ITS chemical engineering

SYLLABUS

MASTER PROGRAM (S2)

CURRICULUM ITS 2018 – 2023

DEPARTMENT OF

CHEMICAL ENGINEERING

FACULTY OF INDUSTRIAL TECHNOLOGY AND SYSTEM ENGINEERING

INSTITUT TEKNOLOGI SEPULUH NOPEMBER

Study Program	Chemical Engineering
Educational Level	Master Program (S2)

Program Learning Outcomes		
KNOWLEDGE		
PLO-1	Able to master engineering science theory, design engineering, the latest methods and techniques required for the analysis and design of processes, processing systems, and equipment needed to convert raw materials into products that have added value	**8.8**
GENERAL SKILL		
PLO-2	Able to develop logical, critical, systematic, and creative thinking through scientific research, design creation or works of art in the field of science and technology that pay attention to and apply humanities values in accordance with their areas of expertise, compile scientific conceptions and study results based on rules, procedures, and scientific ethics in the form of a thesis or other equivalent, and uploaded on the college website, as well as papers that have been published in accredited scientific journals or accepted in international journals	**1.6**
PLO-3	Able to compile ideas, thoughts, and scientific arguments responsibly and based on academic ethics, and communicate them through the media to the academic community and the wider community;	**4.4**
PLO-4	Able to develop themselves and compete at national and international levels	**3.2**
SPECIAL SKILL		
PLO-5	Able to deepen or expand knowledge in the field of processes, processing systems, and equipment needed to convert raw materials into products that have added value with chemical, physical and biological processes to make original and tested contributions through independent research;	**7.2**

PLO-6	Able to formulate new ideas (new research questions) from the results of research carried out for the development of science and technology in the fields of processes, processing systems, and equipment needed to convert raw materials into products that have added value through chemical, physical and biological processes.	**4.4**
ATTITUDE		
PLO-7	show an attitude of responsibility for work in their field of expertise independently	**3.2**
PLO-8	Working together to be able to make the most of their potential	**3.2**

COURSE LIST of MASTER PROGRAM

No.	Course Code	Course Name	SKS
SEMESETER I			
1	TK185101	Advance Chemical Engineering Thermodynamics	4
2	TK185102	Advance Synthesis Process	4
3	TK185xxx	Elective I	3
Number of Credit			11
SEMESTER II			
1	TK185201	Advance Transport Phenomena	4
2	TK185202	Advance Chemical Reaction Engineering	4
3	TK185xxx	Elective II	3
4		Thesis	
Number of Credit			11
SEMESTER III			
1	TK185xxx	Elective III	3
2	TK185xxx	Elective IV	3
3		Thesis	
Number of Credit			6
SEMESTER IV			
1	TK185401	Thesis	8
Number of Credit			8
Total Credit			**36**

Thesis TK185401

No	Semester	Description	Credit
1	II	Proposal	
2	III	Progress	
3	IV	Published article in good reputable international conference	
4		Final presentation	
Total credit for thesis			**8**

LIST of ELECTIVE COURSES

No.	Course Code	Course Name	SKS
1	TK185103	Advance Separation Process	3
2	TK185104	Particle Technology	3
3	TK185105	System Thermal Analysis	3
4	TK185203	Biochemical Reactor	3
5	TK185204	Advance Industrial Waste Management	3
6	TK185205	Computational Fluid Dynamics	3
7	TK185301	Membrane Technology	3
8	TK185302	Processing and Coal Utilization	3
9	TK185303	Electrochemical Reaction Engineering	3
10	TK185304	Heterogenic Catalyst	3
11	TK185305	Aerosol Technology	3
12	TK185306	Natural Gas Processing	3
13	TK185307	Advance Combustion Engineering	3
14	TK185308	Polymer Technology	3
15	TK185309	Research Methodology	3
16	TK185310	Advanced Multi Variable Control	3
17	TK185311	Advance Chemical Engineering Mathematic	3

COURSE	Course Name	:	Advanced Chemical Engineering Thermodynamics
	Course Code	:	TK185101
	Credit	:	4 SKS
	Semester	:	I

DESCRIPTION of COURSE
This course learns the theory / model of the principle of the related state and the group contribution to its application in the estimation of the pure properties such as critical property, normal boiling point, vapor pressure etc.; understand the solution theory and its application to the equation of state in the determination of PVT for binary and multicomponent systems; apply the solution theory in solving problems in phase equilibria; recognize the development of thermodynamic models in phase equilibriumum calculations; understand the component constants, thermodynamic properties of the ideal gas , PVT relations: gas and liquids, mixtures; determine the equilibrium constants and conversions in chemical-reaction equilibria.

LEARNING OUTCOMES
PLO - 1 Able to master engineering science theory, design engineering, the latest methods and techniques required for the analysis and design of processes, processing systems, and equipment needed to convert raw materials into products that have added value
PLO - 3 Able to compile ideas, thoughts, and scientific arguments responsibly and based on academic ethics, and communicate them through the media to the academic community and the wider community
PLO - 4 Able to develop themselves and compete at national and international levels
PLO - 5 Able to deepen or expand knowledge in the field of processes, processing systems, and equipment needed to convert raw materials into products that have added value with chemical, physical and biological processes to make original and tested contributions through independent research.
PLO - 6 Able to formulate new ideas (new research questions) from the results of research carried out for the development of science and technology in the fields of processes, processing systems, and equipment needed to convert raw materials into products that have added value through chemical, physical and biological processes.

PLO - 7 Show an attitude of responsibility for work in their field of expertise independently

PLO - 8 Working together to be able to make the most of their potential

COURSE LEARNING OUTCOMES

The Students are able to

1. understand the theory / model of the principle of the related state and the group contribution to its application in the estimation of the pure properties such as critical property, normal boiling point, vapor pressure etc.;
2. understand the solution theory and its application to the equation of state in the determination of PVT for binary and multicomponent systems;
3. apply the solution theory in solving problems in phase equilibria;
4. recognize the development of thermodynamic models in phase equilibrium calculations;
5. understand the component constants, thermodynamic properties of the ideal gas , PVT relations: gas and liquids, mixtures.
6. determine the equilibrium constants and conversions in chemical-reaction equilibria.

MAIN SUBJECTS

1. Method / model in estimating pure properties such as critical property, normal boiling point, vapor pressure etc.
2. Relationship between thermodynamic properties.
3. Equations of state for the prediction and correlation of pure and mixture components.
4. Solution theory.
5. Analysis of the equations for the activity coefficients.
6. Calculation of the phase equilibria with the methods of activity coefficient and equation of state.
7. Chemical-reaction equilibria
8. Applications in polymer-containing systems.

PREREQUISITES

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REFERENCE

1. B. E. Poling, J. M. Prausnitz, J. P. O’Connell, The Properties of Gases and Liquids, Fifth ed., McGraw-Hill International Editions, Singapore (2001).
2. J. M. Smith, H. C. Van Ness, M. M. Abbott, Introduction to Chemical Engineering Thermodynamics, 6th ed., McGwaw-Hill Co-Singapore (2001).

3. S. M. Walas, Phase Equilibrium in Chemical Engineering, Butterworth Publisher, USA (1985).
4. M. Modell and R. C. Reid, Thermodynamics and Its Applications, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1974.
5. S. I. Sandler, Models for Thermodynamic and Phase Equilibria Calculations, Marcel Dekker, Inc., New York, 1994.

COURSE	Course Name	:	**Advanced Process Synthesis**
	Course Code	:	TK185102
	Credit	:	4 SKS
	Semester	:	I

DESCRIPTION of COURSE
Advanced process synthesis is continuation of synthesis and process simulation course. The main objective of the advanced process synthesis is to enforce students understand how to make the process efficient, profitable, and safe by minimizing the using of natural resources (energy and material). Among these are to deepen the theory and application of heat integration applied to various equipment's such as reactor, evaporator, distillation, and another separator. Steam and cooling systems also greatly influence the use of natural resources, therefore steam and cooling system management including water circulation are included this course. The causes and prevention of air emissions in the plant are also studied. Simulation with commercial software such as ASPEN HYSYS is an easy tool to know the efficiency of the process that has been designed.
LEARNING OUTCOME
PLO – 1 Able to master engineering science theory, design engineering, the latest methods and techniques required for the analysis and design of processes, processing systems, and equipment needed to convert raw materials into products that have added value PLO – 3 Able to compile ideas, thoughts, and scientific arguments responsibly and based on academic ethics, and communicate them through the media to the academic community and the wider community PLO – 4 Able to develop themselves and compete at national and international levels PLO – 5 Able to deepen or expand knowledge in the field of processes, processing systems, and equipment needed to convert raw materials into products that have added value with chemical, physical and biological processes to make original and tested contributions through independent research. PLO – 6 Able to formulate new ideas (new research questions) from the results of research carried out for the development of science and technology in the fields of processes, processing systems, and equipment needed to convert raw materials into products that have added value through chemical, physical and biological processes.

PLO – 7 Show an attitude of responsibility for work in their field of expertise independently PLO – 8 Working together to be able to make the most of their potential
COURSE LEARNING OUTCOME
1. Students understand the importance of energy and natural resources. 2. Students understand how to use energy efficiently in a heat exchanger network. 3. Students understand the theory of heat network of chemical industrial equipment and its application. 4. Students understand management of steam and cogeneration. 5. Students understand the theory of cooling system and water circulation and its application. 6. Students understand the source of air pollution and how to prevent it. 7. Students understand health and safety issues. 8. Simulate the chemical process with Aspen Hysys.
MAIN SUBJECT
1. Theory and application of heat exchanger network 2. Theory and application of network of chemical industry equipment's (reactor, distillation column, evaporator, and equipment). 3. Theory and application of steam management and cogeneration. 4. Theory and application of cooling and refrigeration systems 5. Theory and application of water management 6. Solving environmental and occupational safety issues in industry 7. Simulation for chemical process
PREREQUISITES
REFERENCE
1. Robin Smith, "Chemical Process Design and Integration"", John Wiley and Son, 2005 2. James M Douglas, Conceptual Design of Chemical Processes", New York McGraw-Hill - McGraw-Hill chemical engineering series, 1998 3. Warren D. Seider, J. D. Seader, Daniel R. Lewin, Widagdo," Process Design Principles: Synthesis, Analysis and Evaluation", 3rd edition, John Wiley & Sons, 2008 4. Lorenz T. Biegler, Ignacio E. Grossmann, Arthur W. Westerberg, "Systematic Methods of Chemical Process Design ", Prentice Hall, 1997.

COURSE	Course Name	:	**Advanced Transport Phenomena**
	Course Code	:	TK185201
	Credit	:	4 SKS
	Semester	:	II

DESCRIPTION of COURSE
This course is a graduate level engineering course designed to review the governing relations of momentum, heat, and mass transfer in continua at an advanced level for students who have already been exposed to transport at the undergraduate level. Principal concepts will be illustrated through their application to classical and practical paradigms in transport phenomena. Students will learn useful analytical methods for studying and solving steady state and unsteady state (transient) transport problems with and without fluid convection. Student will also learn boundary layer theory to solve transport problem near boundary surface. Learning method and activities comprises lecture, tutorial (discussion), exercises, group project assignment, presentation, and exam (Midterm Exam and Final Exam)

LEARNING OUTCOME
PLO – 1 Able to master engineering science theory, design engineering, the latest methods and techniques required for the analysis and design of processes, processing systems, and equipment needed to convert raw materials into products that have added value
PLO – 3 Able to compile ideas, thoughts, and scientific arguments responsibly and based on academic ethics, and communicate them through the media to the academic community and the wider community
PLO – 4 Able to develop themselves and compete at national and international levels
PLO – 5 Able to deepen or expand knowledge in the field of processes, processing systems, and equipment needed to convert raw materials into products that have added value with chemical, physical and biological processes to make original and tested contributions through independent research.
PLO – 6 Able to formulate new ideas (new research questions) from the results of research carried out for the development of science and technology in the fields of processes, processing systems, and equipment needed to convert raw materials into products that have added value through chemical, physical and biological processes.
PLO – 7 Show an attitude of responsibility for work in their field of expertise independently

PLO – 8 Working together to be able to make the most of their potential
COURSE LEARNING OUTCOME
1. Student being able to derive differential balance for certain property including momentum, energy and mass of species, accounting appropriately property flux by convective and diffusive (molecular) process, along with property generation. 2. Student being able to write the continuity equation, Navier Stoke equation, energy equation, and species continuity equation and simplify them appropriately for specific transport problem 3. Student being able to determine the appropriate boundary conditions for specific transport problem 4. Student being able to solve steady state isothermal one dimension viscus fluid flow problem and physically interpret the solution 5. Student being able conduct scale or dimensional analyses of transport problems using the analysis to help simplify or enhance understanding of underlying transport process. 6. Student being able to solve steady state one dimension conduction and species diffusion problem in rectangular, cylinder and spherical geometry with/without first or zero order generation and physically interpreted the solution 7. Student being able to solve isothermal viscous fluid flow problem with two independent variables (steady state two dimensions flow, and unsteady state one dimension flow) using similarity transformation, separation variable and stream function concept (creeping flow) and interpreted the solution physically 8. Student being able to solve steady state two dimensions inviscid flow (potential flow) and interpreted the solution physically. 9. Student being able to solve steady state two-dimension fluid flow using boundary layer theory and interpreted the solution physically 10. Student being able to apply separation variable method to solve two-dimension conduction and diffusion problem and interpreted the solution physically 11. Student being able to apply the similarity transformation method to solve unsteady state conduction and diffusion problem in unbounded region and interpreted the solution physically. 12. Student being able to apply Finite Fourier Transform Method to solve unsteady state conduction and diffusion problem in bounded region and interpreted the solution physically. 13. Student being able to solve simultaneous convection and diffusion (or conduction) problem comprising thermal or concentration boundary layer

interaction by developing velocity profile or by using given velocity profile and interpreted the solution physically.

14. Student being able to solve multicomponent mass transfer problem using Stevan-Maxwell equation and interpreted the solution physically.

MAIN SUBJECT

1. Fundamental Concepts (Shell Balance, Equation of Change)
2. Steady state One Dimensional Isothermal Fluid Flow Problems
3. Steady State One Dimensional Conduction and Diffusion Problems
4. Unsteady state One Dimensional Isothermal Fluid Flow Problems (Closed and Open Region)
5. Steady State Two Dimension Fluid Flow Problem (Creeping flow, potential flow, Laminar boundary layer theory)
6. Two Dimension Conduction and Diffusion Problems
7. Two Dimension Conduction and Diffusion with Convection Problems (Asymptotic Approximation)
8. Multicomponent Mass Transport Problems

PREREQUISITES

Fundamental knowledge of Fluid Mechanics, Heat and Mass Transfer, vector analysis, and differential equation

REFERENCE

1. R.Byron Bird, Waren E. Stewart, Edwin N. Lightfoot, Transport Phenomena, second edition, Wiley (2002)
2. L. Gary Leal, Advancrd Transport Phenomena, Cambridge University Press (2010)
3. William M. Deen, Analysis of Transport Phenomena, Oxford University Press (2012).
4. Truskey, Yuan and Katz, Transport Phenomena in Biological Systems, Pearson Prentice Hall (2009).
5. Ali Altway, Sugeng Winardi, Heru Seyawan,*Proses Perpindahan,*ITS Press, Surabaya, 2012

Course			
Course	Course Name	:	**Advanced Chemical Reaction Engineering**
	Course Code	:	TK185202
	Credit	:	4 SKS
	Semester	:	II

DESCRIPTION of COURSE
• This course explains the basics of technology in reaction engineering by paying attention to non-isothermal effects, mass transfer and fluid contact patterns for the design of chemical reactors. • Learning activity strategies: introductory lectures; group discussions, presentations, written examinations (including quizzes, ETS and EAS)
LEARNING OUTCOME
PLO – 1 Able to master engineering science theory, design engineering, the latest methods and techniques required for the analysis and design of processes, processing systems, and equipment needed to convert raw materials into products that have added value PLO – 3 Able to compile ideas, thoughts, and scientific arguments responsibly and based on academic ethics, and communicate them through the media to the academic community and the wider community PLO – 4 Able to develop themselves and compete at national and international levels PLO – 5 Able to deepen or expand knowledge in the field of processes, processing systems, and equipment needed to convert raw materials into products that have added value with chemical, physical and biological processes to make original and tested contributions through independent research. PLO – 6 Able to formulate new ideas (new research questions) from the results of research carried out for the development of science and technology in the fields of processes, processing systems, and equipment needed to convert raw materials into products that have added value through chemical, physical and biological processes. PLO – 7 Show an attitude of responsibility for work in their field of expertise independently PLO – 8 Working together to be able to make the most of their potential
COURSE LEARNING OUTCOME
1. Students can find out in general: Non-isothermal Operation

2. Students can design with the principle of mixed flow reactor stability 3. Students understand the basic techniques of isothermal and non-isothermal system reactor design 4. Students understand the concept of diffusion and kinetics 5. Students can evaluate the kinetic/mass transfer regime in solid catalysts 6. Students can do Reactor design with heat transfer evaluation 7. Students can apply chemical engineering concepts in catalyst engineering and heterogeneous catalytic reactions
MAIN SUBJECT
1. Non-isothermal reactor 2. Stability of the stirred tank reactor 3. Selection of contact systems 4. Catalyst pore diffusion 5. Mass transfer vs kinetics 6. Packed bed reactors 7. The equilibrium of chemical reactions and applications in polymer-containing systems.
PREREQUISITES
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REFERENCE
1. J.M.Smith, "Reaction Kinetics" 3rd ed, McGraw-Hill,1982 2. Octave Levenspiel, " Chemical Reaction Engineering" 3rd Ed. McGraw-Hill, 2000. 3. Fogler," Elements of Chemical Reaction Engineering ", 3rd Ed, Prentice-Hall, 1999.

COURSE	Course Name	:	**Advanced Separation Process**
	Course Code	:	TK185103
	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
PLO – 1 Able to master engineering science theory, design engineering, the latest methods and techniques required for the analysis and design of processes, processing systems, and equipment needed to convert raw materials into products that have added value
PLO – 3 Able to compile ideas, thoughts, and scientific arguments responsibly and based on academic ethics, and communicate them through the media to the academic community and the wider community
PLO – 4 Able to develop themselves and compete at national and international levels
PLO – 5 Able to deepen or expand knowledge in the field of processes, processing systems, and equipment needed to convert raw materials into products that have added value with chemical, physical and biological processes to make original and tested contributions through independent research.
PLO – 6 Able to formulate new ideas (new research questions) from the results of research carried out for the development of science and technology in the fields of processes, processing systems, and equipment needed to convert raw materials into products that have added value through chemical, physical and biological processes.
PLO – 7 Show an attitude of responsibility for work in their field of expertise independently
PLO – 8 Working together to be able to make the most of their potential

COURSE LEARNING OUTCOME

1. Students understand the principles and can analyze the conventional separation process: distillation, absorption, and multicomponent extraction.
2. Students are able can analyze the absorption and distillation process with chemical reaction.
3. Students can analyze supercritical fluid extraction process.
4. Students can 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	:	TK185104
	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
PLO – 1 Able to master engineering science theory, design engineering, the latest methods and techniques required for the analysis and design of processes, processing systems, and equipment needed to convert raw materials into products that have added value PLO – 3 Able to compile ideas, thoughts, and scientific arguments responsibly and based on academic ethics, and communicate them through the media to the academic community and the wider community PLO – 4 Able to develop themselves and compete at national and international levels PLO – 5 Able to deepen or expand knowledge in the field of processes, processing systems, and equipment needed to convert raw materials into products that have added value with chemical, physical and biological processes to make original and tested contributions through independent research. PLO – 6 Able to formulate new ideas (new research questions) from the results of research carried out for the development of science and technology in the fields of processes, processing systems, and equipment needed to convert raw materials into products that have added value through chemical, physical and biological processes. PLO – 7 Show an attitude of responsibility for work in their field of expertise independently PLO – 8 Working together to be able to make the most of their potential
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:

1. Students can use particle characterization concepts.
2. Students can use particle processing procedures.
3. Students can use the concept of particle formation.
4. Students can show the transport mechanism of particles.
5. Students can distinguish various kinds of particle-particle separation.
6. Students can connect the concepts of particle technology to security.

MAIN SUBJECT

1. Particle characterization
2. Particle processing (mixing and segregation, granulation, deposition)
3. Particle formation (size reduction and enlargement, granulation)
4. Particle transportation (multiphase flow, pneumatic transportation, fluidization)
5. Fluid-particle separation (filtration, precipitation, cyclone)
6. Security (fire and explosion hazard of fine particle)

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	:	**System Thermal Analysis**
	Course Code	:	TK185105
	Credit	:	3 SKS
	Semester	:	X

DESCRIPTION of COURSE
This course is intended for graduate students for the 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. Exegetic efficiency. Application on thermos economic. Learning method and activities including home assignments, individual and team assignments, quizzes, and final exam.
LEARNING OUTCOME
PLO – 1 Able to master engineering science theory, design engineering, the latest methods and techniques required for the analysis and design of processes, processing systems, and equipment needed to convert raw materials into products that have added value PLO – 3 Able to compile ideas, thoughts, and scientific arguments responsibly and based on academic ethics, and communicate them through the media to the academic community and the wider community PLO – 4 Able to develop themselves and compete at national and international levels PLO – 5 Able to deepen or expand knowledge in the field of processes, processing systems, and equipment needed to convert raw materials into products that have added value with chemical, physical and biological processes to make original and tested contributions through independent research. PLO – 6 Able to formulate new ideas (new research questions) from the results of research carried out for the development of science and technology in the fields of processes, processing systems, and equipment needed to convert raw materials into products that have added value through chemical, physical and biological processes. PLO – 7 Show an attitude of responsibility for work in their field of expertise independently PLO – 8 Working together to be able to make the most of their potential
COURSE LEARNING OUTCOME
1. Students can define exergy.

2. Students can make an exergy balance on open and closed system.
3. Students can calculate exergy of a process.
4. Students can make an exergy rate balance on control volumes.
5. Students can 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	:	TK185203
	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
PLO – 1 Able to master engineering science theory, design engineering, the latest methods and techniques required for the analysis and design of processes, processing systems, and equipment needed to convert raw materials into products that have added value PLO – 3 Able to compile ideas, thoughts, and scientific arguments responsibly and based on academic ethics, and communicate them through the media to the academic community and the wider community PLO – 4 Able to develop themselves and compete at national and international levels PLO – 5 Able to deepen or expand knowledge in the field of processes, processing systems, and equipment needed to convert raw materials into products that have added value with chemical, physical and biological processes to make original and tested contributions through independent research. PLO – 6 Able to formulate new ideas (new research questions) from the results of research carried out for the development of science and technology in the fields of processes, processing systems, and equipment needed to convert raw materials into products that have added value through chemical, physical and biological processes. PLO – 7 Show an attitude of responsibility for work in their field of expertise independently PLO – 8 Working together to be able to make the most of their potential
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, 3rd edition, 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	:	TK185204
	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
PLO – 1 Able to master engineering science theory, design engineering, the latest methods and techniques required for the analysis and design of processes, processing systems, and equipment needed to convert raw materials into products that have added value
PLO – 3 Able to compile ideas, thoughts, and scientific arguments responsibly and based on academic ethics, and communicate them through the media to the academic community and the wider community
PLO – 4 Able to develop themselves and compete at national and international levels
PLO – 5 Able to deepen or expand knowledge in the field of processes, processing systems, and equipment needed to convert raw materials into products that have added value with chemical, physical and biological processes to make original and tested contributions through independent research.
PLO – 6 Able to formulate new ideas (new research questions) from the results of research carried out for the development of science and technology in the fields of processes, processing systems, and equipment needed to convert raw materials into products that have added value through chemical, physical and biological processes.

PLO – 7 Show an attitude of responsibility for work in their field of expertise independently
PLO – 8 Working together to be able to make the most of their potential

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 can 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	:	TK185205
	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
PLO – 1 Able to master engineering science theory, design engineering, the latest methods and techniques required for the analysis and design of processes, processing systems, and equipment needed to convert raw materials into products that have added value
PLO – 3 Able to compile ideas, thoughts, and scientific arguments responsibly and based on academic ethics, and communicate them through the media to the academic community and the wider community
PLO – 4 Able to develop themselves and compete at national and international levels
PLO – 5 Able to deepen or expand knowledge in the field of processes, processing systems, and equipment needed to convert raw materials into products that have added value with chemical, physical and biological processes to make original and tested contributions through independent research.
PLO – 6 Able to formulate new ideas (new research questions) from the results of research carried out for the development of science and technology in the fields of processes, processing systems, and equipment needed to convert raw materials into products that have added value through chemical, physical and biological processes.
PLO – 7 Show an attitude of responsibility for work in their field of expertise independently
PLO – 8 Working together to be able to make the most of their potential

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	:	TK185301
	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
PLO – 1 Able to master engineering science theory, design engineering, the latest methods and techniques required for the analysis and design of processes, processing systems, and equipment needed to convert raw materials into products that have added value PLO – 3 Able to compile ideas, thoughts, and scientific arguments responsibly and based on academic ethics, and communicate them through the media to the academic community and the wider community PLO – 4 Able to develop themselves and compete at national and international levels PLO – 5 Able to deepen or expand knowledge in the field of processes, processing systems, and equipment needed to convert raw materials into products that have added value with chemical, physical and biological processes to make original and tested contributions through independent research. PLO – 6 Able to formulate new ideas (new research questions) from the results of research carried out for the development of science and technology in the fields of processes, processing systems, and equipment needed to convert raw materials into products that have added value through chemical, physical and biological processes. PLO – 7 Show an attitude of responsibility for work in their field of expertise independently PLO – 8 Working together to be able to make the most of their potential
COURSE LEARNING OUTCOME
1. Understand the membrane material properties selection 2. Understand the manufacturing process and how to characterize membranes

3. Understand the phenomenon of mass transfer on the membrane
4. Understand the membrane applications in industry
5.

MAIN SUBJECT

1. Introduction and material properties selection
2. Preparation of membranes
3. Characterization of membranes
4. Transport phenomena in membranes
5. Membrane applications in industry

PREREQUISITES

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REFERENCE

1. Mulder, M., "Basic Principles of Membrane Technology", 2^{nd} edition, Kluwer Academic Publishers, 1996
2. M.C. Porter (ed), "Handbook of Industrial Membrane Technology", Noyes Publication, New York, 1990.
3. Geankoplis, S.J , "Transport Process and Unit Operation", 3nd edition. 1993.
4. Drioli, E. and Giorno, L., "Membrane Operations: Innovative Separations and Transformations", Wiley VCH, 2009
5. Kucera, J., "Reverse Osmosis: Industrial Applications and Processes", Wiley VCH, 2010

COURSE	Course Name	:	**Coal Processing and Utilization**
	Course Code	:	TK185302
	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
PLO – 1 Able to master engineering science theory, design engineering, the latest methods and techniques required for the analysis and design of processes, processing systems, and equipment needed to convert raw materials into products that have added value
PLO – 3 Able to compile ideas, thoughts, and scientific arguments responsibly and based on academic ethics, and communicate them through the media to the academic community and the wider community
PLO – 4 Able to develop themselves and compete at national and international levels
PLO – 5 Able to deepen or expand knowledge in the field of processes, processing systems, and equipment needed to convert raw materials into products that have added value with chemical, physical and biological processes to make original and tested contributions through independent research.
PLO – 6 Able to formulate new ideas (new research questions) from the results of research carried out for the development of science and technology in the fields of processes, processing systems, and equipment needed to convert raw materials into products that have added value through chemical, physical and biological processes.
PLO – 7 Show an attitude of responsibility for work in their field of expertise independently
PLO – 8 Working together to be able to make the most of their potential

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	:	TK185303
	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
PLO – 1 Able to master engineering science theory, design engineering, the latest methods and techniques required for the analysis and design of processes, processing systems, and equipment needed to convert raw materials into products that have added value PLO – 3 Able to compile ideas, thoughts, and scientific arguments responsibly and based on academic ethics, and communicate them through the media to the academic community and the wider community PLO – 4 Able to develop themselves and compete at national and international levels PLO – 5 Able to deepen or expand knowledge in the field of processes, processing systems, and equipment needed to convert raw materials into products that have added value with chemical, physical and biological processes to make original and tested contributions through independent research. PLO – 6 Able to formulate new ideas (new research questions) from the results of research carried out for the development of science and technology in the fields of processes, processing systems, and equipment needed to convert raw materials into products that have added value through chemical, physical and biological processes. PLO – 7 Show an attitude of responsibility for work in their field of expertise independently PLO – 8 Working together to be able to make the most of their potential
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 can apply the characteristics and behavior of electrochemical processes in certain electrochemical process applications
2. Students can 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	:	TK185305
	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 can 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
PLO – 1 Able to master engineering science theory, design engineering, the latest methods and techniques required for the analysis and design of processes, processing systems, and equipment needed to convert raw materials into products that have added value
PLO – 3 Able to compile ideas, thoughts, and scientific arguments responsibly and based on academic ethics, and communicate them through the media to the academic community and the wider community
PLO – 4 Able to develop themselves and compete at national and international levels
PLO – 5 Able to deepen or expand knowledge in the field of processes, processing systems, and equipment needed to convert raw materials into products that have added value with chemical, physical and biological processes to make original and tested contributions through independent research.
PLO – 6 Able to formulate new ideas (new research questions) from the results of research carried out for the development of science and technology in the fields of processes, processing systems, and equipment needed to convert raw materials into products that have added value through chemical, physical and biological processes.
PLO – 7 Show an attitude of responsibility for work in their field of expertise independently
PLO – 8 Working together to be able to make the most of their potential

COURSE LEARNING OUTCOME
1. Students can understand definition of aerosol and their examples 2. Students can understand the characteristic of aerosols and instrumentations used for measuring the aerosol properties 3. Students can understand the spreading of aerosol in atmosphere 4. Students can understand and analyze the fabrication processes of aerosol including their mechanisms and forces exerted during deposition 5. Students can understand and analyze the applications of aerosol in various industries 6. Students can 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	Course Name	:	**NATURAL GAS PROCESSING**
	Course Code	:	TK185306
	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
PLO – 1 Able to master engineering science theory, design engineering, the latest methods and techniques required for the analysis and design of processes, processing systems, and equipment needed to convert raw materials into products that have added value PLO – 3 Able to compile ideas, thoughts, and scientific arguments responsibly and based on academic ethics, and communicate them through the media to the academic community and the wider community PLO – 4 Able to develop themselves and compete at national and international levels PLO – 5 Able to deepen or expand knowledge in the field of processes, processing systems, and equipment needed to convert raw materials into products that have added value with chemical, physical and biological processes to make original and tested contributions through independent research. PLO – 6 Able to formulate new ideas (new research questions) from the results of research carried out for the development of science and technology in the fields of processes, processing systems, and equipment needed to convert raw materials into products that have added value through chemical, physical and biological processes. PLO – 7 Show an attitude of responsibility for work in their field of expertise independently PLO – 8 Working together to be able to make the most of their potential
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 technology**
	Course Code	:	TK185307
	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
PLO – 1 Able to master engineering science theory, design engineering, the latest methods and techniques required for the analysis and design of processes, processing systems, and equipment needed to convert raw materials into products that have added value PLO – 3 Able to compile ideas, thoughts, and scientific arguments responsibly and based on academic ethics, and communicate them through the media to the academic community and the wider community PLO – 4 Able to develop themselves and compete at national and international levels PLO – 5 Able to deepen or expand knowledge in the field of processes, processing systems, and equipment needed to convert raw materials into products that have added value with chemical, physical and biological processes to make original and tested contributions through independent research. PLO – 6 Able to formulate new ideas (new research questions) from the results of research carried out for the development of science and technology in the fields of processes, processing systems, and equipment needed to convert raw materials into products that have added value through chemical, physical and biological processes. PLO – 7 Show an attitude of responsibility for work in their field of expertise independently PLO – 8 Working together to be able to make the most of their potential
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
-
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	:	TK185308
	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
PLO – 1 Able to master engineering science theory, design engineering, the latest methods and techniques required for the analysis and design of processes, processing systems, and equipment needed to convert raw materials into products that have added value PLO – 3 Able to compile ideas, thoughts, and scientific arguments responsibly and based on academic ethics, and communicate them through the media to the academic community and the wider community PLO – 4 Able to develop themselves and compete at national and international levels PLO – 5 Able to deepen or expand knowledge in the field of processes, processing systems, and equipment needed to convert raw materials into products that have added value with chemical, physical and biological processes to make original and tested contributions through independent research. PLO – 6 Able to formulate new ideas (new research questions) from the results of research carried out for the development of science and technology in the fields of processes, processing systems, and equipment needed to convert raw materials into products that have added value through chemical, physical and biological processes. PLO – 7 Show an attitude of responsibility for work in their field of expertise independently PLO – 8 Working together to be able to make the most of their potential
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 can 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	:	**Research Methodology**
	Course Code	:	TK185309
	Credit	:	3 SKS
	Semester	:	

DESCRIPTION of COURSE
This course provides basic skills in conducting research including knowledge of the research stages and an important part in the writing of proposals and research reports. A review of literature and how to communicate effectively of research results by utilizing research tool determines the quality of research that is reflected in the writing of research proposals and research reports.
LEARNING OUTCOME
PLO – 1 Able to master engineering science theory, design engineering, the latest methods and techniques required for the analysis and design of processes, processing systems, and equipment needed to convert raw materials into products that have added value PLO – 3 Able to compile ideas, thoughts, and scientific arguments responsibly and based on academic ethics, and communicate them through the media to the academic community and the wider community PLO – 4 Able to develop themselves and compete at national and international levels PLO – 5 Able to deepen or expand knowledge in the field of processes, processing systems, and equipment needed to convert raw materials into products that have added value with chemical, physical and biological processes to make original and tested contributions through independent research. PLO – 6 Able to formulate new ideas (new research questions) from the results of research carried out for the development of science and technology in the fields of processes, processing systems, and equipment needed to convert raw materials into products that have added value through chemical, physical and biological processes. PLO – 7 Show an attitude of responsibility for work in their field of expertise independently PLO – 8 Working together to be able to make the most of their potential
COURSE LEARNING OUTCOME

The learning outcome of this course is that students can make draft proposals and research reports that meet the scientific principles in terms of writing and the contents of the proposal in accordance with the field of expertise.
MAIN SUBJECT
1. Introduction: Knowledge and Research (definition, ethics, type, etc.) 2. Research design and preparation 3. Literature review (Literature review) 4. Data analysis 5. Report and presentation of proposals and final reports of research
PREREQUISITES
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REFERENCE
1. Pedoman Penulisan Tesis Pascasarjana ITS 2. Catherine Dawson, 2006, A Practical Guide to Research Methods: A User-Friendly Manual for Mastering Research Techniques and Projects, How to Books Ltd., UK. 3. Uwe Flick, 2013, Introduction Research Methodology: A Beginner's Guide to Doing a Research Project, SAGE Publication 4. John W. Creswell, 2014, Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, fourth ed., Sage Publication Inc., USA.

COURSE	Course Name	:	**Advanced Multi Variable Control**
	Course Code	:	TK185310
	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
PLO – 1 Able to master engineering science theory, design engineering, the latest methods and techniques required for the analysis and design of processes, processing systems, and equipment needed to convert raw materials into products that have added value
PLO – 3 Able to compile ideas, thoughts, and scientific arguments responsibly and based on academic ethics, and communicate them through the media to the academic community and the wider community
PLO – 4 Able to develop themselves and compete at national and international levels
PLO – 5 Able to deepen or expand knowledge in the field of processes, processing systems, and equipment needed to convert raw materials into products that have added value with chemical, physical and biological processes to make original and tested contributions through independent research.
PLO – 6 Able to formulate new ideas (new research questions) from the results of research carried out for the development of science and technology in the fields of processes, processing systems, and equipment needed to convert raw materials into products that have added value through chemical, physical and biological processes.
PLO – 7 Show an attitude of responsibility for work in their field of expertise independently
PLO – 8 Working together to be able to make the most of their potential

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 and 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	:	**Advanced Chemical Engineering Mathematics**
	Course Code	:	TK185311
	Credit	:	3 SKS
	Semester	:	X

DESCRIPTION of COURSE
Translating chemical engineering problems into mathematical models; using mathematical models to solve chemical engineering problems and interpret the results; using mathematical tools to solve chemical engineering problems; using modern software to solve chemical engineering problems.

LEARNING OUTCOME
PLO – 1 Able to master engineering science theory, design engineering, the latest methods and techniques required for the analysis and design of processes, processing systems, and equipment needed to convert raw materials into products that have added value PLO – 3 Able to compile ideas, thoughts, and scientific arguments responsibly and based on academic ethics, and communicate them through the media to the academic community and the wider community PLO – 4 Able to develop themselves and compete at national and international levels PLO – 5 Able to deepen or expand knowledge in the field of processes, processing systems, and equipment needed to convert raw materials into products that have added value with chemical, physical and biological processes to make original and tested contributions through independent research. PLO – 6 Able to formulate new ideas (new research questions) from the results of research carried out for the development of science and technology in the fields of processes, processing systems, and equipment needed to convert raw materials into products that have added value through chemical, physical and biological processes. PLO – 7 Show an attitude of responsibility for work in their field of expertise independently PLO – 8 Working together to be able to make the most of their potential

COURSE LEARNING OUTCOME
1. Students are able to translate chemical engineering problems into mathematical models.

2. Students are able to use mathematical models to solve chemical engineering problems and interpret the results. 3. Students are able to use mathematical tools to solve chemical engineering problems. 4. Students are able to use modern software to solve chemical engineering problems.
MAIN SUBJECT
1. Basic concepts of modeling. 2. Matrices, transformations, series, complex variable methods, curve fitting, numerical methods in linear algebra, nonlinear algebraic equations, ordinary and partial differential equations. 3. Optimization. 4. Special emphasis on problems that arise in chemical engineering applications.
PREREQUISITES
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REFERENCE
1. R.G. Rice, D.D. Do, Applied Mathematics and Modeling for Chemical Engineers, John Wiley & Sons (1995). 2. M.E. Davis, Numerical Methods and Modeling for Chemical Engineers, John Wiley & Sons, New York (1984). 3. T.F. Edgar, D.M. Himmelblau, Optimization of Chemical Process, 2nd ed, Mc Graw Hill, New York (2001).

COURSE	Course Name	:	**Thesis**
	Course Code	:	TK185401
	Credit	:	8 SKS
	Semester	:	II-IV

DESCRIPTION of COURSE
Preparing proposals, conducting research, reporting research progress, processing research data, discussing research results, and compiling final report.

LEARNING OUTCOME
PLO – 1 Able to master engineering science theory, design engineering, the latest methods and techniques required for the analysis and design of processes, processing systems, and equipment needed to convert raw materials into products that have added value
PLO – 2 Able to develop logical, critical, systematic, and creative thinking through scientific research, design creation or works of art in the field of science and technology that pay attention to and apply humanities values in accordance with their areas of expertise, compile scientific conceptions and study results based on rules, procedures, and scientific ethics in the form of a thesis or other equivalent, and uploaded on the college website, as well as papers that have been published in accredited scientific journals or accepted in international journals
PLO – 3 Able to compile ideas, thoughts, and scientific arguments responsibly and based on academic ethics, and communicate them through the media to the academic community and the wider community
PLO – 4 Able to develop themselves and compete at national and international levels
PLO – 5 Able to deepen or expand knowledge in the field of processes, processing systems, and equipment needed to convert raw materials into products that have added value with chemical, physical and biological processes to make original and tested contributions through independent research.
PLO – 6 Able to formulate new ideas (new research questions) from the results of research carried out for the development of science and technology in the fields of processes, processing systems, and equipment needed to convert raw materials into products that have added value through chemical, physical and biological processes.

PLO – 7 Show an attitude of responsibility for work in their field of expertise independently PLO – 8 Working together to be able to make the most of their potential
COURSE LEARNING OUTCOME
The learning outcome of this course is students can carry out research and write research results in national journals accredited or good reputable international conference.
MAIN SUBJECT
1. Introduction 2. Purposes 3. Literature review 4. Methodology 5. Results and Discussion 6. Conclusion
PREREQUISITES
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REFERENCE
1. Journals or books related with their thesis work 2. Guidance Book from Graduate Program ITS 3. Thesis Writing Instructional from Graduate Program ITS