 4 ; Lab: 0)
Prerequisite	Nil
Course Format	Four hours of lectures per week

Formation and Classification of mineral deposits, considering such aspects as tectonic setting, age, rock composition, geometry, and mineralogy.

Mining Systems and Methods: Ore-body definition; Mine planning and design; Mining equipment; Mine services; Blasting; Milling and processing; Environmental considerations; Mine financing; Decision making process related to world market commodity pricing, mine planning and design, mining equipment, blasting and environmental considerations.

Types of In-Situ Leach Mining; Overview of In-Situ Processes; Evaluation of Mine Potential; In-Situ Mining Chemistry; Hydrology Concepts; Economics Summary; Environmental Considerations and Safeguards; Site Characterization; Permeability Enhancement; Well Pattern Design; In-Situ Leach Mining Plants, Methods of Mineral Separation: Size reduction;Classification;Flotation;Flocculation;Gravityconcentration;Magnetic and electrostatic separations; Dewatering Design, Analysis and Operation of Mineral Processes: Flow sheet eval-uation; Process equipment selection and layout; Capital and operating costs; Operating and control strategies

References:

1. Howard L. Hartman, Introductory Mining Engineering. Wiley-Interscience Publication. ISBN 471-82004-0, 1987, pp. 633
2. SME Mining engineering handbook. Editors: Hartman, Howard L., Britton, S.G., Mutmansky, J.M., Society for Mining, Metallurgy, and Exploration, Inc., Vols. 1 & 2. Revised edition, 1992
3. Rudenno, V., The Mining Valuation Handbook: Mining and Energy Valuation for Investors and Management. Wrightbooks; 3rd ed., 2009
4. Uranium Mining Technology Proceedings. First Conference on Uranium Mining Technology, April 24-29, 1977
5. Uranium Mining Technology Proceedings. Update on Uranium Mining Technology. Nov 1978
6. Jones, Meurig P. Applied Mineralogy: A Quantitative Approach. Graham &Trotman Ltd., 1987
7. Napier-Munn, T., Barry, Wills A., Wills' Mineral Processing Technology: An Introduction to the Practical Aspects of Ore Treatment and Mineral Recovery, 7th ed. Butterworth-Heinemann., 2006
8. Recent Advances in Mineral Processing Plant Design. Editors: Deepak Malhotra, Patrick R. Taylor, Erik Spiller, Marc LeVier, Society for Mining, Metallurgy & Exploration, Inc., 2009
9. Mineral Processing Plant Design. Editors: Mular, R.B., Bhappu, A.L., Society for Mining, Metallurgy & Exploration, Inc., 1980

CHEa532	**Process Analytics**
Compulsory	*No*
Credits	*3 (Theory: 3 ; Lab: 1)*
Prerequisite	*Nil*
Course Format	*Three hours of lectures per week*

Sampling and sample preparation, Chromatographic Methods: Gas chromatography; High Performance Liquid Chromatography; Ion exchange chromatography; Molecular Exclusion Chromatography. Spectroscopic Methods: Atomic Absorption and Emission Spectroscopy; Molecular Spectroscopy; Microwave spectroscopy; Neutron Activation and Mass Spectrometry. Electroanalytical Techniques: Ion Selective Electrodes; Potentiometry; Voltametry and Polarography; Conductometry and Coulometry.

Lab Outline:

a) Online determination of H_2S by photoionization detector
b) Online flue gas analysis by electrochemical sensor
c) Online Measurement of conductivity, pH, and ORP of process stream.
d) Separation of aromatic hydrocarbons by chromatographic techniques
e) Determination of heavy metals in industrial effluents by spectrometric techniques

References:

1. Skoog, D. A., Principles of Instrumental Analysis, Saunders College Publishing. 1985
2. Christian, G.D. and O'Reilly J. E., Instrumental Analysis, Allyon and Bacon, 1986.

CHE-533	**Explosives and Propellants**
Compulsory	No
Credits	3 (Theory: 3 ; Lab: 0)
Prerequisite	Nil
Course Format	Three hours of lectures per week

Explosion theory and types of explosions; The chemistry of explosive compounds and mixtures; The concept of fuel and oxidant, oxygen balance; Thermo-chemistry, simple prediction of heat, temperature and pressure of explosion; Introduction to deflagration, detonation and classification of explosives; Commercial and military HE, power, brisance; Aluminized HE; Introduction to wave shaping and shaped charges; Principles of propellant chemistry, solid and liquid propellants for guns, rockets and mortars; Primary explosives, initiation, effect of heat on explosives, explosives trains; Principles and applications of pyrotechnics.; Safety, reliability and testing of explosives; Management of explosive including classification and storage.

References:

1. Bailey, A. and Murray, S.G., Propellants, Explosives, Pyrotechnics. 3rd Edition. 2001

CHE-534	Water Treatment Technology
Compulsory	No
Credits	3 (Theory: 3 ; Lab: 0)
Prerequisite	CHE-412
Course Format	Three hours of lectures per week

Quality of water supplies, Systems for treating waste water and drinking water, Physical Treatment Systems, Chemical Treatment Systems, Biological Treatment Systems, Design of Sewer System, Sewer materials, Sewer Appurtenances, Sewer construction and Maintenance, Characteristics of waste water, Sewage disposal, Primary and Secondary Treatment Systems, Sludge treatment and disposal, Advanced waste water treatment, Miscellaneous waste water treatment techniques, Financial considerations

References:

1. M. J. Hammer and M. J. Hammer Jr., Water and Wastewater Technology, Prentice Hall, 1996.
2. McGhee, Terence J., Water Supply and Sewerage. 6th Edition, McGraw Hill Inc. 1991
3. W.Viessman, Jr and M. J. Hammer Water Supply and Pollution control, 5th edition, Harper Collins Pub-lishers.1993
4. Eckenfelder, W. W. Jr., Industrial Water Pollution Control. McGraw Hill Inc. 1966.
5. Manahan, S.E., Environmental Chemistry. 6th Edition, Lewis Pub. 1994

CHE-535	Gas Dynamics
Compulsory	No
Credits	3 (Theory: 3 ; Lab: 0)
Prerequisite	Nil
Course Format	Three hours of lectures per week

Review Of Fundamental Principles; Governing Equations Of Compressible Fluid Flow; General Features Of Steady One Dimensional Flow Of A Compressible Fluid; Steady One Dimensional Isentropic Flow With Area Change; Steady One Dimensional Flow With Friction; Steady One Dimensional With Heat Transfer; Shock Waves; Expansion Waves

Mass Addition, Combustion Waves And Generalized Steady One Dimensional Flow

References:

1. Zucrow, M,, Hoffman, J. D., Gas Dynamics, John Wiley Inc, 1976
2. Anderson, J. D., Modern Compressible Flow, 2nd Ed., McGraw Hill Book Co., 1990.

CHE-536	Special Topics in Process Engineering - I
Compulsory	No
Credits	3 (Theory: 3 ; Lab: 0)
Prerequisite	Instructor’s Consent
Course Format	Three hours of lectures per week

To be notified at the time of commencement.

CHE-536	Theory of External Flows
Compulsory	No
Credits	3
Prerequisite	Nil
Course Format	3 hrs of lectures per week

Introduction, Fundamental principles and equations, Circulation, Stream function, Velocity Potential, Dynamics of incompressible inviscid flow field, Characteristic parameters for airfoil and wing aerodynamics, Incompressible flow around airfoils, Incompressible flow about wings, Boundary layer flows, Boundary layer equations for incompressible flows, 2D incompressible laminar flows, 2D incompressible turbulent flows, Boundary layer Separation phenomena in laminar flows, Interactive boundary layer theory, Experimental external flows

References:

1. Anderson, J.D.,Fundamentals of Aerodynamics", 3rd edition, McGraw Hill International, 2001
2. Bertin, J. J.,Aerodynamics for Engineers, Prentice Hall Edition, 2002
3. White, F. M. Fluid Mechanics, 5th edition, McGraw Hill International, 2005
4. White, F. M.,Viscous Fluid Flow, McGraw Hill International, 1991
5. Schlichting, H.,Boundary Layer Theory, 8th edition, McGraw Hill International, 2000
6. Young, A. D., Boundary Layers, AIAA, 1989

CHE-537	Special Topics in Process Engineering - II
Compulsory	No
Credits	3 (Theory: 3 ; Lab: 0)
Prerequisite	Instructor's Consent
Course Format	Three hours of lectures per week

To be notified at the time of commencement.

CHE-538	Applied Mathematics – I
Compulsory	Yes
Credits	3 (Theory: 3 ; Lab: 0)
Prerequisite	Nil
Course Format	Two hours of lectures per week

Partial derivatives of explicit and implicit functions; Maxima and minima of functions of several variables; Double and triple integrals; Special functions; Bessel functions; Legendre polynomials; Laplace transforms; Solution of linear differential equations by the Laplace transform method.

References:

1. Kreyszig, E, Advanced Engineering Mathematics, John Wiley, 1988.

NE-513	Nuclear Chemical Engineering
Compulsory	No
Credits	3 (Theory: 3 ; Lab: 0)
Prerequisite	CHE-512, CHE-516
Course Format	Three hours of lectures per week

Chemical engineering and nuclear power industry; Review of Decay chains, Growth and decay of fission products in and out of the reactor; Build-up of heavy actinides

Nuclear fuel cycles; Feed requirements; Burn up and reactivity changes for mixed and unmixed fuel; Plutonium recycle; Nuclear fuel reprocessing; Solvent extraction; McCabe Thiele diagrammatic solution of problems in separation processes; Equipment for reactor materials processing; Hafnium and Zirconium; Important isotopes, their uses and methods of separation; General cascade theory; Ideal, close separation and squared-off cascades; Separative duty and separation potential; Enrichment costs; Heavy water production, its analysis and process optimization; Uranium enrichment process its analysis and optimization.

References:

1. Gregory R. Choppin, Jan-Olov Liljenzin and Jan Rydberg, Radiochemistry and Nuclear Chemistry, 3rd edition, Elsevier Inc, 2002.
2. Benedict. M., T.H. Pigford, and H.W. Levi, Nuclear Chemical Engineering, McGraw-Hill, 1981.
3. Gregory R. Choppin, Jan-Olov Liljenzin and Jan Rydberg, Radiochemistry and Nuclear Chemistry, 3rd edition, 2002.

A. Vértes, S. Nagy, Z. Klencsár, R. G. Lovas and F. Rösch, Handbook of Nuclear Chemistry, Springer US, 2011.
4. Pratt, H.RC., Countercurrent Separation Processes, Elsevier, 1967.
5. Flagg, J.F. (ed.), Chemical Processing of Reactor Fuels, Acadenuc, 1961.
6. London, H., Separation of Isotopes, Newnes, London, 1963.
7. Villani, S., Isotope Separation, American Nuclear Society, 1976.
8. Becker, E.W., Production of Heavy Water, IAEA, Vienna, 1961.
9. Low Temperature Heavy Water Plant, USAEC report, NYO-889, 1951.

CHE-522	**Nuclear Chemical Engineering-II**
Compulsory	No
Credits	3 (Theory: 3 ; Lab: 0)
Prerequisite	Nil
Course Format	Three hours of lectures per week

Properties of Irradiated Fuel and Other Reactor materials; Plutonium and other Actinide; Fuel Reprocessing and Radioactive waste management; Uranium isotope Separation; Isotopic makeup of the elements; Methods of Isotopic Analysis; The Physical Principles of Isotope Separation; The Theory of Cascades; UF6 Diffusion Plants; Centrifugation; Mass Diffusion; The Separation Nozzle;

References:

1. Nuclear Chemical Engineering by M. Benedict, T.H. Pigford and H.W. Levi, McGraw-Hill Book Company, 2009
2. Isotope Separation by StelioVillani, American Nuclear Society,1976

CHE-413	**Fundamentals of Radiation Protection**
Compulsory	No
Credits	4 (Theory: 3 ; Lab: 1)
Prerequisite	Nil
Course Format	3 hrs of lectures per week 48 hrs of lab-work in the semester

Radiation sources; interaction of radiation with matter; basic principles of radiation detection; Radiation detectors & their applications; Nuclear Instrumentation; Radiation units, natural & man made radiation sources; Elementary biology & biological effects of radiation; Standards of radiation protection; Calculation of expo-sure & dose; Attenuation coefficient & buildup factors for gamma rays; Shielding of sources with different geometrical shapes; Shields with internal sources; Multi-layered shields; Concept of removal cross section; Removal-attenuation & removal diffusion calculations; Dispersion of effluents from nuclear facilities; Radia-tion doses from nuclear plants.

References:

1. Knoll, G. F, Radiation detection and measurement, John Wiley 1989
2. Lamarsh, J. R, Introduction to nuclear engineering, Addison Wesley, 1983.

CHE-412	**Environmental Engineering**
Compulsory	No
Credits	3 (Theory: 3 ; Lab: 0)
Prerequisite	Nil
Course Format	Three hours of lectures per week

The environment and its segments- atmosphere, hydrosphere and lithosphere, Ecosystem and effects of human activities on it; Biochemical cycles; Dynamics of environmental cycles; Different patterns of air circulation; Coriolis effect; Radiation balance of the earth and green house effect; Environmental engineering principles, Pollution from natural sources and human activities; Solid and radioactive waste management; Miscellaneous topics of current interest in environmental engineering.

References:

1. G. M.Masters, Introduction to Environments Engineering and Science , John Wiley & Sons, 1995.
2. P.W. Purdom and S. H. Anderson, Environmental Science, Charles E. Merril Publishing Co., Columbus, Ohio, USA, 1983
3. A.K. De,. S. J. Williamson, Fundamentals of Air Pollution, Addison-Wesley Pub., Co., 1973.
4. J. Glynn. Henrry and Gary W. Heinke, Environmental Science and Engineering, Prentice Hall, 1996.
5. Mackenzie L. Devis and David A. Cornell, McGraw-Hill, Inc., GEC (General Electric Company)
6. Solid Waste Management, Van Nostrand Reinhold Co., 1975.
7. N. J. Sell, Industrial pollution control, Van Nostrand Reinhold Company, 1981.

CHE-415	**Process Engineering Laboratory – I**
Compulsory	No
Credits	3 (Theory: 0 ; Lab: 3)
Prerequisite	Nil
Course Format	Nine hours of laboratory work per week

a) Conduction heat transfer experiment
b) Double pipe heat exchanger experiment
c) Friction loss experiment
d) Pumping experiment
e) Size reduction experiment
f) Gravity separation experiment
g) Study of G. M. counter and NaI(Tl) scintillation detector
h) Calibration and use of health physics instruments.
i) Basic Experiments of Environmental Analysis
j) Determination of Biological and Chemical Oxygen Demand of Waste Water
k) Temperature Control of a Heat Exchanger
l) Level and Pressure Control Experiment

CHE-416	**Thermo-fluids – I**
Compulsory	No
Prerequisite	Nil
Course Format	2 hrs of lectures per week 48 hrs of lab-work in the semester

The physical properties of fluids, phase change thermodynamics, latent heats, steam tables, use of phase diagrams in chemical engineering, the first law of thermodynamics, applications to flowing and non flowing systems; the second law of thermodynamics, entropy, ideal and lost work. Fluid static, manometry, gravity separation. Elementary fluid dynamics, continuity and bernoulli equations, concept of friction factor and application to flow in pipes and special devices.

Lab Outline:

a) Manometry: Practice of U-tube, Inclined and Two-Fluid Manometers.
b) Fluid flow experiments on Bernoulli's Apparatus.
c) Study of flow meters.

References:

1. Smith, J. M., Van Ness, H. C., Abott, M. M., "Introduction to Chemical Engineering Thermodynamics - 7th Edition", McGraw-Hill Book Co., 2005.
2. McCabe, W. L., Smith, J. and Harriott, P., "Unit Operations in Chemical Engineering - 7th Edition", McGraw-Hill Book Co., 2004.

CHE-417	**Thermo-fluids – II**
Compulsory	No
Credits	3 (Theory: 2 ; Lab: 1)

Prerequisite	CHE-416
Course Format	2 hrs of lectures per week 48 hrs of lab-work in the semester

Introductory chemical thermodynamics; heat of formation, heat of reaction, heat of combustion etc. Conversion of nuclear energy into thermal energy; fission and nuclear radiation. Control volume analyses for fluid flow (differential approach). Introduction to turbulence and its effects on velocity profiles. Pumping machinery: types, applications and sizing calculations. Introduction to thermal conductivity and one-dimensional heat conduction in solids. Introduction to convection and radiation heat transfer; concept of film- and overall- heat transfer co-efficients.

Lab Outline:

a) Heat Conduction Experiment
b) Double pipe Heat Exchanger Experiment
c) Study of Pumps

References:

1. Smith, J. M., Van Ness, H. C., Abott, M. M., "Introduction to Chemical Engineering Thermodynamics - 7th Edition", McGraw-Hill Book Co., 2005.
2. McCabe, W. L., Smith, J. and Harriott, P., "Unit Operations in Chemical Engineering - 7th Edition", McGraw-Hill Book Co., 2004.
3. El-Wakil, M. M., "Nuclear Heat Transport", American Nuclear Society, 1981.
4. Incropera, F. P., et al., "Introduction to Heat Transfer, 5th Edition", Whiley (2006).

Dissertation (To be approved by the Board of Studies)	
Compulsory	No
Credits	3 (Theory: 2 ; Lab: 1)
Prerequisite	CHE-416
Course Format	2 hrs of lectures per week 48 hrs of lab-work in the semester