MSc / PG Diploma Course in Sustainable Process Engineering

Curriculum and Scheme of Evaluation

Code	Course Modules	Credits[1]	Evaluation[2] (%)	
			Assignments	Final Exam
Compulsory Modules				
CH 5010	Energy Management	3	40±20	60±20
CH 5020	Environmental Biotechnology	4	40±20	60±20
CH 5030	Sustainable Process Industry	3	40±20	60±20
CH 5040	Chemical Engineering Principles	4	40±20	60±20
CH 5050	Process Analysis and mapping	3	40±20	60±20
CH 5060	Process Safety and Risk Management	3	40±20	60±20
CH 5070	Sustainable Process Development Techniques	3	40±20	60±20
CH 5080	Engineering Research Techniques	3	40±20	60±20
CH 5200	Special Study	2	-	100
CH 6099	Dissertation (for MSc)	20	-	100
Elective Modules (Norm: 12 credits)				
CH 5210	Sustainable Process Design	3	40±20	60±20
CH 5220	Process Management in Industries	3	40±20	60±20
CH 5230	Air Pollution Control	3	40±20	60±20
CH 5240	Sustainable Supply Chain Management	3	40±20	60±20
CH 5250	Process Modeling and Simulation	3	40±20	60±20
CH 5260	Process Optimization	3	40±20	60±20

[1] 1 credit corresponds to 14 hours of lectures or equivalent.

[2] The mean value in the evaluation scheme is the default value. It can be changed by the Lecturer/Examiner concerned, within the specified range, by announcement to the students at the commencement of the course unit.

Syllabi of Course Units

1.

Module Code	**CH5010**	**Title**	**Energy Management**	**Credits: 3**

Learning Outcomes:

On completion of this module, students should be able to;

1. *Understand* energy efficiency, losses, and saving/recovery methods of different energy systems.
2. *Apply* them along with system thinking to *analyze* energy systems by performing energy audits.
3. *Apply* proper economic measures to *evaluate* the cost-effectiveness of energy-saving/recovery methods.

Outline Syllabus:

1. Introduction to energy management
2. Energy auditing
3. Combustion and waste as a fuel
4. Steam generation and distribution
5. Combined Heat and Power (CHP)
6. Cooling systems
7. Energy recovery
8. Alternative energy sources

2.

Module Code	**CH5020**	**Title**	**Environmental Biotechnology**	**Credits: 4**

Learning Outcomes:

On completion of this module, students should be able to;

1. *Understand* the basic principles of biological wastewater treatment.
2. *Apply* these principles to analyze, evaluate, design, and simulation of wastewater treatment processes.
3. *Understand* the environmental management system and conduct life cycle analysis.

Outline Syllabus:

1. Principles of biological wastewater treatment
2. Wastewater treatment technologies and design
3. Principles of biological process modeling
4. Wastewater treatment plant modeling and simulation
5. Solid waste management
6. Environmental Management systems
7. Environmental Impact Assessment and system analysis

3.

Module Code	CH5030	Title	Sustainable Process Industry	Credits: 3

Learning Outcomes:

On completion of this module, students should be able to;

1. *Analyze* and *develop* processes considering their economic, social, and environmental impact.

Outline Syllabus:

1. Introduction to process engineering
2. Key concepts, strategies, and evaluation methods in sustainable process engineering
3. Waste and its sources in process and utility systems and waste minimization strategies
4. Planning, development, design, and operations in the sustainable process industry
5. Case study analysis on the practical implementation of sustainable processes

4.

Module Code	CH5040	Title	Chemical Engineering Principles	Credits: 4

Learning Outcomes:

On completion of this module, students should be able to;

1. *Describe* principles of Unit Processes in Process Engineering industries
2. *Select* a suitable mode of operation and equipment for a given process
3. *Apply* material and energy balance to a variety of process equipment
4. *Perform* Design calculations for process equipment and evaluate the performance
5. *Apply* novel software packages for chemical engineering design calculations

Outline Syllabus:

1. Introduction to Chemical and Process Engineering- Concept of Unit processes
2. Mode of Operations – Continuous, batch, steady and unsteady state processes, reactor types
3. Fundamentals of transport phenomena: principles and applications - Moment, Heat and Mass Transfer
4. Unit operations
   Mass Transfer separations - Distillation, Extraction, Absorption, and Stripping
   Mechanical separation processes –Sedimentation, Filtration, Centrifugation

5.

Module Code	CH5050	Title	Process Analysis and Mapping	Credits: 3

Learning Outcomes:

On completion of this module, students should be able to;

1. *Understand* the basics of process maps
2. *Understand* the different applications of process maps in the industry
3. *Evaluate* different types of process maps used in the industry

Outline Syllabus:

1. Process mapping basics
2. Conceptual modeling using diagrams and maps
3. Applications of process mapping
4. Suitability of process maps in business process renovation projects
5. Knowledge maps and their applications
6. Identification of process improvement opportunities
7. Automation emerging from process mapping
8. Process mapping and QMS
9. Value stream maps and process efficiency
10. Process evaluation using swim-lane-value-stream-maps (SLVSM) as a tool

6.

Module Code	CH5060	Title	Process Safety and Risk Management	Credits: 3

Learning Outcomes:

On completion of this module, students should be able to;

1. *Identify* hazards in the chemical and process industry
2. *Apply* appropriate technologies or measures to reduce process hazards and risks
3. *Analyze* hazards and risks in the chemical and process industry
4. *Evaluate* hazards and risks in the chemical and process industry
5. *Assess* and *manage* hazards and risks in the chemical and process industry

Outline Syllabus:

1. hazards identification and structured analysis tools:
2. hazards assessment (Fire, explosion, and toxic releases consequence assessment):
3. risk terminology and quantified risk analysis (QRA) techniques:
4. Inherent safety and risk management strategies (passive, active, procedural):
5. Operating procedures; Industrial and Process Safety systems; Human factors in safety:
6. Management of change; Process safety culture:
7. Learn from experience: accident case histories:

7.

Module Code	CH5070	Title	Sustainable Process Development Techniques	Credits: 3

Learning Outcomes:

On completion of this module, students should be able to;

1. *Describe* sustainable process development techniques and methodologies
2. *Apply* sustainable process development techniques
3. *Analyze* and *evaluate* alternate processes
4. *Select* environmentally sustainable processes
5. *Select* economically and environmentally sustainable processes
6. *Select* technologically and environmentally sustainable processes

Outline Syllabus:

1. Life Cycle Assessment for Environmental Performance;
2. Life Cycle thinking for social and inherently safer chemical processes
3. Design for sustainability and eco-design
4. Cleaner Production Assessment
5. Process integration solutions for waste avoidance (water pinch)
6. Sustainable development mechanisms (SDM): (Clean Development Mechanism (CDM) and carbon trading)
7. Sustainability assessment tools: (carbon footprint, water footprint, ecological footprint, GHG quantification methods)
8. Best Available Technology (BAT) for selecting processes and technologies
9. Source Reduction and Waste Minimization
10. Resource recovery from waste and recycling techniques
11. Environmental Accounting

8.

Module Code	CH5080	Title	Engineering Research Techniques	Credits: 3

Learning Outcomes:

On completion of this module, students should be able to;

1. *Understand* the basic concepts and methodologies needed to conduct research from the inception of the research problem to the dissemination of new knowledge as a publication.

Outline Syllabus:

1. Research problem formulation
2. Literature review
3. Research proposal writing
4. Ethics in engineering research
5. Experimental planning and designing
6. Data analysis
7. Synthesizing and preparation of a research article

9.

Module Code	CH5210	Title	Sustainable Process Design	Credits: 3

Learning Outcomes:

On completion of this module, students should be able to;

1. *Define and identify* a sustainable process and its key parameters
2. *Evaluate* the environmental impact of a proposed design
3. In-depth *analysis* of an existing design and its impact on society throughout the life cycle
4. *Communicate* SPD and its effects to the management
5. *Align* organizational elements and production processes for SPD

Outline Syllabus:

1. An introduction to Sustainable Process Design (SPD)
2. A life-cycle approach to design assessment – In-depth study on raw material to the waste stream of a process design
3. Environment impact assessment (EIA) and its link to SD
4. Reconsideration of existing designs: examples from the industry
5. Sustainable Design strategies – Innovation, Low-Impact Raw Materials, Optimized Manufacturing, Efficient Distribution, Low-Impact Use … etc.
6. Sustainable process design optimization with data and machine intelligence
7. Participatory approaches to SPD
8. Case studies – Several case studies related to a process design covering the selection of raw materials, identification, and calculation of key design parameters, commissioning for optimum operating conditions, and waste disposal.

10.

Module Code	CH5220	Title	Process Management in Industries	Credits: 3

Learning Outcomes:

On completion of this module, students should be able to;

1. *Understand* the basic concepts of BPM
2. *Describe* the applications of BPM in industries
3. *Analyze* the role played by BPM in optimizing energy consumption
4. *Apply* various management theories that connect with the operationalization of BPM/ IPM

Outline Syllabus:

1. Work process management
2. Manufacturing process management and Industrial Process Management (IPM)
3. Introduction to Business Process Management (BPM)
4. Applications of BPM and IPM
5. Applications of Work Flow Management
6. Process Management theories
7. Energy management in the process industry
8. BPM and manufacturing/ services quality management
9. Operational decision making in the process industry

10. New trends in Industrial Process Management (IPM)

11.

Module Code	**CH5230**	**Title**	**Air Pollution Control**	**Credits: 3**

Learning Outcomes:

On completion of this module, students should be able to;

1. *Understand* air pollution, principles of atmospheric environmental pollution management
2. *Design* air pollution control equipment and processes.

Outline Syllabus:

1. Introduction to air pollution
2. Atmospheric pollution problems and their impact assessment
3. Atmospheric pollution monitoring
4. Control technologies for air pollution
   Stack emission modeling
   Particulate emission control: Technologies and equipment design
   Gaseous pollutants control: absorption, adsorption, biological, thermal destruction and advanced methods

12.

Module Code	**CH5240**	**Title**	**Sustainable Supply Chain Management**	**Credits: 3**

Learning Outcomes:

On completion of this module, students should be able to;

1. *Understand* the principles of supply chain management
2. *Apply* sustainability principles in supply chain management
3. *Analyze* supply chain operations
4. *Evaluate* sustainable supply chain performance
5. *Assess* and *manage* sustainable supply chains
6. *Evaluate and appraise* emerging supply chain sustainability models and strategies

Outline Syllabus:

1. Introduction to sustainable supply chain management
2. Design for environment
3. Sustainable sourcing
4. Green manufacturing
5. Green warehousing
6. Green transportation
7. Collaboration and multi-stakeholder partnerships
8. Assessment and Certification tools and methodologies
9. Strategic Corporate Sustainability
10. Emerging supply chain sustainability concepts and strategies

13.

Module Code	CH5250	Title	Process Modeling and Simulation	Credits: 3

Learning Outcomes:

On completion of this module, students should be able to;

1. *Formulate* dynamic models based on the mechanisms that drive the systems, with special emphasis on simplifying assumptions.
2. *Apply* methods for simulating (solving) the resulting mathematical models.
3. *Apply* basic techniques for model analysis.

Outline Syllabus:

1. Formulation of dynamic models based on material, momentum, and energy balances.
2. Mass conservation in reactions.
3. Overview of constitutive equations (reaction kinetics, thermodynamic models, transport laws).
4. Modeling of coupled systems (co- and counter-current flow, recirculation, etc.).
5. Elementary systems theory: solution of linear models, stability.
6. Solution of models using computers.
7. Accuracy and sources of error in numerical work.
8. Numerical solution of sets of linear- and non-linear equations.
9. Interpolation and extrapolation.
10. Numerical differentiation and integration.
11. Numerical solution of ordinary differential equations and systems of equations.
12. Boundary-value problems for ordinary differential equations.
13. Partial differential equations.
14. Optimization and curve fitting.
15. The use of computer tools for numerical computations.

14.

Module Code	CH5260	Title	Process Optimization	Credits: 3

Learning Outcomes:

On completion of this module, students should be able to;

1. *Understand* the concept of modeling and optimization of industrial processes and *analyze* system behavior.
2. *Apply* advanced process control methods based on multivariable & model predictive control strategies.

Outline Syllabus:

1. Introduction to Matlab for solving numerical problems.
2. Introduction to optimization theory: Unconstrained problems and constrained problems.
3. Primal and dual formulation.
4. Lagrange multipliers.
5. Karush-Kuhn-Tucker conditions for optimum of constrained problems.
6. Nonlinear programming for nonlinear optimization problems, where some of the constraints or the objective function are nonlinear.
7. Numerical methods for solving optimization problems.

8. Solutions using Matlab.

15.

Module Code	**CH5200**	**Title**	**Special Study**	**Credits: 2**

Learning Outcomes:

On completion of this module, students should be able to;

1. *Understand* the theoretical nature of the case.
2. *Analyze* a case to explain the practical nature of a process or system in the real-world scenario.

Outline Syllabus:

1. This is a course in project work, preferably in co-operation with industry.
2. The assignments will normally be of a cross-disciplinary nature. It may necessitate that the students attain theoretical understanding within a specific subject field not covered in the ordinary courses. Assignments can also be research-related. The work can be of theoretical, experimental, and/or practical nature.
3. The project work is to be carried out in small groups (3-6 students). In some cases, one single student can be allowed to carry out a project alone.

16.

Module Code	**CH6099**	**Title**	**Dissertation**	**Credits: 20**

Learning Outcomes:

On completion of this module, students should be able to;

1. *Review* literature critically and *identify* research gaps/problem
2. *Develop* new experimental set ups/ models/strategies
3. *Construct* new ideas or approaches independently
4. *Develop* self-integrity under challenging environment
5. *Analyze* data obtained from an experiment or modeling
6. *Evaluate* results in the context of related literature
7. *Produce* research findings as a published material

Outline Syllabus:

1. The main thesis should incorporate an experimental and/or theoretical topic.
2. The work is to be carried out on an individual basis, even when more students work on the same or related topics.
3. Assignments are suggested by the tutors (researchers). The students have the opportunity to suggest topics in which they are interested. In this case, the tutor will still have to be the author of the assignment texts.

Resource Persons

***Head of the Department*:** Prof. S. Walpalage

***Course Coordinator*:** Dr. (Mrs.) R.M.D.S. Gunarathne

Lecturers:

Department of Chemical and Process Engineering:

1. Senior Prof. A.A.P. de Alwis
2. Prof. (Mrs.) B.M.W.P.K. Amarasinghe
3. Prof. P.G. Rathnasiri
4. Prof. A.D.U.S. Amarasinghe
5. Prof. M. Narayana
6. Dr. (Miss.) M.Y. Gunasekara
7. Dr. S.A.D.T. Subasinghe
8. Dr. (Mrs.) R.M.D.S. Gunarathne
9. Dr. H.H.M.P. Rathnayake

Visiting Staff:

1. Dr. Asoka Fonseka
2. Ms. Gayani de Alwis
3. Dr. Deshai Botheju
4. Mr. Veditha de Silva

Subject coordinators

CODE	Course Modules	Coordinated by
CH 5010	Energy Management	Dr. (Mrs.) R.M.D.S. Gunarathne
CH 5020	Environmental Biotechnology	Prof. P.G. Rathnasiri
CH 5030	Sustainable Process Industry	Prof. A.D.U.S. Amarasinghe
CH 5040	Chemical Engineering Principles	Prof. (Mrs.) B.M.W.P.K. Amarasinghe
CH 5050	Process Analysis and mapping	Dr. S.A.D.T. Subasinghe
CH 5060	Process Safety and Risk Management	Dr. (Miss.) M.Y. Gunasekara
CH 5070	Sustainable Process Development Techniques	Dr. H.H.M.P. Rathnayake
CH 5080	Engineering Research Techniques	Prof. P.G. Rathnasiri
CH 5210	Sustainable Process Design	Dr. H.H.M.P. Rathnayake
CH 5220	Process Management in Industries	Dr. (Mrs.) R.M.D.S. Gunarathne
CH 5230	Air Pollution Control	Prof. (Mrs.) B.M.W.P.K. Amarasinghe
CH 5240	Sustainable Supply Chain Management	Dr. S.A.D.T. Subasinghe
CH 5250	Process Modeling and Simulation	Prof. M. Narayana
CH 5260	Process Optimization	Prof. M. Narayana
CH 5200	Special Study	Prof. M. Narayana