SYLLABUS
DOCTORAL PROGRAM (S3)
CURRICULUM ITS 2018 – 2023

CHEMICAL ENGINEERING DEPARTMENT
FACULTY OF INDUSTRIAL TECHNOLOGY
INSTITUT TEKNOLOGI SEPULUH NOPEMBER
SURABAYA 2018

Study Program	Chemical Engineering
Educational Level	Doctoral Program (S3)

EXPECTED LEARNING OUTCOME		
ATTITUDE	1.1	Believing in the oneness of God and able to demonstrate religious attitude
	1.2	Upholding the value of humanity in undertaking the task based on religion, morality and ethics
	1.3	Contributing in improving the quality of community life, nation and state and the advance of civilization based on Pancasila
	1.4	Playing a role as a proud citizen who loves his/her homeland, having a nationalism and responsibility to the country and nation
	1.5	Appreciating the diversity of cultures, point of view, religion and belief as well as opinion or the original findings of others
	1.6	Working together, having social sensitivity and caring for community and environment
	1.7	Law abiding and disciplined in community and state life
	1.8	Internalizing values, norms and academic ethics
	1.9	Demonstrating attitude of responsibility on work in his/her field of expertise independently
	1.10	Internalizing spirit of independence, struggle and entrepreneurship
	1.11	Trying his/her best to achieve perfect results
	1.12	Working together to be able to make the most of his/her potential
GENERAL SKILL	1.1	Being able to discover or develop new theories or concepts or scientific ideas, contribute to the development and practice of science and / or technology that concerns and implements the value of the humanities in its field of expertise, by producing scientific research based on scientific methodology, logical thinking, critical, systematic, and creative
	1.2	Capable of preparing interdisciplinary, multidisciplinary or transdisciplinary research, including theoretical and / or experimental studies in the fields of science, technology, art and innovation as outlined in the form of dissertations, and papers published in reputable international journals

	1.3	capable of selecting appropriate, current, advanced, and beneficial research on humanity through interdisciplinary, multidisciplinary, or transdisciplinary approaches, in order to develop and / or produce problem solving in the fields of science, technology, art or society, based on the results of a study of the availability of internal and external resources
	1.4	Being able to develop a roadmap of research with interdisciplinary, multidisciplinary, or transdisciplinary approaches, based on a study of the main objectives of the study and its constellations on broader objectives
	1.5	Being able to develop scientific and technological or art arguments and solutions based on a critical view of facts, concepts, principles or theories that can be accounted for scientifically and academically, and communicate them through mass media or directly to the community
	1.6	Being able to demonstrate academic leadership in the management, development and fostering of resources and organizations under their responsibility
	1.7	Being able to manage, including storing, auditing, securing, and rediscovering data and information of research results under his responsibility
	1.8	Being able to develop and maintain collegial and welfare relationships within their own environment or through networks of collaboration with non-institutional research communities
	1.9	Being able to develop themselves and compete in national and international level
	1.10	Being able to implement the principle of sustainability in developing knowledge
	1.11	Being able to implement information and communication technology in the context of execution of its work
KNOWLEDGE	1.1	Philosophy of science and engineering, design engineering, cutting-edge technology required for process design and analysis, processing system, and equipment required for converting raw materials into value-added products through chemical, physical, and biological processes
	1.2	The foremost and most substantial body of knowledge through systematic knowledge acquisition on chemical engineering discipline or professional part of chemical engineering

SPECIAL SKILL	1.1	Able to solve engineering and technology problems of process, processing system, and equipment required for converting raw materials into value-added products through chemical, physical, and biological processes through interdisciplinary, multidisciplinary or trans-disciplinary approach by taking account factors, such as economic, public health and safety, cultural, social, and environment
	1.2	Able to develop new knowledge and/or technology by conducting research in process, processing system, and equipment required for converting raw materials into value-added products through chemical, physical, and biological processes in order to put together original, proven, creative works
	1.3	Able to conceptualize, design, and implement research in the field of process, processing system, and equipment required for converting raw materials into value-added products through chemical, physical, and biological processes in order to invent new knowledge, or to put together new concept or applicable cutting-edge technology

COURSE LIST of MASTER PROGRAM

No.	Course Code	Course Name	SKS
SEMESETER I			
1	TK18610x	Selected Topics in Chemical Engineering:	3
2	TK186104	Scientific Article Writing	2
3	TK186xxx	Elective I	3
4	TK186xxx	Elective II	3
Number of Credit			11
SEMESTER II			
1	TK186xxx	Elective III	3
2		Dissertation	
Number of Credit			3
SEMESTER III			
1		Dissertation	
Number of Credit			
SEMESTER IV			

1		Dissertation	
Number of Credit			
SEMESTER V			
1		Dissertation	
Number of Credit			
SEMESTER VI			
1	TK186601	Dissertation	28
Number of Credit			28
Total Credit			**36**

Course Name: Selected Topics in Chemical Engineering

No.	Course Code	Course Name	Credits
SEMESETER I			
1	TK186101	Chemical Engineering Principles	3
2	TK186102	Environmental Engineering Management	3
3	TK186103	Analysis and Instrumentation Method	3

Course Name: Dissertation

No	Semester	Description	SKS
1	II	Seminar	
2	III	Progress Report I	
3	IV	Progress Report II	
4	V	International Conference Indexed (1)	
5		International Journal Indexed (1)	
6		Progress Report III	
7	VI	Closed Oral Defense	
8		Open Oral Defense	
Total Credit for Dissertation			**28**

LIST of ELECTIVE COURSES

No.	Course Code	Course Name	SKS
1	TK186105	Advance Separation Process	3
2	TK186106	Particle Technology	3
3	TK186107	System Thermal Analysis	3
4	TK186108	Biochemical Reactor	3

5	TK186109	Advance Industrial Waste Management	3
6	TK186110	Computational Fluid Dynamics	3
7	TK186201	Membrane Technology	3
8	TK186202	Coal Processing and Utilization	3
9	TK186203	Electrochemical Reaction Engineering	3
10	TK186204	Heterogenic Catalyst	3
11	TK186205	Aerosol Technology	3
12	TK186206	Natural Gas Processing	3
13	TK186207	Advance Combustion Engineering	3
14	TK186208	Polymer Technology	3
15	TK186209	Advanced Multi Variable Control	3

COURSE	Course Name	:	**Chemical Engineering Principles**
	Course Code	:	TK186101
	Credit	:	3 SKS
	Semester	:	I

DESCRIPTION of COURSE

This course is a doctoral level course designed to discuss several advanced problems in chemical engineering. There are several selected topics. In this course the selected topics will be transport phenomena problems (especially heat and mass transport) and chemical reaction engineering problem. Several advanced problems in transport phenomena (simultaneous conduction/ diffusion and convection with more than one independent variable, simultaneous heat and mass transport and multicomponent mass transport) and chemical reaction engineering (design, optimization, and stability of reactor under non-isothermal condition) and their solution will be described in this course. Learning method and activities comprises lecture, tutorial (discussion), exercises, group project assignment, presentation, and exam (Midterm Exam and Final Exam).

LEARNING OUTCOME

1.1 Philosophy of science and engineering, design engineering, cutting-edge technology required for process design and analysis, processing system, and equipment required for converting raw materials into value-added products through chemical, physical, and biological processes;

1.2 The foremost and most substantial body of knowledge through systematic knowledge acquisition on chemical engineering discipline or professional part of chemical engineering.

2.1 Able to solve engineering and technology problems of process, processing system, and equipment required for converting raw materials into value-added products through chemical, physical, and biological processes through interdisciplinary, multidisciplinary or trans-disciplinary approach by taking account factors, such as economic, public health and safety, cultural, social, and environment;

3.1 Being able to develop scientific and technological or art arguments and solutions based on a critical view of facts, concepts, principles or theories that can be accounted for scientifically and academically, and communicate them through mass media or directly to the community;

3.2 Being able to manage, including storing, auditing, securing, and rediscovering data and information of research results under his responsibility;

3.3 Being able to implement the principle of sustainability in developing knowledge; and
3.4 Being able to implement information and communication technology in the context of execution of its work.
4.1 Demonstrating attitude of responsibility on work in his/her field of expertise independently.

COURSE LEARNING OUTCOME

1. Student being able to formulate conduction-convection heat transfer problem with two independent variables (derive the governing differential equation and boundary conditions) and being able to solve the problem using approximation method (such as asymptotic approximation method)
2. Student being able to formulate diffusion-convection mass transfer problem with two independent variables (derive the governing differential conservation equation and boundary conditions) and being able to solve the problem using analytical (exact) method or approximation method (such as asymptotic approximation method)
3. Student being able to formulate simultaneous heat and mass transfer problem with and without convection (derive the governing differential conservation equation and boundary conditions) and being able to solve the problem using analytical method or approximation method.
4. Student being able to formulate multicomponent (more than two component) mass transport problem (derive the governing differential conservation equation and boundary conditions) and being able to solve the problem using analytical (exact) method or approximation method
5. Student being able to analyze and design reactor in non-isothermal operation
6. Student being able to analyze stability of mixed flow reactor in non-isothermal condition
7. Student being able to conduct optimum design of heterogeneous reactor under non-isothermal condition
8. Student being able to conduct design of solid catalyzed reactor under isothermal and non-isothermal condition.

MAIN SUBJECT

1. Conduction-convection heat transfer
2. Diffusion-convection mass transfer
3. Simultaneous heat and mass transfer
4. Multicomponent mass transport
5. Non-isothermal operation

6. Stability condition in mixed flow reactor
7. Reactor design under optimum temperature profile
8. Heterogeneous (solid catalyzed) reactor design under isothermal and non-isothermal

PREREQUISITES

Fundamental knowledge of Fluid Mechanics, Heat and Mass Transfer, chemical reaction engineering and differential equation

REFERENCE

1. R.Byron Bird, Waren E. Stewart, Edwin N. Lightfoot, Transport Phenomena, second edition, Wiley (2002)
2. L. Gary Leal, Advanced Transport Phenomena, Cambridge University Press (2010)
3. William M. Deen, Analysis of Transport Phenomena, Oxford University Press (2012).
4. H. Scott Fogler, Elements of Chemical Reaction Engineering, 5th ed., Prentice-Hall, 2016
5. Octave Levenspiel, Chemical Reaction Engineering, 3rd ed., Wiley, 1999

COURSE	Course Name	:	**Environmental Engineering Management**
	Course Code	:	TK186102
	Credit	:	3 SKS
	Semester	:	I

DESCRIPTION of COURSE
Studying the economic analysis of zero pollution; studying minimization of industrial waste by recovery, reuse and external sale; study environmental management engineering methods by forming industrial complexes.

LEARNING OUTCOME
1.1 The foremost and most substantial body of knowledge through systematic knowledge acquisition on chemical engineering discipline or professional part of chemical engineering. 2.1 Able to solve engineering and technology problems of process, processing system, and equipments required for converting raw materials into value-added products through chemical, physical, and biological processes through interdisciplinary, multidisciplinary or trans-disciplinary approach by taking account factors, such as economic, public health and safety, cultural, social, and environment. 3.1 Being able to develop scientific and technological or art arguments and solutions based on a critical view of facts, concepts, principles or theories that can be accounted for scientifically and academically, and communicate them through mass media or directly to the community. 3.2 Being able to manage, including storing, auditing, securing, and rediscovering data and information of research results under his responsibility. 3.3 Being able to implement the principle of sustainability in developing knowledge; 3.4 Being able to implement information and communication technology in the context of execution of its work; 4.1 Demonstrating attitude of responsibility on work in his/her field of expertise independently.

COURSE LEARNING OUTCOME
1. Students understand the economic analysis of zero pollution. 2. Students understand the minimization of industrial waste by means of recovery, reuse and external sale.

3. Students understand the method of environmental engineering management by forming an industrial complex.
MAIN SUBJECT
1. Reasons of the achievement of zero pollution. 2. Economic analysis of zero pollution. 3. Minimization of industrial waste by recovery, reuse and external sale. 4. Management of environmental engineering by forming industrial complex.
PREREQUISITES
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REFERENCE
Nelson Leonard Nemerow, 'Zero Pollution for Industry', A. Wiley-Interscience Publication; John wiley & Sons, Inc, New York , 1995.

COURSE	Course Name	:	**Analysis and Instrumentation Method**
	Course Code	:	TK186103
	Credit	:	3 SKS
	Semester	:	I

DESCRIPTION of COURSE

Delivering the importance of chemical and instrumental analysis for conducting research and experiments; describes the selection of appropriate chemical analysis methods and instruments for conducting research on a particular field.

LEARNING OUTCOME

1.1 Philosophy of science and engineering, design engineering, cutting-edge technology required for process design and analysis, processing system, and equipments required for converting raw materials into value-added products through chemical, physical, and biological processes;

1.2 The foremost and most substantial body of knowledge through systematic knowledge acquisition on chemical engineering discipline or professional part of chemical engineering;

2.1 Able to solve engineering and technology problems of process, processing system, and equipments required for converting raw materials into value-added products through chemical, physical, and biological processes through interdisciplinary, multidisciplinary or trans-disciplinary approach by taking account factors, such as economic, public health and safety, cultural, social, and environment;

3.1 Being able to develop scientific and technological or art arguments and solutions based on a critical view of facts, concepts, principles or theories that can be accounted for scientifically and academically, and communicate them through mass media or directly to the community;

3.2 Being able to manage, including storing, auditing, securing, and rediscovering data and information of research results under his responsibility;

3.3 Being able to implement the principle of sustainability in developing knowledge;

3.4 Being able to implement information and communication technology in the context of execution of its work;

4.1 Demonstrating attitude of responsibility on work in his/her field of expertise independently.

COURSE LEARNING OUTCOME
1. Students understand the importance of methods of chemical analysis and instrumentation to conduct research and experiment. 2. Students are able to choose appropriate chemical analysis methods and instruments to conduct research on a particular field.
MAIN SUBJECT
1. Review basic chemical measurements, units and concentrations. 2. Theory and application of spectrophotometric methods (IR, UV - VIS and fluorescence). 3. Nuclear magnetic resonance, spectroscopy, mass spectrometry and electrochemical techniques. 4. Some experiments related to the separation of the mixture using chromatography method (Column chromatography, TLC, paper chromatography, GC, HPLC). 5. Practice the laboratory as a case study consisting of several modules.
PREREQUISITES
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REFERENCE
1. Robert L.Grob 1977, "Modern of Gas Chromatography", 3rd . ed., John Wiley and Sons, Inc., New York. 2. Svehla, G, "Vogel's Textbook of Marco and Semi – Micro Qualitative Inorganic Analysis", 5th ed, 1982. 3. Day, RA Jr & Underwood, AL. "Quantitative Analysis", 6th ed, 1991.

COURSE	Course Name	:	**Scientific Article Writing**
	Course Code	:	TK186104
	Credit	:	2 SKS
	Semester	:	I

DESCRIPTION of COURSE
This course studies the criterion of quality articles, types of scientific publications, the structure of scientific articles, and how to submit articles and reply to review results. It is expected that by following this course, the students can write quality articles.
LEARNING OUTCOME
COURSE LEARNING OUTCOME
The learning outcome of this course is student should be able to publish reputable scientific international articles. Sub-learning outcome of this course: 1. Students are able to apply the criteria of quality articles in the articles that are compiled 2. Students are able to sort out various types of scientific publications 3. Students are able to apply good and correct article structure to the articles they are composing 4. Students are able to submit articles compiled
MAIN SUBJECT
1. Criterion of quality articles 2. Types of scientific publications 3. The structure of scientific articles 4. Submit articles and reply to review results
PREREQUISITES
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REFERENCE
1. Day, R. A., "How to Write & Publish a Scientific Paper", 5th edition, The Oryx Press, 1998 2. Englander, K., "Writing and Publishing Science Research Papers in English, A Global Perspective", Springer, 2014 3. Jalongo, M.R. and Saracho, O.N., "Writing for Publication, Transitions and Tools that Support Scholars' Success", Springer International Publishing, Switzerland, 2016 4. Wallwork, A., English for Writing Research Papers", 2nd edition, Springer International Publishing, Switzerland, 2016

COURSE	Course Name	:	**Advanced Separation Process**
	Course Code	:	TK186105
	Credit	:	3 SKS
	Semester	:	X

DESCRIPTION of COURSE
Studying principles and analyzing conventional separation processes: distillation, absorption and multicomponent extraction; analyze the absorption and distillation process with chemical reactions; analyzing supercritical fluid extraction process; analyze membrane technology for separation process.

LEARNING OUTCOME	
1.1	Science engineering theory, design engineering, cutting-edge method and technology required for analysis, process design, processing system, and the required equipments;
1.2	Natural science concept and applied mathematical engineering principles on the analysis and process design, processing system, and equipments required for converting raw materials into value-added products with chemical, physical, and biological processes;
1.3	Process design techniques and principles, processing system, and equipments required for converting raw materials into value-added products with chemical, physical, and biological processes;
1.4	Latest issues and principles in economy, social, ecology.
2.1	Able to go deep into the knowledge in order to get a better understanding of the process, processing system, and equipments required for converting raw materials into value-added products through chemical, physical, and biological processes to give original and proven contribution by conducting independent research work.
3.1	Capable of managing, developing and maintaining networking with colleagues, peers within the broader institutes and research community;
3.2	Being able to improve the capacity of learning independently;
3.3	Capable of documenting, storing, securing, and rediscovering research data in order to ensure validity and prevent plagiarism;
3.4	Being able to implement the principle of sustainability in developing knowledge;
3.5	Being able to implement information and communication technology in the context of execution of his work.

4.1 Demonstrating attitude of responsibility on work in his/her field of expertise independently.
COURSE LEARNING OUTCOME
1. Students understand the principles and can analyze the conventional separation process: distillation, absorption and multicomponent extraction. 2. Students are able to can analyze the absorption and distillation process with chemical reaction. 3. Students are able to analyze supercritical fluid extraction process. 4. Students are able to analyze membrane technology for process separation.
MAIN SUBJECT
1. Conventional Separation Process: Distillation, Absorption, Extraction. 2. Azeotropic Distillation & Extractive Distillation. 3. Distillation with Chemical Reaction. 4. Absorption with Chemical Reaction. 5. Extraction with Supercritical Fluid. 6. Separation by Membrane Technology.
PREREQUISITES
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REFERENCE
1. J. D. Seader and Ernest J. Henley, Separation Process Principles', John Wiley, New York 1998. 2. W.E. Treybal, Mass Transfer Operation",McGrawHill, NewYork.

COURSE	Course Name	:	**Particle Technology**
	Course Code	:	TK186106
	Credit	:	3 SKS
	Semester	:	X

DESCRIPTION of COURSE
This course studies the basics and applications of particle technology in fields/industries that require knowledge for process and handling of particles and powders. The learning method is case study by conducting advanced literature discussion where students can work independently and in teamwork.

LEARNING OUTCOME
1.1 Science engineering theory, design engineering, cutting-edge method and technology required for analysis, process design, processing system, and the required equipment;
1.2 Natural science concept and applied mathematical engineering principles on the analysis and process design, processing system, and equipment required for converting raw materials into value-added products with chemical, physical, and biological processes;
1.3 Process design techniques and principles, processing system, and equipment required for converting raw materials into value-added products with chemical, physical, and biological processes;
1.4 Latest issues and principles in economy, social, ecology.
2.1 Able to go deep into the knowledge in order to get a better understanding of the process, processing system, and equipment required for converting raw materials into value-added products through chemical, physical, and biological processes to give original and proven contribution by conducting independent research work;
3.1 capable of managing, developing and maintaining networking with colleagues, peers within the broader institutes and research community;
3.2 Being able to improve the capacity of learning independently;
3.3 Capable of documenting, storing, securing, and rediscovering research data in order to ensure validity and prevent plagiarism;
3.4 Being able to implement the principle of sustainability in developing knowledge; and
3.5 Being able to implement information and communication technology in the context of execution of his work
4.1 Demonstrating attitude of responsibility on work in his/her field of expertise independently.

COURSE LEARNING OUTCOME
The learning outcome of this course is students can apply particle technology to fields / industries that require knowledge for process and handling of particles and powders. Sub-learning outcome of this course: 5. Students are able to use particle characterization concepts. 6. Students are able to use particle processing procedures. 7. Students can use the concept of particle formation. 8. Students are able to show the transport mechanism of particles. 9. Students are able to distinguish various kinds of particle-particle separation. 10. Students are able to connect the concepts of particle technology to security.
MAIN SUBJECT
5. Particle characterization 6. Particle processing (mixing and segregation, granulation, deposition) 7. Particle formation (size reduction and enlargement, granulation) 8. Particle transportation (multiphase flow, pneumatic transportation, fluidization) 9. Fluid-particle separation (filtration, precipitation, cyclone) 10. Security (fire and explosion hazard of fine particle)
PREREQUISITES
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REFERENCE
5. Bard, A. J. and Faulkner, L. R., "Electrochemical Methods, Fundamentals and Applications", 2nd edition, John Wiley & Sons, Inc., 2001 6. Perez, N., "Electrochemistry and Corrosion Science", Kluwer Academic Publishers, 2004 7. Goodridge, F. and Scott, K., "Electrochemical Process Engineering", Plenum Press, New York, 1995

COURSE			
	Course Name	:	**System Thermal Analysis**
	Course Code	:	TK186107
	Credit	:	3 SKS
	Semester	:	X

DESCRIPTION of COURSE
This course is intended for graduate students for the basic fundamentals to solve problems in energy and exergy. Students will be given introduction to basic theory on exergy. Exergy application in process design. Exergy analysis on simple processes. Closed system Exergy Balance. Exposure to exergy rate balance for control volumes. Exergetic efficiency. Application on thermoeconomic. Learning method and activities including home assignments, individual and team assignments, quizzes and final exam.

LEARNING OUTCOME
1.1 Science engineering theory, design engineering, cutting-edge method and technology required for analysis, process design, processing system, and the required equipments;
1.2 Natural science concept and applied mathematical engineering principles on the analysis and process design, processing system, and equipments required for converting raw materials into value-added products with chemical, physical, and biological processes;
1.3 Process design techniques and principles, processing system, and equipments required for converting raw materials into value-added products with chemical, physical, and biological processes;
1.4 Latest issues and principles in economy, social, ecology.
2.1 Being able to perform academic validation or studies in accordance with their areas of expertise in solving problems in relevant communities or industries through the development of knowledge and expertise;
3.1 Able to solve engineering and technology problems of process, processing system, and equipments required for converting raw materials into value-added products through chemical, physical, and biological processes by making use of other disciplines (if required) and by taking account factors, such as economic, public health and safety, cultural, social, and environment;
4.1 Demonstrating attitude of responsibility on work in his/her field of expertise independently.

COURSE LEARNING OUTCOME
1. Students are able to define exergy.

2. Students are able to make an exergy balance on open and closed system.
3. Students are able to calculate exergy of a process.
4. Students are able to make an exergy rate balance on control volumes.
5. Students are able to design a process using exergy.
6. Students understand the second law of thermodynamics and the concepts of entropy production "irreversible" along with the ability to analyze and to design system related to energy using exergy method.

MAIN SUBJECT

1. Definition, concepts and formula for energy and exergy and its correlation.
2. Background development of exergy method as a tool for analyzing exergy from systems related to energy.
3. Example of profit obtained by using exergy method to determine e3xergy loss and its cause in a power plant.
4. Example of application exergy method on analyzing individual chemical engineering system (simple system), that is heat exchange system, combustion system, and process reactions and many others.
5. Block method from exergy analyzes
6. Application of exergy analyzes for complex system consist of loops of individual systems.

PREREQUISITES

REFERENCE

1. Michael J. Moran, Howard N. Sapiro, "Fundamentals of Engineering Thermodynamics ", 5th edition, John Wiley & Sons, New York, 2006
2. T.J. Kotas, "The Exergy Method of Thermal Plant Analysis, 2nd edition, Krieger Publishing Company, New York, 1995.

COURSE	Course Name	:	**Biochemical Reactor**
	Course Code	:	TK186108
	Credit	:	3 SKS
	Semester	:	X

DESCRIPTION of COURSE
The course learns the basic bioreactor design using enzyme or whole cell of microorganisms as biocatalyst, kinetics of enzymatic reaction using free or immobilized enzyme, as well as kinetics of reaction catalyzed by living organism. The class is conducted through lecturing, discussion, presentation, case study, problem based learning, and written test (quiz, assignment, final exam).

LEARNING OUTCOME
1.1 Engineering science concepts, engineering principles, and design engineering required for process design and analysis, processing system, and equipments required for converting raw materials into value-added products through chemical, physical, and biological processes;
1.2 Natural science concepts and mathematical engineering application principles on the design and analysis of process, processing system, and equipments required for converting raw materials into value-added products through chemical, physical, and biological processes;
1.3 Process design technique and principles, processing system, and equipments required for converting raw materials into value-added products through chemical, physical, and biological processes;
1.4 Principles and the latest issues in economy, social, general ecology;
2.1 Able to apply mathematics, natural science, and engineering principles to solve complex engineering problems of process, processing system, and equipments required for converting raw materials into value-added products through chemical, physical, and biological processes;
3.1 Being able to apply logical, critical, systematic and innovative thinking in the context of development or implementation of science and technology that concerns and implements the value of humanities in accordance with their area of expertise;
3.2 Being able to take responsibility for the achievement of group work and supervise and evaluate the work completion assigned to the worker under his/her responsibility;
3.3 Being able to conduct self-evaluation process to work group under his/her responsibility, and able to manage learning independently;

4.1 Demonstrating attitude of responsibility on work in his/her field of expertise independently.

COURSE LEARNING OUTCOME

Students must be able to design basic biochemical reactor using enzyme or living cells as catalyst, must be able to design various type of ideal reactor, i.e. batch, mixed flow and plug flow reactor.

MAIN SUBJECT

1. Basic bioreactor design using enzyme or living cells as biocatalyst
2. Kinetics of enzymatic reaction and reaction employing living microorganism
3. Immobilization of enzyme and whole cells.
4. Design of batch, mixed flow and plug flow bioreactor

PREREQUISITES

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REFERENCE

1. James M. Lee: Biochemical Engineering, Prentice Hall International series, 1992
2. Octave Levenspiel, Chemical Reaction Engineering, Edisi 3, 1997.
3. Bailey and Ollis: Fundamental of biochemical engineering, 2nd edition, Mc Graw Hill, 1986
4. Harvey W. Blanch and Douglas S. Clark: Biochemical Engineering, Marcell Dekker, Inc., 1997
5. Michael L. Shuler and Fikret Kargi: Bioprocess Engineering Basic Concept, 2nd edition, Prentice Hall International Edition, 2002.
6. Published articles/international journals related with these topics (whole cell or enzyme)

COURSE	Course Name	:	**Advanced Industrial Waste Management**
	Course Code	:	TK186109
	Credit	:	3 SKS
	Semester	:	X

DESCRIPTION of COURSE

- Giving knowledge of the impacts of industrial activities on the environment such as environmental damage and pollution, water quality, air and soil, key parameters and their health effects.
- Establish knowledge of the basics of industrial waste treatment, water and air sampling techniques
- Provide knowledge on industrial waste management which includes: main factors in the form of planning (legislation), environmental quality standards, net program, blue sky program, reduced net production (reduced, recovery, reused, recycle, and case study) environmental management, identification systems to industrial activities, environmental impact assessments, environmental audits. Approach system in the form of approach of technology, social and institutional

LEARNING OUTCOME

1.1 Science engineering theory, design engineering, cutting-edge method and technology required for analysis, process design, processing system, and the required equipment;
1.2 Natural science concept and applied mathematical engineering principles on the analysis and process design, processing system, and equipment required for converting raw materials into value-added products with chemical, physical, and biological processes;
1.3 Process design techniques and principles, processing system, and equipment required for converting raw materials into value-added products with chemical, physical, and biological processes;
1.4 Latest issues and principles in economy, social, ecology.
2.1 Able to go deep into the knowledge in order to get a better understanding of the process, processing system, and equipment required for converting raw materials into value-added products through chemical, physical, and biological processes to give original and proven contribution by conducting independent research work;
3.1 capable of managing, developing and maintaining networking with colleagues, peers within the broader institutes and research community;
3.2 Being able to improve the capacity of learning independently;

3.3 Capable of documenting, storing, securing, and rediscovering research data in order to ensure validity and prevent plagiarism;
3.4 Being able to implement the principle of sustainability in developing knowledge; and
3.5 Being able to implement information and communication technology in the context of execution of his work.
4.1 Demonstrating attitude of responsibility on work in his/her field of expertise independently.

COURSE LEARNING OUTCOME

1. Students are aware of the impacts of industrial activities on the environment such as environmental damage and pollution, water quality, air and soil, key parameters and their health effects.
2. Students are able to apply the basics of industrial waste treatment, water and air sampling techniques
3. Students understand about industrial waste management which includes: main factors in the form of planning (legislation), environmental quality standard, net program, blue sky program, reduced net production (reduced, recovery, reused, recycle and case study) environmental management, identification systems to industrial activities, environmental impact assessments, environmental audits. Approach system in the form of approach of technology, social and institutional.

MAIN SUBJECT

1. Industry and the environment
2. Industrial waste management: (i) Planning: Environmental Management System; (ii) Industrial impacts impact identification system; (iii) Environmental Impact Assessment Environmental Audit; Supervision; Technology: Waste processing, hazardous and toxic industrial waste management, Technology, social and institutional approach systems.

REFERENCE

1. Connell : " Chemistry an ecotoxicology of pollution", John Wiley & sons, Singapore
2. W.W. Eckenfelder,"Water Pollution Control", Jenkins Publishing Company,1970
3. Michael R.Overcash,"Techniques for Industrial Pollution Prevention", Lewis Publishers Inc.

COURSE	Course Name	:	**Computational Fluid Dynamics**
	Course Code	:	TK186110
	Credit	:	3 SKS
	Semester	:	X

DESCRIPTION of COURSE
This course explains and practices the fundamentals of skills to demonstrate expertise in the field of process simulation, especially Computational Fluid Dynamics (CFD) based chemical industry analysis tools and presents meaningful simulation results

LEARNING OUTCOME
1.1 Science engineering theory, design engineering, cutting-edge method and technology required for analysis, process design, processing system, and the required equipments;
1.2 Natural science concept and applied mathematical engineering principles on the analysis and process design, processing system, and equipments required for converting raw materials into value-added products with chemical, physical, and biological processes;
1.3 Process design techniques and principles, processing system, and equipments required for converting raw materials into value-added products with chemical, physical, and biological processes;
1.4 Latest issues and principles in economy, social, ecology.
2.1. Able to solve engineering and technology problems of of process, processing system, and equipments required for converting raw materials into value-added products through chemical, physical, and biological processes by making use of other disciplines (if required) and by taking account factors, such as economic, public health and safety, cultural, social, and environment;
3.1 Being able to develop logical, critical, systematic, and creative thinking through scientific research, the creation of designs or works of art in the field of science and technology which concerns and applies the humanities value in accordance with their field of expertise, prepares scientific conception and result of study based on rules, procedures and scientific ethics in the form of a thesis or other equivalent form, and uploaded on a college page, as well as papers published in scientific journals accredited or accepted in international journals;
3.2 Being able to improve the capacity of learning independently;

3.3 capable of documenting, storing, securing, and rediscovering research data in order to ensure validity and prevent plagiarism;
4.1 Demonstrating attitude of responsibility on work in his/her field of expertise independently.

COURSE LEARNING OUTCOME

1. Able to re-explain the definition of CFD.
2. Able to analyze phenomena and correlate with relevant equations
3. Able to explain again three CFD stages (pre-processor, solver, and post-processor)
4. Able to demonstrate expertise in process simulation on fluid flow in pipes
5. able to demonstrate expertise in simulating the process of separation on cyclone
6. Able to demonstrate expertise in simulating homogeneous combustion process
7. Able to demonstrate expertise in conducting simulations of heterogeneous combustion processes

MAIN SUBJECT

1. Definition of CFD.
2. Governing equations on CFD methods.
3. Three stages of CFD (pre-processor, solver, and post-processor).
4. Simulation of fluid flow.
5. Simulation of separation process.
6. Simulation of homogeneous combustion process.
7. Simulation of heterogeneous combustion process.

PREREQUISITES

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REFERENCE

1. Versteeg, H.K., Malalasekera, W. (2007). *An Introduction to Computational Fluid Dynamics* (2 ed.). Pearson, Prentice Hall.
2. Fluent User's Guide.

COURSE			
	Course Name	:	**Membrane Technology**
	Course Code	:	TK186201
	Credit	:	3 SKS
	Semester	:	X

DESCRIPTION of COURSE
This course studies to understand the introduction and material properties selection, preparation of membranes and characterization of membranes, transport phenomena in membranes and membrane applications in industry. With learning methods include lectures, discussions, case studies, problem-based learning, writing examination, (including quiz, assignments and EAS)

LEARNING OUTCOME
1.1 Engineering science concepts, engineering principles, and design engineering required for process design and analysis, processing system, and equipments required for converting raw materials into value-added products through chemical, physical, and biological processes;
1.2 Natural science concepts and mathematical engineering application principles on the design and analysis of process, processing system, and equipments required for converting raw materials into value-added products through chemical, physical, and biological processes;
1.3 Process design technique and principles, processing system, and equipments required for converting raw materials into value-added products through chemical, physical, and biological processes;
1.4 Principles and the latest issues in economy, social, general ecology;
2.2 Able to do research that includes identification, formulation, and analysis on engineering problems of process, processing system, and equipments required for converting raw materials into value-added products through chemical, physical, and biological processes;
3.1 Being able to apply logical, critical, systematic and innovative thinking in the context of development or implementation of science and technology that concerns and implements the value of humanities in accordance with their area of expertise;
3.2 Being able to take responsibility for the achievement of group work and supervise and evaluate the work completion assigned to the worker under his/her responsibility;
3.3 Being able to conduct self-evaluation process to work group under his/her responsibility, and able to manage learning independently;

4.1 Demonstrating attitude of responsibility on work in his/her field of expertise independently

COURSE LEARNING OUTCOME

1. Students are aware of the impacts of industrial activities on the environment such as environmental damage and pollution, water quality, air and soil, key parameters and their health effects.
2. Students are able to apply the basics of industrial waste treatment, water and air sampling techniques
3. Students understand about industrial waste management which includes: main factors in the form of planning (legislation), environmental quality standard, net program, blue sky program, reduced net production (reduced, recovery, reused, recycle and case study) environmental management, identification systems to industrial activities, environmental impact assessments, environmental audits. Approach system in the form of approach of technology, social and institutional.

MAIN SUBJECT

1. Industry and the environment
2. Industrial waste management: (i) Planning: Environmental Management System; (ii) Industrial impacts impact identification system; (iii) Environmental Impact Assessment Environmental Audit; Supervision; Technology: Waste processing, hazardous and toxic industial waste management, Technology, social and institutional approach systems

PREREQUISITES

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REFERENCE

1. Connell : " Chemistry an ecotoxicology of pollution", John Wiley & sons, Singapore
2. W.W. Eckenfelder,"Water Pollution Control", Jenkins Publishing Company,1970
3. Michael R.Overcash,"Techniques for Industrial Pollution Prevention", Lewis Publishers Inc.

COURSE	Course Name	:	**Coal Processing and Utilization**
	Course Code	:	TK186202
	Credit	:	3 SKS
	Semester	:	X

DESCRIPTION of COURSE
This course studies the process of preparing coal for use as direct fuel or converted into other materials, coal analysis, and coal utilization for electricity, liquid fuel and coal by-product processing. Learning methods include lectures, discussions, case studies and problem-based learning. Evaluation conducted in the form of written and non-write evaluation.

LEARNING OUTCOME
1.1 Engineering science concepts, engineering principles, and design engineering required for process design and analysis, processing system, and equipments required for converting raw materials into value-added products through chemical, physical, and biological processes;
1.2 Natural science concepts and mathematical engineering application principles on the design and analysis of process, processing system, and equipment required for converting raw materials into value-added products through chemical, physical, and biological processes;
1.3 Process design technique and principles, processing system, and equipment required for converting raw materials into value-added products through chemical, physical, and biological processes;
1.4 Principles and the latest issues in economy, social, general ecology;
2.1 Able to do research that includes identification, formulation, and analysis on engineering problems of process, processing system, and equipment required for converting raw materials into value-added products through chemical, physical, and biological processes;
3.1 Being able to apply logical, critical, systematic and innovative thinking in the context of development or implementation of science and technology that concerns and implements the value of humanities in accordance with their area of expertise;
3.2 Being able to take responsibility for the achievement of group work and supervise and evaluate the work completion assigned to the worker under his/her responsibility;
3.3 Being able to conduct self-evaluation process to work group under his/her responsibility, and able to manage learning independently;

4.1 Demonstrating attitude of responsibility on work in his/her field of expertise independently.

COURSE LEARNING OUTCOME

1. Understand the process of coal formation
2. Understand the coal preparation process that will be used further
3. Application to know the quality of coal
4. Analyze the various benefits of coal and its processing
5. Coal synthesis for electricity
6. Coal synthesis for liquid fuels
7. Synthesis of byproducts of coal processing

MAIN SUBJECT

1. The process of coal formation
2. Coal preparation process
3. Analysis of coal quality
4. Benefits and process of coal mocking
5. Coal for electricity
6. Coal for liquid fuel
7. Coal processing byproducts

PREREQUISITES

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REFERENCE

1. Matthias W. Haenel, Book Review: Chemistry of Coal Utilization, Second Supplementary Volume. Edited by M. A. Elliot, Angewandte Chemie International Edition in English, 1982.
2. Shirley Cheng Tsai, Fundamentals of coal beneficiation and utilization, Amsterdam, the Netherlands; New York: Elsevier Scientific Pub. Co., 1982.
3. James G. Speight, Handbook of coal analysis, John Wiley and Sons, Inc., Publication, 2005.
4. Alpha Coal Handbook, ed 2012.

COURSE	Course Name	:	**Electrochemical Reaction Engineering**
	Course Code	:	TK186203
	Credit	:	3 SKS
	Semester	:	X

DESCRIPTION of COURSE

This course studies the characteristics and behavior of electrochemical processes, the application of electrochemical reaction techniques to practical applications such as material synthesis (electrolysis), battery, electrochemical based instrumentation, and corrosion. The conventional assessment method is combined with a review of the advanced literature and case studies where students can work independently and in teamwork.

LEARNING OUTCOME

1.1 Science engineering theory, design engineering, cutting-edge method and technology required for analysis, process design, processing system, and the required equipment;
1.2 Natural science concept and applied mathematical engineering principles on the analysis and process design, processing system, and equipment required for converting raw materials into value-added products with chemical, physical, and biological processes;
1.3 Process design techniques and principles, processing system, and equipment required for converting raw materials into value-added products with chemical, physical, and biological processes;
1.4 Latest issues and principles in economy, social, ecology.
2.1 Able to go deep into the knowledge in order to get a better understanding of the process, processing system, and equipment required for converting raw materials into value-added products through chemical, physical, and biological processes to give original and proven contribution by conducting independent research work;
3.1 capable of managing, developing and maintaining networking with colleagues, peers within the broader institutes and research community;
3.2 Being able to improve the capacity of learning independently;
3.3 Capable of documenting, storing, securing, and rediscovering research data in order to ensure validity and prevent plagiarism;
3.4 Being able to implement the principle of sustainability in developing knowledge; and
3.5 Being able to implement information and communication technology in the context of execution of his work

4.1 Demonstrating attitude of responsibility on work in his/her field of expertise independently.

COURSE LEARNING OUTCOME

The learning outcome of this course is student should be able to apply the electrochemical principles in the specific application such as nanomaterial (electrolysis), battery, instrumentation based electrochemistry, and corrosion.
Sub-learning outcome of this course:

1. Students are able to apply the characteristics and behavior of electrochemical processes in certain electrochemical process applications
2. Students are able to develop engineering science of electrochemical reaction for practical application such as material synthesis (electrolysis), battery, electrochemical based instrumentation, corrosion, etc.

MAIN SUBJECT

1. Reactor performance criteria, electrochemical and catalytic reactions
2. Kinetic reaction electrode
3. Design of electrochemical reactor
4. Electrochemical reaction in electrolysis/battery/corrosion process

PREREQUISITES

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REFERENCE

1. Bard, A. J. and Faulkner, L. R., "Electrochemical Methods, Fundamentals and Applications", 2nd edition, John Wiley & Sons, Inc., 2001
2. Perez, N., "Electrochemistry and Corrosion Science", Kluwer Academic Publishers, 2004
3. Goodridge, F. and Scott, K., "Electrochemical Process Engineering", Plenum Press, New York, 1995

COURSE	Course Name	:	**Aerosol Technology**
	Course Code	:	TK186205
	Credits	:	3 Credits
	Semester	:	X

DESCRIPTION of COURSE
This course learns about the properties and characteristics of aerosol, instrumentation and aerosol measurements, particle motion of aerosol, atmospheric aerosol, adhesion of aerosol particles, fabrication method of aerosols, and application of aerosol in various industries. The relevance of this course to the real world is the application of aerosol processes for fabrication in electronic devices, coating technology, pharmacy, energy and environmental. Following this course, students are able to understand the properties and characterizations of aerosol with their applications in various fields, including the deposition mechanism. The learning method involves a lecture, assignment, discussion, and presentation.

LEARNING OUTCOME
1.1 Comprehend the science engineering theory, design engineering, cutting-edge method and technology required for analysis, process design, processing system, and the required equipments;
1.2 Able to apply of natural science concepts and mathematical engineering application principles on the design and analysis of process, processing system, and equipments required for converting raw materials into value-added products through chemical, physical, and biological processes;
1.3 Comprehend and apply of the process design technique and principles, processing system, and equipment required for converting raw materials into value-added products through chemical, physical, and biological processes;
1.4 Able to apply the principles and the latest issues in economy, social, general ecology;
2.1 Able to go deep into the knowledge in order to get a better understanding of the process, processing system, and equipment required for converting raw materials into value-added products through chemical, physical, and biological processes to give original and proven contribution by conducting independent research work;
3.1 Capable of managing, developing and maintaining networking with colleagues, peers within the broader institutes and research community;
3.2 Being able to improve the capacity of learning independently;

3.3 Capable of documenting, storing, securing, and rediscovering research data in order to ensure validity and prevent plagiarism;
3.4 Being able to implement the principle of sustainability in developing knowledge;
3.5 Being able to implement information and communication technology in the context of execution of his work;
4.1 Demonstrating attitude of responsibility on work in his/her field of expertise independently.

COURSE LEARNING OUTCOME

1. Students are able to understand definition of aerosol and their examples
2. Students are able to understand the characteristic of aerosols and instrumentations used for measuring the aerosol properties
3. Students are able to understand the spreading of aerosol in atmosphere
4. Students are able to understand and analyze the fabrication processes of aerosol including their mechanisms and forces exerted during deposition
5. Students are able to understand and analyze the applications of aerosol in various industries
6. Students are able to review the latest articles (journals) and present their work in the class.

MAIN SUBJECT

1. Definition and characteristic of aerosol
2. Instrumentation devices for measuring of aerosol
3. Spreading of aerosol in atmosphere
4. Fabrication methods of aerosol
5. Applications of aerosol in industries

PREREQUISITES

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MAIN REFERENCE

1. Hinds, W. C., Aerosol Technology: Properties, Behavior, and Measurement of Airborne Particles, John Wiley & Sons, 2nd ed. (1999).

SUPPORTING REFERENCE

1. The latest relevance articles (journals) published in good reputable journals

Course	Course Name	:	**NATURAL GAS PROCESSING**
	Course Code	:	TK186206
	Credit	:	3 SKS
	Semester	:	X

DESCRIPTION of COURSE

This course studies the important role of phase behavior in natural gas processing; studies the important properties, which used to characterize natural gas and condensate; studies some important applications of phase behavior in production operations; and make basic design of major equipments in natural gas processing, using lecture learning methods that include lectures, brainstorming; written exams (including Quiz I & II, and EAS) and discussion of group assignments.

LEARNING OUTCOME

1.1. Understanding the engineering science concepts, engineering principles, and design engineering required for process design and analysis, processing system, and equipments required for converting raw materials into value-added products through chemical, physical, and biological processes.
1.2. Understanding the natural science concepts and mathematical engineering application principles on the design and analysis of process, processing system, and equipments required for converting raw materials into value-added products through chemical, physical, and biological processes.
1.3. Understanding the process design technique and principles, processing system, and equipments required for converting raw materials into value-added products through chemical, physical, and biological processes.
1.4. Understanding the principles and the latest issues in economy, social, general ecology in general.
2.1. Able to deepen or expand scientific knowledge in the areas of processes, processing systems, and equipment necessary to convert raw materials into value-added products with chemical, physical and biological processes to contribute original and tested through research independently.
3.1. Able to maintain an expanded network with mentors, colleagues, colleagues within broader institutions and research communities.
3.2. Able to improve the capacity of learning independently.

3.3. Able to document, store, secure, and recover data of research results in order to guarantee the authenticity and prevent plagiarism.
3.4. Able to implement the principle of sustainability in developing the knowledge.
3.5. Able to implement information and communication technology in the context of execution of its work.
4.1. Able to demonstrate responsible attitude towards the work in the field of expertise independently.

COURSE LEARNING OUTCOME

1. The students must able to understand the important role of phase behavior in natural gas processing.
2. The students must able to understand the important properties used to characterize natural gas and condensate.
3. The students must able to develop some important applications of phase behavior in production operations.
4. The students must able to make basic design of main equipment in natural gas processing

MAIN SUBJECT

1. Reserve and utilization of natural gas
2. Properties of thermodynamics of natural gas
3. Natural gas products and specifications
4. Natural gas processing technology
5. Natural gas transmission system

PREREQUISITES

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MAIN REFERENCE

1. Gas Processors Suppliers Association, Engineering Data Book, 12th Ed., 2004.
2. Kidnay, Athur J. and Parrish, William R., Fundamental of Natural Gas processing, CRC Press, 2006.
3. Campbell, John Morgan, Gas conditioning and processing (Campbell Petroleum Series), 3rd Ed., Campbell Petroleum; 1974.
4. Mokhatab, Saeid; Poe, William; Mak, John, Handbook of Natural Gas Transmission and Processing, 3rd Ed., Gulf Professional Publishing, 2015.

5. Poling, Bruce E.; Prausnitz, John M.; O' Connell, John, The Properties of Gases and liquids, 5th Ed., McGraw-Hill Education, 2001.

COURSE	Course Name	:	**Advance Combustion Engineering**
	Course Code	:	TK186207
	Credit	:	3 SKS
	Semester	:	X

DESCRIPTION of COURSE

This course concentrates on the combustion process with different types of fuel as well as the calculation and investigation of various properties of the combustion process.

COURSE LEARNING OUTCOME

1.1 Science engineering theory, design engineering, cutting-edge method and technology required for analysis, process design, processing system, and the required equipments;

1.2 Natural science concept and applied mathematical engineering principles on the analysis and process design, processing system, and equipments required for converting raw materials into value-added products with chemical, physical, and biological processes;

1.3 Process design techniques and principles, processing system, and equipments required for converting raw materials into value-added products with chemical, physical, and biological processes;

1.4 Latest issues and principles in economy, social, ecology;

2.1. Able to solve engineering and technology problems of of process, processing system, and equipments required for converting raw materials into value-added products through chemical, physical, and biological processes by making use of other disciplines (if required) and by taking account factors, such as economic, public health and safety, cultural, social, and environment;

3.1 Being able to develop logical, critical, systematic, and creative thinking through scientific research, the creation of designs or works of art in the field of science and technology which concerns and applies the humanities value in accordance with their field of expertise, prepares scientific conception and result of study based on rules, procedures and scientific ethics in the form of a thesis or other equivalent form, and uploaded on a college page, as well as papers published in scientific journals accredited or accepted in international journals;

3.2 Being able to improve the capacity of learning independently;

3.3 capable of documenting, storing, securing, and rediscovering research data in order to ensure validity and prevent plagiarism;

4.1 Demonstrating attitude of responsibility on work in his/her field of expertise independently.
COURSE LEARNING OUTCOME
Able to provide qualitative and quantitative analysis on the characteristics of the combustion process with various types of fuel.
MAIN SUBJECT
1. Fuel and its properties 2. Stoichiometry of combustion. 3. Thermodynamics in combustion 4. Combustion Kinetics 5. Flame structure and propagation 6. Turbulent mixing 7. Liquid fuel combustion process. 8. Solid fuel combustion process.
PREREQUISITES
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REFERENCE
1. El-Mahallawy, F., El-din Habik, S.(2002). Fundamentals and Technology of Combustion. Elsevier. 2. Glassman, I., Yetter, R.,A.(2008). *Combustion.* Elsevier.

COURSE	Course Name	:	**Polymer Technology**
	Course Code	:	TK186208
	Credit	:	3 SKS
	Semester	:	X

DESCRIPTION of COURSE

Studying the basics of polymers, the relationship between the nature and structure and behavior of the process.

LEARNING OUTCOME

1.1 Science engineering theory, design engineering, cutting-edge method and technology required for analysis, process design, processing system, and the required equipments;
1.2 Natural science concept and applied mathematical engineering principles on the analysis and process design, processing system, and equipments required for converting raw materials into value-added products with chemical, physical, and biological processes;
1.3 Process design techniques and principles, processing system, and equipments required for converting raw materials into value-added products with chemical, physical, and biological processes;
1.4 Latest issues and principles in economy, social, ecology;
1.1 Able to go deep into the knowledge in order to get a better understanding of the process, processing system, and equipments required for converting raw materials into value-added products through chemical, physical, and biological processes to give original and proven contribution by conducting independent research work;
3.1 Capable of managing, developing and maintaining networking with colleagues, peers within the broader institutes and research community;
3.2 Being able to improve the capacity of learning independently;
3.3 Capable of documenting, storing, securing, and rediscovering research data in order to ensure validity and prevent plagiarism;
3.4 Being able to implement the principle of sustainability in developing knowledge;
3.5 Being able to implement information and communication technology in the context of execution of his work;
4.1 Demonstrating attitude of responsibility on work in his/her field of expertise independently.

COURSE LEARNING OUTCOME
1. Students understand the basics of polymer, the relationship between the nature with the structure and behavior of the process. 2. Students are able to develop polymer applications.
MAIN SUBJECT
1. Classification of polymers, and polymer properties. 2. Basics of polymerization kinetics and polymerization techniques. 3. Predict some of the properties of the polymer and its solution. 4. Polymer processing.
PREREQUISITES
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REFERENCE
1. Billmeyer. F.W. Jr., "Textbook of Polymer Science". Wilcy, New York, 1971. 2. Griskey, R.G. "Polymer Process Engineering ", Chapman & Hall, New York, 1995. 3. Fried, J.R., "Polymer Science and Technology", Prentice Hall, New Jersey, 1995.

COURSE	Course Name	:	**Advanced Multi Variable Control**
	Course Code	:	TK186209
	Credit	:	3 SKS
	Semester	:	X

DESCRIPTION of COURSE
This course is intended for graduate students for mastering in multi variable control. Two to three weeks will be used to review conventional feedback control system. Students will be given introduction to multi variable control. Exposure to linear system will also be given to simplify the process. Limitation on SISO and MIMO system performance. Limitation resulting from time delay and RHP-poles and zeroes.

LEARNING OUTCOME
1.1 Science engineering theory, design engineering, cutting-edge method and technology required for analysis, process design, processing system, and the required equipments;
1.2 Natural science concept and applied mathematical engineering principles on the analysis and process design, processing system, and equipments required for converting raw materials into value-added products with chemical, physical, and biological processes;
1.3 Process design techniques and principles, processing system, and equipments required for converting raw materials into value-added products with chemical, physical, and biological processes;
1.4 Latest issues and principles in economy, social, ecology.
2.1. Being able to perform academic validation or studies in accordance with their areas of expertise in solving problems in relevant communities or industries through the development of knowledge and expertise;
3.1 Able to solve engineering and technology problems of of process, processing system, and equipments required for converting raw materials into value-added products through chemical, physical, and biological processes by making use of other disciplines (if required) and by taking account factors, such as economic, public health and safety, cultural, social, and environment;
4.1 Demonstrating attitude of responsibility on work in his/her field of expertise independently.

COURSE LEARNING OUTCOME
1. Students are able to make a MIMO control system

2. Students understand deeply the limitation on performance of SISO and MIMO system.
3. Students understand deeply limitations due to time delay, RHP-poles and zeroes.
4. Students understand deeply robust stability and performance of control system.
5. Students are able to design control system and control structure.
6. Students are able to build matrix transfer function of MIMO system.
7. Students are able to control MIMO process
8. Students understand deeply the robust and its stability MIMO process
9. Students are able to do analysis on controllability
10. Students are able to do performance analysis on robust and its stability
11. Students are able to design MIMO control system and MIMO control structure
12. Students are able to do reduction model.

MAIN SUBJECT

1. Review on Conventional Feedback Control System
2. Introduction to Multi variable control
3. Element of linear system theory
4. Limitations of performance on SISO sytem
5. Limitations of performance on MIMO system
6. SISO anad MIMO stability and robust performance
7. Design Control System and Control Structure
8. Model reduction....

PREREQUISITES

REFERENCE

1. Dale E. Seborg, Thomas F. Edgar, Duncan A. Mellichamp, Francis J. Doyle III, "Process Dynamics and Control", 4th ed., John Wiley & Sons, New. York., 2016.
2. Sigurd Skogestad, Ian Postlethwaite," Multivariable Feedback Control", 2nd edition, John Wiley & Sons, New York, 2005.

COURSE	Course Name	:	**Dissertation**
	Course Code	:	TK186601
	Credit	:	28 SKS
	Semester	:	II-VI

DESCRIPTION of COURSE
Prepare proposals, conduct research, report research progress, process research data, discuss research results, and create final report.
LEARNING OUTCOME
1.1 Philosophy of science and engineering, design engineering, cutting-edge technology required for process design and analysis, processing system, and equipments required for converting raw materials into value-added products through chemical, physical, and biological processes; 1.2 The foremost and most substantial body of knowledge through systematic knowledge acquisition on chemical engineering discipline or professional part of chemical engineering; 2.1 Able to solve engineering and technology problems of process, processing system, and equipments required for converting raw materials into value-added products through chemical, physical, and biological processes through interdisciplinary, multidisciplinary or trans-disciplinary approach by taking account factors, such as economic, public health and safety, cultural, social, and environment; 2.2 Able to develop new knowledge and/or technology by conducting research in process, processing system, and equipments required for converting raw materials into value-added products through chemical, physical, and biological processes in order to put together original, proven, creative works; 2.3 Able to conceptualize, design, and implement research in the field of process, processing system, and equipments required for converting raw materials into value-added products through chemical, physical, and biological processes in order to invent new knowledge, or to put together new concept or applicable cutting-edge technology; 3.1 Being able to discover or develop new theories or concepts or scientific ideas, contribute to the development and practice of science and / or technology that concerns and implements the value of the humanities in its field of expertise, by producing scientific research based on scientific methodology, logical thinking, critical, systematic, and creative; 3.2 Capable of preparing interdisciplinary, multidisciplinary or transdisciplinary research, including theoretical and / or experimental

studies in the fields of science, technology, art and innovation as outlined in the form of dissertations, and papers published in reputable international journals;

3.3 Capable of selecting appropriate, current, advanced, and beneficial research on humanity through interdisciplinary, multidisciplinary, or transdisciplinary approaches, in order to develop and / or produce problem solving in the fields of science, technology, art or society, based on the results of a study of the availability of internal and external resources;

3.4 Being able to develop a roadmap of research with interdisciplinary, multidisciplinary, or transdisciplinary approaches, based on a study of the main objectives of the study and its constellations on broader objectives;

3.5 Being able to develop scientific and technological or art arguments and solutions based on a critical view of facts, concepts, principles or theories that can be accounted for scientifically and academically, and communicate them through mass media or directly to the community;

3.6 Being able to demonstrate academic leadership in the management, development and fostering of resources and organizations under their responsibility;

3.7 Being able to develop and maintain collegial and welfare relationships within their own environment or through networks of collaboration with non-institutional research communities;

3.8 Being able to develop themselves and compete in national and international level;

3.9 Being able to implement information and communication technology in the context of execution of its work;

4.1 Demonstrating attitude of responsibility on work in his/her field of expertise independently.

COURSE LEARNING OUTCOME

Students are able to develop and carry out research, and write research results in international journals and doctoral dissertation.

MAIN SUBJECT

1. Background
2. Aims
3. Literature review
4. Methodology
5. Results and discussion
6. Conclusion of the study

PREREQUISITES

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REFERENCE
1. Rules of preparation of dissertation. 2. Postgraduate quality standards.