DEPARTMENT OF CHEMICAL ENGINEERING

The Department of Chemical Engineering offers a Bachelor of Engineering degree, a Master of Engineering degree, and a Doctor of Engineering degree in Chemical Engineering. The department currently accepts a sophomore class of about 70 students for Bachelor's program, 100 students for Master program (50-60 for M.Eng.program, 30-40 for weekend M.Eng.program) and 5-10 students for Doctoral program.

The Bachelor of Engineering's degree program offers a complete set of basic courses in Chemical Engineering. The curriculum also allows the students to choose several elective courses. This special feature broadens the student's knowledge to meet his or her interest and the demands of the industries. The senior project introduces the students to the integration of knowledge and gives them hand-on experiences in solving the engineering and technological problems. The curriculum additionally stresses the training of the student to think and present oneself logically and independently.

The department of Chemical Engineering offers two graduate programs leading to the degree of Master of Engineering and the degree of Doctor of Engineering

Students entering graduate study in the Department normally have a bachelor's degree in Chemical Engineering. The Department also admits exceptional students who majored in another branch of engineering, or science at the undergraduate level. Depending on their background, these students have to take undergraduate chemical engineering courses as necessary, while simultaneously taking graduate level subjects for which they have adequate preparation.

The applicant for a doctoral degree must hold either a Bachelor's degree in Chemical Engineering with Second Class Honors or equivalent or a master's degree in Chemical Engineering.

The research activities at the department are grouped into 10 areas of interest, namely, biochemical engineering, catalysts and catalytic reaction engineering, control and system engineering, environmental chemical engineering and safety, life cycle engineering, oleochemical, particle technology and material processing, polymer science and polymer engineering, process systems engineering, and separation technology. Each student can choose to do his or her research in any one of these research areas.

The collaboration between the department and top universities in several countries such as Japan, Canada, England, Australia and China will strengthen graduate program of the department.

The above curriculum and research activities together with strong interaction between faculties and students in all levels have produced the graduates who can meet the demands and needs of the chemical, petrochemical, and related industries as well as various governmental organizations. Additionally, these have paved the way for the Department of Chemical Engineering to establish herself as an active partner in the advancement of Chemical Engineering discipline in Thailand.

HEAD :

Paisan	Kittisupakorn,	Ph.D. (London)

PROFESSORS :

Paisan	Kittisupakorn,	B.Eng. (Chula), M.Sc., D.I.C., Ph.D. (London)
Piyasan	Praserthdam,	B.Eng. (Chula), M.Sc. (P.I.N.Y.), Dr.Ing. (I.N.S.A.) (Toulouse)
Suttichai	Assabumrungrat,	B.Eng. (Chula), M.Sc., D.I.C., Ph.D. (London)

ASSOCIATE PROFESSORS :

Artiwan	Shotipruk,	Ph.D. (Michigan, Ann Arbor)
Anongnat	Somwangthanaroj,	Ph.D. (Michigan)
Bunjerd	Jongsomjit,	Ph.D. (Pittsburgh)
Deacha	Chatsiriwech,	B.Eng. (Chula), D.I.C., Ph.D. (London)
Joongjai	Panpranot,	Ph.D. (Clemson)
Kasidit	Nootong,	Ph.D. (Pennsylvania)
Prasert	Pavasant,	B.Eng. (Chula), M.Sc., D.I.C., Ph.D. (London)
Sarawut	Rimdusit,	B.Eng. (Chula), M.S.,Ph.D. (CWRU)
Seeroong	Prichanont,	B.Eng. (Chula), M.Sc., D.I.C., Ph.D. (London)
Siriporn	Damrongsukkul,	B.Eng. (Chula), M.Sc., D.I.C., Ph.D. (London)
Soorathep	Kheawhom,	Ph.D. (Tokyo)
Tawatchai	Charinpanitkul,	B.Eng. (Chula) M.Eng., D.Eng. (Tokyo)
Tharathon	Mongkhonsi,	B.Eng. (Chula), M.Sc., D.I.C., Ph.D. (London)
Muenduen	Phisalaphong,	B.Sc. (Kasetsart), M.Eng. (Chula), M.Sc. (Lehigh), Ph.D. (Colorado State)
Varong	Pavarajarn,	Ph.D. (Oregon State)
Ura	Pancharoen,	B.S. (Newark), M.Sc., D.Eng.Sc. (NJIT)

ASSISTANT PROFESSORS :

Amornchai	Arpornwichanop,	D.Eng. (Chula)
Apinan	Soottitantawat,	B.Eng.(Chula), M.Sc.,D.eng. (Tottori)
Nattaporn	Tonanon,	D.Eng. (Kyoto)
Sorada	Kanokpanont,	Ph.D. (Drexel)
Suphot	Phatanasri,	B.Sc. (Chiangmai), M.Eng. (Chula), D.Eng. (Kyoto)

LECTURERS :

Akawat	Sirisuk,	Ph.D. (Wisconsin)
Chutimon	Satirapipathkul,	D.Eng (Tokyo Tech)
Jirdsak	Tscheikuna,	Ph.D. (OklahomaState)
Sirijutaratana	Covavisaruch,	Ph.D. (Michigan, Ann Arbor)
Sirikanya	Singcuna,	M.S. (Waterloo)
Varun	Taepaisitphongse,	Ph.D. (UCLA)
Pimporn	Ponpesh	Ph.D. (California)

CHEMICAL ENGINEERING CURRICULUM
FIRST YEAR CURRICULUM
COMMON TO ALL ENGINEERING STUDENTS

COURSE NO.	SUBJECT	CREDITS
	THIRD SEMESTER	
2103213	ENG MECHANICS I	3
2105220	CHE CHEM	3
2105221	CHE CHEM LAB	1
2105222	CHE THERMO I	3
2105261	CHEM PROD IND	3
2105262	CHE PRIN	3
5500208	COM PRES SKIL	3
		19
	FOURTH SEMESTER	
2103231	MECH OF MAT I	3
2105223	CHE THERMO II	3
2105230	CHE MATH I	3
2105251	UNIT OP I	3
XXXXXXX	GENERAL EDUCATION	6
		18
	FIFTH SEMESTER	
2105331	CHE MATH II	3
2105332	CHE STAT	3
2105352	UNIT OP II	3
2105356	UNIT OP LAB I	1
2105373	CHEM ENG KIN REACT	3
5500308	TECH WRIT ENG	3
XXXXXXX	GENERAL EDUCATION	3
		19

COURSE NO.	SUBJECT	CREDITS
	SIXTH SEMESTER	
2105301	CHE SEM I	1
2102391	ELEC ENG	3
2102392	ELEC ENG LAB I	1
2105333	TRANS PHENO	3
2105353	UNIT OP III	3
2105357	UNIT OP LAB II	1
2105362	CHEM PROC ECON ASSESS	3
XXXXXXX	GENERAL EDUCATION	3
		17
	SUMMER SEMESTER	
2100301	ENG PRACTICE	2
	SEVENTH SEMESTER	
2105458	UNIT OP LAB III	1
2105463	CHE PROC	3
2105464	CHEM PROC DSGN	3
2105472	PROC DYN CONTROL	3
2105480	SAFETY IN CHEM OPER	3
2105491	CHE PROJ I	1
21054xx	ELECTIVE COURSE	3
		17
	EIGHTH SEMESTER	
2105402	CHE SEM II	1
2105465	CHEM PLANT DSGN	3
2105482	ENV CHEM ENG	3
2105498	CHE PROJ II	
OR 210099	ENGINEERING PROJECT	3
21054xx	ELECTIVE COURSE	3
XXXXXXX	FREE ELECTIVE	3
XXXXXXX	FREE ELECTIVE	3
		19

TOTAL CREDITS FOR GRADUATION = 146

NAME OF THE DEGREE

: Master of Engineering
: M.Eng.

PROFESSORS :

Paisan	Kittisupakorn,	B.Eng. (Chula), M.Sc., D.I.C., Ph.D. (London)
Piyasan	Praserthdam,	B.Eng. (Chula), M.Sc. (P.I.N.Y.), Dr.Ing. (I.N.S.A.) (Toulouse)
Suttichai	Assabumrungrat,	B.Eng. (Chula), M.Sc., D.I.C., Ph.D. (London)

ASSOCIATE PROFESSORS :

Artiwan	Shotipruk,	Ph.D. (Michigan, Ann Arbor)
Anongnat	Somwangthanaroj,	Ph.D. (Michigan)
Bunjerd	Jongsomjit,	Ph.D. (Pittsburgh)
Deacha	Chatsiriwech,	B.Eng. (Chula), D.I.C., Ph.D. (London)
Joongjai	Panpranot,	Ph.D. (Clemson)
Kasidit	Nootong,	Ph.D. (Pennsylvania)
Prasert	Pavasant,	B.Eng, (Chula), M.Sc., D.I.C., Ph.D. (London)
Sarawut	Rimdusit,	B.Eng. (Chula), M.S.,Ph.D. (CWRU)
Seeroong	Prichanont,	B.Eng. (Chula), M.Sc., D.I.C., Ph.D. (London)
Siriporn	Damrongsukkul,	B.Eng. (Chula), M.Sc., D.I.C., Ph.D. (London)
Soorathep	kheawhom,	Ph.D. (Tokyo)
Tawatchai	Charinpanitkul,	B.Eng. (Chula) M.Eng., D.Eng. (Tokyo)
Tharathon	Mongkhonsi,	B.Eng. (Chula), M.Sc., D.I.C., Ph.D. (London)
Muenduen	Phisalaphong,	B.Sc. (Kasetsart), M.Eng. (Chula), M.Sc. (Lehigh), Ph.D. (Colorado State)
Varong	Pavarajarn,	Ph.D. (Oregon State)
Ura	Pancharoen,	B.S. (Newark), M.Sc., D.Eng.Sc. (NJIT)

ASSISTANT PROFESSORS :

Amornchai	Arpornwichanop,	D.Eng. (Chula)
Apinan	Soottitantawat,	B.Eng.(Chula), M.Sc.,D.eng. (Tottori)
Nattaporn	Tonanon,	D.Eng. (Kyoto)
Sorada	Kanokpanont,	Ph.D. (Drexel)
Suphot	Phatanasri,	B.Sc. (Chiengmai), M.Eng. (Chula), D.Eng. (Kyoto)

LECTURERS :

Akawat	Sirisuk,	Ph.D. (Wisconsin)
Chutimon	Satirapipathkul,	D.Eng (Tokyo Tech)
Jirdsak	Tscheikuna,	Ph.D. (OklahomaState)

Sirijutaratana	Covavisaruch,	Ph.D. (Michigan, Ann Arbor)
Sirikanya	Singcuna,	M.S. (Waterloo)
Varun	Taepaisitphongse,	Ph.D. (UCLA)
Pimporn	Ponpesh	Ph.D. (California)

ADMISSION

An applicant must hold a Bachelor's Degree in Chemical Engineering or equivalent and also meets the requirements of the Graduate School.

DEGREE REQUIREMENTS
(for bachelor degree of chemical engineering graduated)

Students with bachelor degree of chemical engineering are required to complete 24 credits of courses and a thesis of 12 credits. The course consists of 9 credits of required courses in 1,not less than 6 credits of approved elective course from the same group in 2, and 9 credits of free elective courses in 3 or from another groups in 2. Chemical engineering seminar I and II are no credit required courses (S/U) and not counted to fulfill the program.

COURSE REQUIREMENTS

1. Required Courses   2 credits   from
| 2105605 | Seminar I | 1(1-0-3) |
| 2105606 | Seminar II | 1(1-0-3) |

2) Core Course   15 credits   from
- Group I
| 2105602 | Advanced Transport Phenomena | 3(3-0-9) |
| 2105685 | Selected Topics in Transport Phenomena | 3(3-0-9) |

- Group II
| 2105603 | Advanced Chemical Engineering Thermodynamics | 3(3-0-9) |
| 2105686 | Selected Topics in Chemical Engineering Thermodynamics | 3(3-0-9) |

- Group III
2105604	Advanced Chemical Engineering Kinetics and Chemical Reactor Design	3(3-0-9)
2105687	Advanced Chemical Kinetics and Catalysis	3(3-0-9)
2105688	Selected Topics in Chemical Engineering Kinetics	3(3-0-9)

- Group IV
2105601	Advance Engineering Mathematics for Chemical Engineers	3(3-0-9)
2105607	Chemical Engineering Process Scale-up	3(3-0-9)
2105612	Chemical Engineering Process and Product Development	3(3-0-9)
2105617	Research Methodology and Statistical Analysis	3(3-0-9)
2105618	Characterization and Instrumental Analysis	3(3-0-9)

2105676	Instrumentation in Chemical Process	
		3(3-0-9)
2105671	Process Dynamics	3(3-0-9)
2105623	Optimization of Chemical Processes	
		3(3-0-9)
2105689	Safe Process Operation and Design	
		3(3-0-9)
2105699	Multifunctional Reactor	3(3-0-9)

3) Elective Courses   9 credits   from

- Chemical Engineering Fundamental Division

2105526	Total Productive Management for	
	Chemical Process Industry	3(3-0-9)
2105608	Adsorption Process	3(3-0-9)
2105610	Membrane Technology	3(3-0-9)
2105611	Separation Technology Via Liquid	
	Membrane And Application	3(3-0-9)
2105613	Mass Transfer Operation	3(3-0-9)
2105626	Advanced Heat Transfer	3(3-0-9)
2105663	Heat Transfer Operation	3(3-0-9)
2105682	Surface Technology	3(3-0-9)
2105684	Chemical Analysis for Chemical	
	Process Control I	3(3-0-9)
2105690	Independent Study I	3(3-0-9)
2105691	Independent Study II	3(3-0-9)
2105692	Independent Study III	3(3-0-9)

- Process Control and System Engineering Division

2105522	Dyanamic Process Simulation	3(3-0-9)
2105599	Batch Chemical Processes	3(3-0-9)
2105619	Advanced Automatic Process Control	
		3(3-0-9)
2105693	Special Problems in Process	
	Control Engineering	3(3-0-9)

- Petrochemical Engineering Division

2105630	Heterogeneous Catalytic Reactor	
	Modeling	3(3-0-9)
2105631	Advanced Catalysts for Polymers	3(3-0-9)
2105632	Petrochemical Technology	3(3-0-9)
2105634	Catalysis	3(3-0-9)
2105636	Heterogeneous Catalysis	3(3-0-9)
2105637	Design of Industrial Catalysis	3(3-0-9)
2105681	Catalyst Deactivation	3(3-0-9)
2105694	Special Problems in Petrochemical	
	Engineering	3(3-0-9)

- Polymer Engineering Division

2105527	Polymer Characterization and Fracture	
		3(3-0-9)
2105638	Advanced Polymer Engineering	3(3-0-9)
2105643	Polymer Processing	3(3-0-9)
2105649	Polymer Blends and Composites	3(3-0-9)
2105675	Polymer Chemistry for Engineers	3(3-0-9)
2105695	Special Problems in Polymer	
	Engineering	3(3-0-9)

- Biochemical Engineering Division

2105641	Biodegradable Material Engineering	
		3(3-0-9)
2105650	Biochemical Engineering	3(3-0-9)

2105652	Bioreactor Analysis and Control	
	Design	3(3-0-9)
2105654	Biosensors	3(3-0-9)
2105655	Bioprocess Plant Design	3(3-0-9)
2105659	Biochemical Separation Technology	
		3(3-0-9)
2105679	Bioactive Compounds	3(3-0-9)
2105683	Bioenergy Technology	3(3-0-9)
2105696	Special Problems in Biochemical	
	Engineering	3(3-0-9)

- Cleaner Production Engineering Division

2105666	Source Control of Particulate Emission	
		3(3-0-9)
2105667	Loss Prevention in Chemical Operations	
		3(3-0-9)
2105697	Special Problems in Cleaner Production	
	Engineering	3(3-0-9)

- Particle Technology Division

2105572	Encapsulation Process	3(3-0-9)
2105609	Advanced Particulate Technology	3(3-0-9)
2105616	Fluid and Particle Mechanics	3(3-0-9)
2105672	Simulation of Particulate and Material	
	Processing	3(3-0-9)
2105678	Introduction to Nanotechnology	3(3-0-9)
2105698	Special Problems in Particle	
	Technology	3(3-0-9)

4) THESIS

| 2105811 | THESIS | 12 | credits |
| 2105816 | THESIS | 36 | credits |

Master of Chemical Engineering Program

First Year

First Semester

2105602	ADV TRANS PHENOM	3
2105603	ADV CHE THERMO	3
2105604	ADV CHE KINETICS	3
21056xx/5xx	Free Elective	3
		12

Second Semester

2105605	Seminar I	1
21056xx	Approved Elective	3
21056xx	Approved Elective	3
21056xx/5xx	Free Elective	3
21056xx/5xx	Free Elective	3
2105811	Thesis	2
		15

Second Year

First Semester

2105606	Seminar II	1
2105811	Thesis	6
21056xx/5xx	Free Elective(Option)	3
		7,10

Second Semester

2105811	Thesis	4
21056xx/5xx	Free Elective(Option)	<u>3</u>
		4,7

DEGREE REQUIREMENTS
(for non-bachelor degree of chemical engineering graduated)

Students with non-bachelor degree of chemical engineering are required to complete 30 credits of engineering and chemical engineering fundamental courses, 24 credits of courses and a thesis of 12 credits. The fundamental courses of 30 credits are lists in 5. The course consists of 9 credits of required courses in 1, not less than 6 credits of approved elective course from the same group in 2, and 9 credits of free elective courses in 3 or from another groups in 2. The fundamental, chemical Engineering Seminar I and II are non credit required courses (S/U) and not counted for in order to fulfill the program.

Master of Chemical Engineering Program
First Year
First Semester

2105373	Chemical Engineering Kinetics and Reactor Design	3
2105331	Chemical Engineering Mathematics II	3
2103106	Engineering Drawing	3
2105603	ADV CHE THERMO	3
21056xx/5xx	Free Elective	<u>3</u>
		6

Second Semester

2105333	Transport Phenomena	3
2105251	Unit Operations I	3
21056xx	Approved Elective	3
21056xx/5xx	Free Elective	3
2105605	Seminar I	<u>1</u>
		6

Second Year
First Semester

2105352	Unit Operations II	3
2105356	Unit Operations Laboratory I	1
2105602	ADV TRANS PHEHOM	3
2105604	ADV CHE KINETICS	3
2105606	Seminar II	<u>1</u>
		6

Second Semester

2105353	Unit Operation III	3
2105357	Unit Operations Laboratory II	1
21056xx	Approved Elective	3
21056xx/5xx	Free Elective	3
2105811	Thesis	<u>2</u>
		8

Third Year
First Semester

2105464	Chemical Process Design	3
2105472	Process Dynamics and Control	3
2105458	Unit Operations Laboratory III	1
2105811	Thesis	4
21056xx/5xx	Free Elective (Option)	<u>3</u>
		4,7

Second Semester

2105811	Thesis	6
21056xx/5xx	Free Elective (Option)	<u>3</u>
		6,9

COURSE REQUIREMENTS
1) Fundamental Courses

2103106	Engineering Drawing	3(1-4-4)
2105251	Unit Operations I	3(3-0-6)
2105331	Chemical Engineering Mathematics II	3(3-0-6)
2105333	Transport Phenomena	3(3-0-6)
2105352	Unit Operations II	3(3-0-6)
2015353	Unit Operations III	3(3-0-6)
2105356	Unit Operations Laboratory I	1(0-3-0)
2105357	Unit Operations Laboratory II	1(0-3-0)
2105373	Chemical Engineering Kinetics and Reactor Design	3(3-0-6)
2105458	Unit Operations Laboratory III	1(0-3-0)
2105464	Chemical Process Design	3(2-3-4)
2105472	Process Dynamics and Control	3(3-0-6)

2) Required Courses   9   credits

2105602	Advanced Transport Phenomena	3(3-0-9)
2105603	Advanced Chemical Engineering Thermodynamics	3(3-0-9)
2105604	Advanced Chemical Engineering Kinetics and Chemical Reactor Design	3(3-0-9)
2105605	Chemical Engineering Seminar I	1(1-0-3)
2105606	Chemical Engineering Seminar II	1(1-0-3)

3) Approved Elective   6   credits

2105601	Advanced Engineering Mathematics for Chemical Engineers	3(3-0-9)
2105607	Chemical Engineering Process Scale-up	3(3-0-9)
2105612	Chemical Engineering process and Product Development	3(3-0-9)
2105617	Research Methodology and Statistical Analysis	3(3-0-9)
2105618	Characterization and Instrumental Analysis	3(3-0-9)
2105622	Chemical Process Simulation and Optimization	3(3-0-9)
2105676	Instrumentation in Chemical Process	3(3-0-9)

4) Elective Courses   9   credits

Group 1 : Chemical Engineering Fundamental Division

2105526	Total Productive Management for Chemical Process Industry	3(3-0-9)
2105608	Adsorption Process	3(3-0-9)
2105610	Membrane Technology	3(3-0-9)
2105611	Separation Technology via Liquid Membrane and Application	3(3-0-9)
2105613	Mass Transfer Operations	3(3-0-9)
2150626	Advanced Heat Transfer	3(3-0-9)
2150661	Special Problems in Chemical Engineering	3(3-0-9)
2105662	Selected Topics in Chemical Engineering	3(3-0-9)
2150663	Heat Transfer Operation	3(3-0-9)
2105665	Cryogenic Engineering	3(3-0-9)
2105673	Design and Analysis of Experiments in Chemical Engineering	3(3-0-9)
2105680	Multifunctional Reactor	3(3-0-9)
2105682	Surface Technology	3(3-0-9)
2105684	Chemical Analysis for Chemical Process Control I	3(3-0-9)

Group 2 : Process Control and Systems Engineering Division

2105522	Dynamic Process Simulation	3(3-0-9)
2105599	Batch Chemical Process	3(3-0-9)
2105619	Advanced Automatic Process Control	3(3-0-9)
2105621	Multivariable Process Control	3(3-0-9)
2105623	Optimization of Chemical Processes	3(3-0-9)
2105624	Computer Process Control	3(2-3-7)
2105625	Process Control and Management	3(3-0-9)
2105628	Process Control Instrumentation	3(3-0-9)
2105629	Process Identification and Data Analysis	3(3-0-9)
2105671	Process Dynamics	3(3-0-9)
2105674	Computer-Aided Process and Product Engineering	3(3-0-9)

Group 3 : Petrochemical Engineering Division

2105630	Heterogeneous Catalytic Reactor Modelling	3(3-0-9)
2105631	Advanced Catalysts for Polymers	3(3-0-9)
2105632	Petrochemical Technology	3(3-0-9)
2105634	Catalysis	3(3-0-9)
2105636	Heterogeneous Catalysis	3(3-0-9)
2105637	Design of Industrial Catalysts	3(3-0-9)
2105681	Catalyst Deactivation	3(3-0-9)

Group 4 : Polymer Engineering Division

2105527	Polymer Characterization and Fracture	3(3-0-9)
2105638	Advanced Polymer Engineering	3(3-0-9)
2105643	Polymer Processing	3(3-0-9)
2105649	Polymer Blends and Composites	3(3-0-9)
2105675	Polymer Chemistry for Engineers	3(3-0-9)

Group 5 : Biochemical Engineering Division

2105641	Biodegradable Material Engineering	3(3-0-9)
2105650	Biochemical Engineering	3(3-0-9)
2105652	Bioreactor Design Analysis and Control	3(3-0-9)
2105654	Biosensors	3(3-0-9)
2105655	Bioprocess Plant Design	3(3-0-9)
2105656	Bioremediation Engineering	3(3-0-9)
2105659	Biochemical Separation Technology	3(3-0-9)
2105679	Bioactive Compounds	3(3-0-9)
2105683	Bioenergy Technology	3(3-0-9)

Group 6 : Cleaner Production Engineering Division

2105666	Source Control of Particulate Emissions	3(3-0-9)
2105667	Loss Prevention in Chemical Operations	3(3-0-9)
2105668	Energy Conservation in Chemical Processes	3(3-0-9)
2105669	Cleaner Technology	3(3-0-9)

Group 7 : Particle Technology Division

2105571	Aerosol Engineering	3(3-0-9)
2105572	Encapsulation Process	3(3-0-9)
2105609	Advanced Particulate Technology	3(3-0-9)
2105616	Fluid and Particle Mechanics	3(3-0-9)
2105672	Simulation of Particulate and Material Processing	3(3-0-9)
2105678	Introduction to Nanotechnology	3(3-0-9)

    4) Thesis

2105811	Thesis	12 Credits

NAME OF THE DEGREE

  : Doctor of Engineering
  : D.Eng.

PROFESSORS :

Paisan	Kittisupakorn,	B.Eng. (Chula), M.Sc., D.I.C., Ph.D. (London)
Piyasan	Praserthdam,	B.Eng. (Chula), M.Sc. (P.I.N.Y.), Dr.Ing. (I.N.S.A.) (Toulouse)
Suttichai	Assabumrungrat,	B.Eng. (Chula), M.Sc., D.I.C., Ph.D. (London)

ASSOCIATE PROFESSORS :

Artiwan	Shotipruk,	Ph.D. (Michigan, Ann Arbor)
Anongnat	Somwangthanaroj,	Ph.D. (Michigan)
Bunjerd	Jongsomjit,	Ph.D. (Pittsburgh)
Deacha	Chatsiriwech,	B.Eng. (Chula), D.I.C., Ph.D. (London)
Joongjai	Panpranot,	Ph.D. (Clemson)
Kasidit	Nootong,	Ph.D. (Pennsylvania)
Prasert	Pavasant,	B.Eng, (Chula), M.Sc., D.I.C., Ph.D. (London)
Sarawut	Rimdusit,	B.Eng. (Chula), M.S.,Ph.D. (CWRU)

Seeroong	Prichanont,	B.Eng. (Chula), M.Sc., D.I.C., Ph.D. (London)
Siriporn	Damrongsukkul,	B.Eng. (Chula), M.Sc., D.I.C., Ph.D. (London)
Soorathep	kheawhom,	Ph.D. (Tokyo)
Tawatchai	Charinpanitkul,	B.Eng. (Chula) M.Eng., D.Eng. (Tokyo)
Tharathon	Mongkhonsi,	B.Eng. (Chula), M.Sc., D.I.C., Ph.D. (London)
Muenduen	Phisalaphong,	B.Sc. (Kasetsart), M.Eng. (Chula), M.Sc. (Lehigh), Ph.D. (Colorado State)
Varong	Pavarajarn,	Ph.D. (Oregon State)
Ura	Pancharoen,	B.S. (Newark), M.Sc., D.Eng.Sc. (NJIT)

ASSISTANT PROFESSORS :

Amornchai	Arpornwichanop,	D.Eng. (Chula)
Apinan	Soottitantawat,	B.Eng.(Chula), M.Sc.,D.eng. (Tottori)
Nattaporn	Tonanon,	D.Eng. (Kyoto)
Sorada	Kanokpanont,	Ph.D. (Drexel)
Suphot	Phatanasri,	B.Sc. (Chiengmai), M.Eng. (Chula), D.Eng. (Kyoto)

LECTURERS :

Akawat	Sirisuk,	Ph.D. (Wisconsin)
Chutimon	Satirapipathkul,	D.Eng (Tokyo Tech)
Jirdsak	Tscheikuna,	Ph.D. (OklahomaState)
Sirijutaratana	Covavisaruch,	Ph.D. (Michigan, Ann Arbor)
Sirikanya	Singcuna,	M.S. (Waterloo)
Varun	Taepaisitphongse,	Ph.D. (UCLA)
Pimporn	Ponpesh	Ph.D. (California) Ph.D.(UCD)

ADMISSION

The applicant must hold either a Bachelor's Degree in Chemical Engineering or equivalent with Second Class Honors, or a Master's Degree in Chemical Engineering,

which is required for Pattern II. The additional requirement for Pattern I is the minimum grade point average of 3.5 on Master's Degree in Chemical Engineering.

COURSE REQUIREMENTS

	1)	*Required Courses for Pattern II (1)*	*12 credits*
2105601		Advanced Engineering Mathematics for Chemical Engineers	3(3-0-9)
2105602		Advanced Transport Phenomena	3(3-0-9)
2105603		Advanced Chemical Engineering Thermodynamics	3(3-0-9)
2105604		Advanced Chemical Engineering Kinetics and Chemical Reactor Design	3(3-0-9)
2105717		Seminar in Chemical Engineering III	1(1-0-3)
2105718		Seminar in Chemical Engineering IV	1(1-0-3)
	2)	*Elective Courses for Pattern II (2)*	*12 credits*
2105645		Polymer Extrusion Process and Design	3(3-0-9)
2105701		Advanced Process System Engineering	3(3-0-9)
2105702		Advanced Separation Technology	3(3-0-9)
2105703		Optimal Process Control	3(3-0-9)
2105709		Special Projects in Chemical Engineering	3(3-0-9)
2105710		Air Engineering and Control of Gaseous Air Pollutants	3(3-0-9)

Students may select other courses offered by the Graduate School, Chulalongkorn University, with approval from their academic advisor or Chemical Engineering Department.

DEGREE REQUIREMENTS

There are two patterns of study as follows:

	Pattern I	Pattern II (1)	Pattern II (2)
	Master's Degree Holder	Bachelor's Degree Holder	Master's Degree Holder
Required Courses	0	12	0
Elective Courses	0	12	12
Seminar in Chem Eng.	2*	2*	2*
Dissertation	48	48	48
Total course requirements	48	72	60

* Seminar in Chemical Engineering III and IV are non credit required courses (s/u) and not counted for in order to fulfill the program.

DOCTOR OF CHEMICAL ENGINEERING PROGRAM

Pattern I for Master's degree holder

First Semester

2105717	Seminar in Chemical Engineering III	1 (s/u)**
2105829	Dissertation	10
		10

Second Semester

2105718	Seminar in Chemical Engineering IV	1 (s/u)**
2105829	Dissertation	10
		10

Third Semester

2105894	Doctoral Dissertation Seminar	0 (s/u)**
2105829	Dissertation	10
		10

Fourth Semester

2105894	Doctoral Dissertation Seminar	0 (s/u)**
2105829	Dissertation	10
		10

Fifth Semester

2105894	Doctoral Dissertation Seminar	0 (s/u)**
2105829	Dissertation	10
		10

Sixth Semester

2105894	Doctoral Dissertation Seminar	0 (s/u)**
2105829	Dissertation	10
		10

Pattern II (1) for Bachelor's degree holder

First Semester

2105717	Seminar in Chemical Engineering III	1 (s/u)**
2105830	Dissertation	9
		9

Second Semester

2105718	Seminar in Chemical Engineering IV	1 (s/u)**
2105830	Dissertation	9
		9

Third Semester

2105894	Doctoral Dissertation Seminar	0 (s/u)**
2105830	Dissertation	9
		9

Fourth Semester

2105894	Doctoral Dissertation Seminar	0 (s/u)**
2105830	Dissertation	9
		9

Fifth Semester

2105894	Doctoral Dissertation Seminar	0 (s/u)**
2105830	Dissertation	9
		9

Sixth Semester

2105894	Doctoral Dissertation Seminar	0 (s/u)**
2105830	Dissertation	9
		9

Seventh Semester

2105894	Doctoral Dissertation Seminar	0 (s/u)**
2105830	Dissertation	9
		9

Eighth Semester

2105894	Doctoral Dissertation Seminar	0 (s/u)**
2105830	Dissertation	9
		9

Pattern II (2) for Master's degree holder

First Semester

21056xx	Elective in CHE	3
21056xx	Elective in CHE	3
2105717	Seminar in Chemical Engineering III	1 (s/u)**
2105828	Dissertation	<u>4</u>
		10

Second Semester

21056xx	Elective in CHE	3
21056xx	Elective in CHE	3
2105718	Seminar in Chemical Engineering IV	1 (s/u)**
2105828	Dissertation	<u>4</u>
		10

Third Semester

2105894	Doctoral Dissertation Seminar	0 (s/u)**
2105828	Dissertation	<u>10</u>
		10

Fourth Semester

2105894	Doctoral Dissertation Seminar	0 (s/u)**
2105828	Dissertation	<u>10</u>
		10

Fifth Semester

2105894	Doctoral Dissertation Seminar	0 (s/u)**
2105828	Dissertation	<u>10</u>
		10

Sixth Semester

2105894	Doctoral Dissertation Seminar	0 (s/u)**
2105828	Dissertation	<u>10</u>
		10

Pattern II (2) for Bachelor's degree holder

First Semester

2105602	Advanced Transport Phenomena	3
2105603	Advanced CHE ENG Transport Phenomena	3
2105604	Advanced CHE ENG Kinetics and CHE Reactor Design	3
21056xx	Elective in CHE	3
2105717	Seminar in Chemical Engineering III	1 (s/u)**
		12

Second Semester

21056xx	Approve Elective in CHE	3
21056xx	Approve Elective in CHE	3
21056xx	Elective in CHE	3
21056xx	Elective in CHE	3
2105718	Seminar in Chemical Engineering IV	<u>1</u> (s/u)**
		12

Third Semester

2105894	Doctoral Dissertation Seminar	0 (s/u)**
2105828	Dissertation	<u>8</u>
		8

Fourth Semester

2105894	Doctoral Dissertation Seminar	0 (s/u)**
2105828	Dissertation	<u>8</u>
		8

Fifth Semester

2105894	Doctoral Dissertation Seminar	0 (s/u)**
2105828	Dissertation	<u>8</u>
		8

Sixth Semester

2105894	Doctoral Dissertation Seminar	0 (s/u)**
2105828	Dissertation	<u>8</u>
		8

Seven Semester

2105894	Doctoral Dissertation Seminar	0 (s/u)**
2105828	Dissertation	<u>8</u>
		8

Eight Semester

2105894	Doctoral Dissertation Seminar	0 (s/u)**
2105828	Dissertation	<u>8</u>
		8

COURSES DESCRIPTIONS
IN CHEMICAL ENGINEERING (B.ENG.)

2105220   Chemical Engineering Chemistry 3(3-0-6)
Principles of chemical analysis for chemical engineers for quality control, process control, and researches, utilization of quantitative analysis and interpretation, techniques of chemical analysis, using traditional methods, and use of analysis instruments, principles of organic chemistry to be applied in chemical industries and bio-engineering, properties and reactions of basic functional groups: hydrocarbons, hydroxyl, ether, carbonyl, carboxylic, and organic complexes.

2105221   Chemistry for Chemical Engineering Laboratory   1(0-3-0)
Practice in chemical analysis using various techniques for quality control, process control, and research.

2105222   Chemical Engineering Thermodynamics I   3(3-0-6)
Prediction of thermodynamic properties of single components, ideal gas law, equation of states of gas and liquid, gaseous and liquid mixtures, thermodynamic laws, relationships of thermodynamic properties, phase equilibrium of single components, refrigeration cycle.

2105223   Chemical Engineering Thermodynamics II   3(3-0-6)
Prediction of thermodynamic properites of mixtures, phase equilibrium of mixtures, vapour-liquid equilibrium, liquid-liquid equilibrium, liquid-solid equilibrium, vapour-solid equilibrium, vapour-liquid-liquid equilibrium, chemical equilibrium, thermodynamics of chemical processes.

2105230   Chemical Engineering Mathematics I   3(3-0-6)
Fundamental of line integration and surface integration, polar co-ordinates, calculus of real value multivariable functions and application, analysis principles for solving chemical engineering problems.

2105251   Unit Operations I   3(3-0-6)
Units for transporting liquid and gas, fluidized systems, pneumatic system for transport particles, unit operations for separating particles from gaseous and

liquid system with centrifugal forces, filtration, and diffusion.

2105261   Chemicals Production Industries   3(3-0-6)
Industrial standard, law related to chemical industries, components of chemical plants, responsibilities of engineers.

2105262   Chemical Engineering Principles   3(3-0-6)
Principles of chemical engineering, relationship of mass with chemical reactions, conservation of mass and energy, use of phase equilibrium and thermodynamic properties.

2105301   Chemical Engineering Seminar I   1(0-3-0)
Softskill improvement for quality chemical engineer. Discussion of various topics relevant for recent chemical engineering development.

2105331   Chemical Engineering Mathematics II   3(3-0-6)
Numerical techniques for solving chemical engineering problems, application of computer for solving chemical engineering problems.

2105332   Chemical Engineering Statistics   3(3-0-6)
Elementary principles of statistics and probability, random variables and probability distributions, experimental data analysis, chemical process parameter estimation, linear regression and correlation, multiple regression, design and analysis of chemical experiments with single factor and with several factors, chemical process modeling with stochastic approach.

2105333   Transport Phenomena   3(3-0-6)
Viscosity, mathematical models of momentum transports in isothermal fluid systems, thermal conduction and convection, mathematical models of energy transports in solids and in fluids for isothermal

systems and non-isothermal systems, diffusion in binary mixtures, mathematical models of mass transports in isothermal mixtures without chemical reactions and with chemical reactions, simultaneous mass and energy transports in fluid mixtures.

2105352   Unit Operations II   3(3-0-6)
Unit Operations for separating gaseous and liquid mixtures with distillation, absorption, extraction, adsorption and crystallization.

2105353   Unit Operations III   3(3-0-6)
Unit operations for exchanging heat, boilers, evaporators, condensers, dryers, and cooling water systems.

2105356   Unit Operations Laboratory I   1(0-3-0)
Condition: Prerequisite 2105251
Practice unit operations for momentum transports.

2105357   Unit Operations Laboratory II   1(0-3-0)
Condition: Prerequisite 2105352
Practice unit operations for mass transport and reaction kinetics.

2105362   Chemical Process Economic Assessment   3(3-0-6)
Cost components of chemical industries, chemical industrial cost indexes, capital cost components, capital investment estimates, purchase costs of process equipments, manufacturing cost components, manufacturing cost estimates, chemical process depreciation estimates, feasibility analysis, alternative investments and replacements

2105373   Chemical Engineering Kinetics and Reactor Design   3(3-0-6)

Fundamental principles of chemical kinetics; diffusion and catalysis; concepts of reactor design; the effect of reactor geometry, operating conditions, and flow characteristics on mass and energy conservation equations; single and multiple reactor systems.

2105385   Recycling of Agricultural and Agro Inductrial Waste   3(2-3-4)

Wealth of Thailand, bio-diversity in Thailand, role of technology in full utilization of agri-waste or agro-industrial waste; cycles of agri-waste and agro-industrial waste; characterization of agri-waste and agro-industrial waste; utilization of agri-waste and agro-industrial waste; project/product evaluation.

2105402   Chemical Engineering Seminar II   1(0-3-0)

Softskill improvement for quality chemical engineer. Discussion of various topics relevant for recent chemical engineering development.

2105403   Special Topics in Chemical Engineering I   3(3-0-6)
Condition: Consent of Faculty

Special topics in Chemical Engineering including new technology.

2105404   Special Topics in Chemical Engineering II   3(3-0-6)
Condition: Consent of Faculty

Special topics in Chemical Engineering including new technology.

2105405   Study Abroad I   2(2-0-4)
Condition: Consent of Faculty

Knowledge in chemical engineering obtains during the study abroad.

2105406   Study Abroad II   2(2-0-4)
Condition: Consent of Faculty

Knowledge in chemical engineering obtains during the study abroad.

2105407   Study Abroad III   2(2-0-4)
Condition: Consent of Faculty

Knowledge in chemical engineering obtains during the study abroad.

2105409   Study Abroad IV   3(3-0-6)
Condition: Consent of Faculty

Knowledge in chemical engineering obtains during the study abroad.

2105410   Study Abroad V   3(3-0-6)
Condition: Consent of Faculty

Knowledge in chemical engineering obtains during the study abroad.

2105430   Particle Technology   3(3-0-6)

Particle characterization, transport of powder, selection of transport equipment (screw conveyor, belt conveyor, bucket elevator, pneumatic conveyor, air slide, etc.), storage of powder (hopper and silo design), powder feeding and discharging systems, classification of particles, granulation and agglomeration, comminution (size reduction), mixing and agitation of powder, kneading filter press (expression), extrusion.

2105445   Catalyst Reaction Engineering Fundamentals   3(3-0-6)

Catalyst structures and functions; fundamentals of catalyst manufacturing processes and catalyst rection engineering; applications of catalysts in petrochemical and chemical engineering processes; catalyst reactor design.

2105452   Fermentation Processes   3(3-0-6)

Detailed study of the processes, operations, technology involved in selected industrial fermentation processes directed towards the production of pharmaceuticals and industrial chemicals.

2105453   Introduction to Biochemical Engineering   3(3-0-6)

Importance of biochemical reactions in the industries, health & medicine, and daily life. A review of biochemical reaction kinetics for enzymes and cells including introduction to bioreactor design and downstream processing of the desire products. Separation fo natural derived bioactive agents or cell components. Processes in pharmaceutical industry. Principles and instrumentation of the related techniques. Application of naturally derived biomaterial for various industries, especially for medical products, cosmetics, foods, agriculture, and environment. Molecular genetics, proteis, and metabolic engineering. Entrapeneurship and trends of technology related to biological engineering.

2105456   Introduction to Polymer Science   3(3-0-6)

Polymer structures and physical properties, technology and mechanical properties of polymers, applications of polymers, polymer processing, plastic technology; fibre technology and elastomer technology.

2105458   Unit Operations Laboratory III   1(0-3-0)
Condition: Prerequisite 2105353

Practice unit operations for heat transport, and simultaneous heat and mass transports.

2105463   Chemical Engineering Processes   3(3-0-6)

Development of industrial chemical processes, relationship of unit operations, with raw materials, products, and energy for production, process energy, by-products and wastes managements.

2105464   Chemical Process Design   3(2-3-4)

Design principles of reaction sections, selection of reactors, design principles of separation sections, development principles of process simulation model with commercial process simulator.

2105465   Chemical Plant Design   3(2-3-4)
Condition: Prerequisite 2105464

Design principles of heat exchanger network, process energy recovery principles, estimate equipment

dimensions, selection principles of process equipment materials, and plant layout design.

2105466 Natural Gas and Petroleum Oil Conditioning 3(3-0-6)
Condition: Senior Standing

Water content estimate, hydrate formation estimate, prevention of hydrate formation, dehydration methods, methods of acid gas removals, liquefaction of natural gas, petroleum oil refinery, reforming petroleum oil products, sulfur compound removals.

2105472 Process Dynamics and Control 3(3-0-6)

Mathematical modeling of chemical engineering systems; solution techniques and dynamics of these systems; introduction to automatic control; feedback control concept; stability analysis; frequency response and control system designs; introduction to measurement and control instrument characteristics.

2105475 Total Productive Management for Chemical Process 3(3-0-6)

Related to Total Productive Management in Chemical Process Industries, Calculation of Key Management Index, Application of Chemical Engineering, such as Thermodynamics, Energy and Mass Transfer, and Statistics including Distribution Diagram, Control Chart.

2105477 Computer Application in Chemical Engineering 3(3-0-6)

Computer software application for calculating and design related to chemical engineering.

2105478 Petrochemical Engineering Processes 3(3-0-6)

Natural Gas Utilization Plan of Thailand; natural gas liquefaction plant; methanol plant; ethylene plant; gas separation plant; ammonia, urea, and phosphate plants; polypropylene plant; vinyl chloride monomer plant; polyvinyl chloride plant; polyethylene plant; ethylene oxide plant; polyester plant; polystyrene plant.

2105479 Polymer Engineering 3(3-0-6)

Definitions and concepts; crystalline and glassy polymers; molecular architecture: structure, steric factors, conformation and morphology; polymer synthesis: step and chain polymerization; transition phenomena, mechanical properties affected by the transition phenomena; elastomer, theory of rubber elasticity; Polymer rheology: types of mechanical deformations, simple rheological responses, viscoelastic properties of polymer, linear viscoelastic models; yielding and theories on yielding of glassy polymer.

2105480 Safety in Chemical Operations 3(3-0-6)
Condition: Senior Standing

Principles of industrial safety and loss control. Hazards of chemicals. Hazards of chemical operations, Hazards assessment. Prevention and control of hazards: Control system design for safe operation; Personal protective devices. Storage and transportation of hazardous materials. Industrial safety management. Emergency planning.

2105482 Environmental Chemical Engineering 3(3-0-6)

Effects of pollutants on environments standard environmental qualities, sources and industrial wastewater characteristics and treatment methods, sources of air pollutants, control of particles and gaseous, compositions of solid wastes and hazardous wastes, method of treatments.

2105486 Modern Techniques in Process Control 3(3-0-6)
Condition: Corerequisite 2105472

Principle and practice of modern control techiques in chemical processing; distributed control systems; computer integrated processing.

2105487 Digital Process Control Laboratory 3(1-4-2)
Condition: Prerequisite 2105472 or Consent of Faculty

Application of direct digital control principles of laboratory excercises supported by microcomputers; real time programming; data aquisition and control using simple and advanced control strategies; experiments in temperature, liquid level, pH controls; sequence control; term project.

2105491 Chemical Engineering Project I 1(0-2-1)

Data collection and assessment of suitable chemical industrial problems for chemical engineering projects.

2105492 Chemical Engineering Project II 2(0-4-2)
Condition: Prerequisite 2105491

A research on chemical engineering projects related to chemical industrial problems or innovations.

2105522   Dynamic Process Simulation   3(3-0-9)

Fundamental of dynamic model development, lumped parameter systems, solution strategies for lumped parameter systems, distributed parameter systems, Solution strategies for distributed system, parameter system empirical model development, computer aided process modeling, static and dynamic simulation of chemical processes.

**2105526   Total Productive Management for Chemical
Process Industry   3(3-0-9)**

Total Productive Management, usage of Key Management Index, Key Performance Index, Key Activity Index, cascading of organizational resposibility autonomous management, productive maintenance, focused improvement, expansion based on knowledge transfer, quality management, initial phase management, management of safety, health and environment, management of social responsibility.

**2105527   Polymer Characterization and Fracture
3(3-0-9)**

Structures-Properties-Performance relationship of polymers, the petrochemical and the plastic processing industrial approaches to polymer characterization, modification of polymers by compounding, blending & alloying and composites and their influences on fracture, transitions in polymers, thermal degradation of polymers, deformation in semi-crystalline and glassy polymers, shear yielding and crazing, fracture of polymers, modes of crack growth, brittle and ductile fracture of polymers, fracture morphology and fractography of polymers.

2105572   Encapsulation Process   3(3-0-9)

Encapsulation process, use of encapsualtion process in chemical industry and related industry, main techniques and methods in encapsualtion process, the selection of wall materials, the selection of appropriate technique for core materials, the application of encapsulation process in industries and their products.

2105599   Batch Chemical Processes   3(3-0-9)

Batch chemical processes: dynamics behavior, start-up, shut-down, batch distillation, batch reaction, batch mixing, batch extraction.

**2105601   Advanced Engineering Mathematics for
Chemical Engineers   3(3-0-9)**

Matrices and solutions of sets of ordinary differential equations. Solution of partial differential equations using metod of infinite series and separation of variables. Bessel functions and legendre polynomials. Vector and tensor analysis. Complex variables. Analytic functions, harmonic functions, Cauchy's integral theorem, Laurent's expansion, and theory of residues. Calculus of variation.

2105602   Advanced Transport Phenomena   3(3-0-9)

Fundamentals of momentum, energy and mass transport. Determination of transport properties. Conservation of mass, momentum and energy in laminar flow and turbulent flow in microscopic approach. Equation of change for multicomponent systems. Dimensional analysis of equation of change. Simultaneous heat, mass, momentum transfer. Laminar and turbulent boundary layer theory.

**2105603   Advanced Chemical Engineering
Thermodynamics   3(3-0-9)**

Introduction to molecular thermodynamics, equations of state, equations for activity coefficients, thermodynamic property determination, multicomponent phase equilibrium, process analysis.

**2105604   Advanced Chemical Engineering Kinetecs and
Chemical Reactor Design   3(3-0-9)**

Review of fundamental principles. Order of reactions and rate equations. Theory of rate processes; diffusion, types of reactors, catalysis, mechanical arrangement of reactors for agitation, heat and mass transfer. Methods of designing chemical reactors with emphasis on continuous processing.

2105605   Chemical Engineering Seminar I   1(1-0-3)

Seminar and discussions on current research in chemical engineering for first year students.

2105606   Chemical Engineering Seminar II   1(1-0-3)

Seminar and discussions on current research in chemical engineering for second year students in the first semester.

**2105607   Chemical Engineering Process Scale-up
3(3-0-9)**

This course examines the technical isses associated with transforming a chemical process from small scale (e.g.lavoratory)tocommercial operation. The concepts underlying chemical principles, unit operations and transport phenomena are integrated to give students an understanding of the methodology involved in converting a laboratory experiment into a process with commercial potential. Specific topics include the effects of scale on the relative rates of mass, heat and momentum transfer, mixing effects, utility of various reactor operating modes (e.g. batch, semi-batch, continuous).

2105608   Adsorption process   3(3-0-9)

Adsorption phenomena, adsorption equilibrium, kinetics of mass transfers in porous particles, adsorption processes with steady-state and periodic operations, mathematical models of adsorption processes, chromatographic separation and gas separation with pressure swing adsorption

2105609   Advanced Particulate Technology   3(3-0-9)

Particle characterization and measurement of physical and chemical properties of powder; transport phenomena and related topics; advanced powder

handling operations in the industry; detonation and dust explosion.

2105610   Membrane Technology   3(3-0-9)
Membrane structure and function; Production of membrane; characterization, selection and use of membrane system. Applications for membrane separations in various chemical and biochemical processes.

2105611   Separation Technology Via Liquid Menbrane And Application   3(3-0-9)
Variety of separation process via liquid membrane; selection of single/multiple extractant systems; design of a particular metal lon separation fromits mixture; the applications of hollow fiber supported liquid membrane in separation of toxic metals, precious metals, rare earth metals and radioactive metals.

2105612   Chemical Engineering Process and product Development   3(3-0-9)
Strategies for chemical product design: Needs, Ideas, Selection, Manufacture, Strategies for chemical process design: Process synthesis, Process simulation, selection and design of reactors, synthesis of separation system, energy recovery, environmental protection.

2105613   Mass Transfer operation   3(3-0-9)
Phase equilibrium, General selection criteria for processes. Fundamental principles and calculation methods, distillation, absorption, extraction and adsorption. Capacities and efficiencies of contracting devices. Energy requirements of mass transfer processes. Optimal design operation.

2105616   Fluid and Particle Mechanics   3(3-0-9)
Nature of two-phase gas-liquid flows. Flow regime maps. Flow with phase change. Modeling of regime transition, Conservation equations. Correlations and empirical models for two-phase flow. Annular flow. Slug flow. Bubble flow. Mechanical and surface properties of particles. Fundamentals of particle particle interaction. Powder flow and conveying. Agglomeration. Separation Process.

2105617   Research Methodology and Statistical Analysis   3(3-0-9)
Steps employed in planning research and conducting research; Steps employed in writing a thesis or a research paper; Plagiarism; Presentation of the research; Test of statistical hypothesis; Analysis of variance; Design and analysis of experiments, Full and fractional factorial designs; Simple linear regression analysis; Multiple linear regression analysis; Basic nonlinear regression analysis.

2105618   Characterization and Instrumental Analysis   3(3-0-9)
Basic concepts of characterization and instrumental analysis: Thermal analysis, Crystallography, Surface analysis, Microscopy, FTIR, Raman spectroscopy, Chromatography, Mechanical testing.

2105619   Advanced Automatic Process Control   3(3-0-9)
Advanced control techniques, control of multiple-input multiple-output processes, discrete-time models. Dynamic response of discrete-time systems. Non-linear process control.

2105621   Multivariable Process Control   3(3-0-9)
Introduction to multivariable control, uncertainty and robustness for multivariable control system, controller design and control structure design.

2105622   Chemical Process Simulation and Optimization   3(3-0-9)
Process analysis and simulation: concept of model synthesis, model characterization based on behavioral principles and on mathematical properties, subsystems and systems analysis. To give a broad coverage of the field of computer applications to chemical engineering, with emphasis on steady-state flowsheeting and process simulation.

2105623   Optimization of Chemical processes   3(3-0-9)
Nature and organization of optimization problems. Fitting models to data. Formulation of objective functions. Optimization of unconstrained functions. Unconstrained multivariable optimization. Linear programming and application. Nonlinear programming with constraints. Optimization of staged and discrete processes. Application of optimization to chemical processes.

2105624   Computer Process Control   3(3-0-9)
Computer hardware, interfacing, control algorithms and their implementation, distributed control system, predicitive control techniques, automatic tuning.

2105625   Process Control and Management   3(3-0-9)
Generalization concepts of process control; hierarchy in process concess control; planning and scheduling; manufacturing execution systems, plant information systems; process plan business function.

2105626   Advanced Heat Transfer   3(3-0-9)
Radiative heat transfer, radiative properties of real materials, radition exchange between black surfaces and between diffuse gray surfaces, special radiaive problems. Forced convection heat tranfer, convection processes, similarity theory, correlations of heat transfer coefficients, effect of viscous dissipation, non-continum effect. Analytical methods in conduction heat transfer. Bessel equation, the method of separation of variables, Laplace transforms, finite differences and finite elements. Heat transfer with vapourization, condensation and natural convection.

2105628   Process Control Instrumentation 3(3-0-9)
Sensors and actuators used in proess industries; signal conditioning and transmissionl analog and difital controllers; interfacing and communication;

programmable logic controlers; distributed process control systems; safety in process automation.

**2105629   Process Identification and Data
                      Analysis   3(3-0-9)**
Methods for modeling the dynamic behaviour of a process and its disturbances using data collected from the process; transfer function and time series modeling theory and techniques; statistical methods for structure determination parameter estimation, model validation, experiment design, and closed-loop data analysis, analysis and control, multivariate statistical methods including Principal Component Analysis (PCA), and Partial Least Squares (PLS) used for the efficient extraction of information from large databases typically collected by on-line process computer; analysis of process problems and on-line process improvement by using these model.

**2105630 Heterogeneous Catalytic Reactor
                      Modelling   3(3-0-9)**
Introduction to catalytic reactor modelling; criterriafor selection a suitable model; mathematical models of different types of catalytic reactor; catalyst activity model; steady and transient state model.

2105631   Advanced catalysts for polymers   3(3-0-9)
Catalyst preparation and characterization of polymers : ziegler-natta catalysts, metallocene catalysts, and late transition metal complex catalysts the application of these catalysts in polymer production.

2105632   Petrochemical Technology   3(3-0-9)
The position today, the chemistry, the economics and where possible, the solid implications. The basis for petrochemicals: catalysts, economic and engineering Chemical components, or elements recovered from petroleum or natural gas. Petrochemical processes with emphasis on the chemical reactions and their kinetics.

2105634   Catalysis   3(3-0-9)
Adsorption and kinetics of surface reactions; poisoning, selectivity; and empirical activity patterns in catalysis; surface chemistry, catalytic mechanisms and modern experimental techniques in catalytic research; descriptive examples of industrial catalytic system.

2105636   Heterogeneous Catalysis   3(3-0-9)
Theory of adsorption and catalysis. Preparative methods for catalysts.Techniques for catalyst characterization. Chemical reaction in porous catalyst pellets. Effect of intraparticle diffusion, effect of temperature gradient, criteria for diffusion   effect. Kientics of heterogenous catalytic reactions. Experimental methods for developing design data. General aspects of catalytic reactor design.

2105637   Design of Industrial Catalysis   3(3-0-9)
The overall design of catalysts, design of the primary and secondary constituents of the catalyst, choice of support materials, experimental testing, summary of some useful general information for catalyst designers, specific example of catalyst design.

2105638   Advanced Polymer Engineering   3(3-0-9)
Polymers and their applications as engineering materials. Structure and properties of polymers. Crystalline and glassy polymer. Polymerisation. Polymer solutions. Mechanical properties of polymers. Theory of rubber elasticity. Yielding of polymers. Polymers. Polymer rheology; viscoelastic properties of polymers and viscoelastic models. Polymer composites.

**2105641   Biodegradable Material Engineering
                                                                 3(3-0-9)**
Types of biodegradable materials : synthetic and natural materials, sources and production, properties biocompatibility, biodegradation mechmism, test methods for biodegradable plastics; polysaccharides, biopolyester protein (collagen, gelatin), biodegradable polymers for tissue engineering and controlled release.

2105643   Polymer Processing   3(3-0-9)
Application of heat transfer, fluid mechanics and thermodynamics to the design and control of polymer processing equipment. Detailed consideration of extrusion, calendering, rotational molding, stamping and injection molding.

2105649   Polymer Blends and Composites   3(3-0-9)
Terms and Definitions in multicomponent Polymer Systems, Advantages, Interfaces, Polymer Blends, Thermodynamics of Polymer Blends, Phase Separation, Miscibility, Block Coploymers, Polymer Composites Including Filled Polymers and Reinforced Polymers, Processing and Rheology of Multicomponent Systems, Coatings.
Microbial kinetics of growth. Barious fermentation reactors for pure cultures. Mass transfer in fermentors. Instrumentation and control of biochemical processes, downstream separation in biotechnology and their importance.

2105650   Biochemical Engineering   3(3-0-9)
Microbial kinetics of growth. Various fermentation reactors for pure cultures. Mass transfer in fermentors. Instrumentation and control of biochemical processes, downstream separation in biotechnology and their importance.

**2105652   Bioreactor Design Analysis and Control
                                                                 3(3-0-9)**
Analysis of microbial kinetics for bioreactor design; Design and analysis of batch, continuous, and multiphase bioreactors; Advanced control strategies of bioreactors.

**2105654   Bioreactor Design Analysis and Control
                                                                 3(3-0-9)**
Analysis of microbial kinetics for bioreactor design; Design and analysis of batch, continuous, and multiphase bioreactors; Advanced control strategies of bioreactors.

2105655   Bioprocess Plant Design   3(3-0-9)
Design and cost analysis of equipment and plant for bioprocess industries; process waste treatments; Case study of bioprocess design.

2105656
Bioremediation Engineering   **3(3-0-9)**
Concept of bioremediation engineering, use of microorganisms for pollution control; biodegradation kinetics, bioreaction design and insitu bioremediation.

2105659 Biochemical Separation Technology
     3(3-0-9)
Separation technology in biological processing industries. Cell separation process. Recovery of intracellular and extracellular product. Technology in liquid-solid separation. Technology in liquid mixture separation. Technology in gas mixture separation. Current topics of research.

2105661 Special Problems in Chemical Engineering
     3(3-0-9)
Study of investigation of special problems in chemical engineering assigned by the instructor with the consent of the head of department. The work must be completed within one semester and an examination taken.

2105662 Selected Topics in Chemical Engineering
     3(3-0-9)
Study of specialized topics of interest in chemical engineering assigned by the lecturer with the consent of the head of the department. Written report and oral examination are required.

2105663 Heat Transfer Operation   **3(3-0-9)**
Heat transfer phenomena in Chemical Process Equipment, Conduction, Convection, Radiation, Overall heat transfer coefficient, mean temperature different, heat exchanger in chemical process, design of double pipe heat exchanger, design of shell and tube heat exchanger, boiling and condensing heat transfer, industrial furnace, heat recovery in chemical process, rating of heat exchanger.

2105665 Cryogenic Engineering   **3(3-0-9)**
Basic principles involved in the production at low temperature and the separation of gases. Physical properties of cryogenic fluids and recent developments in their engineering applications.

2105666 Source Control of Particulate Emissions
     3(3-0-9)
Contents of controlling air pollution emissions. Control of particulate emissions-mechanical collectors, filters, electrostatic precipitators, scrubbers, Modeling, design, equipment selection and cost.

2105667 Loss Prevention in Chemical Operation
     3(3-0-9)
Identification of hazards. Risk assessment. Preventive measures: control system design for safe operation. Personal protective devices. Emergency Planning.

2105668 Energy Conservation in Chemical Processes   **3(3-0-9)**
Basic considerations and objective of energy conservation in chemical industry; Fundamentals of energy integration for chemical engineers; Synthesis, and optimization of heat exchanger networks in chemical processes; Other energy recovery technques; Alternative sources of energy.

2105669 Cleaner Technology   **3(3-0-9)**
Fundamental of clean technology; Pollution prevention in industrial processes: principles, approaches, application in process and equipment design; waste minimization: industrial waste reduction techniques; Life cycle analysis: concept, methods, application of pollution prevention.

2105671 Process Dynamics   **3(3-0-9)**
Dynamic modeling of chemical engineering process; control system design for chemical engineering process dynamic simulation of controlled manufacturing process.

2105672 Simulation of Particulate and Material Processinf   **3(3-0-9)**
Various approaches to mathematical modeling; modeling and simulation of industrial processes involved with particulate material, such as aerosol filtration with fibrous filters, capturing of suspended dust particles using liquid spraying, pneumatic conveying drying, spray drying, fluidization phenomena as well as multi-phase flow of particles using discrete simulation technique.

2105673 Design and Analysis of Experiments in Chemical Engineering   **3(3-0-9)**
Simple comparative experiments; experiments with a single factor; analysis of variance; randomized blocks and Latin squares designs; Factorial design, Tow-level factorial design; Three-level and mixed-level factorial design; Robustness experiments with random factors.

2105674 Computer-aided Process and Product Engineering   **3(3-0-9)**
Computer-aided modeling and simulation; Computer-aided process and product design; Computer-aided process operation, Modeling in the process life cycle.

2105675 Polymer Chemistry for Engineers 3 (3-0-9)
Basic concepts and knowledge of polymer chemistry for engineers and their applications; mechanism of polymerizations, kinetics model of polymerization, chemical and physical characterization methods in polymer chemistry to understand polymerization from engineering basis.

2105676 Instrumentation in Chemical Process
     3(3-0-9)
The types and fundamental concepts of instrumentation in chemical process and related industry such as temperature, pressure, flow rate, concentration and level. Sensors and actuators used in process industries; signal conditioning and transmission analog and digital controllers; interfacing and communication; programmable logic controllers; distributed process control systems; safety in process automation.

2105678   Introduction to Nanotechnology   3(3-0-9)
Fundamentals of nanotechnology, instrumentation in nanotechnology, nanopowders and nanomaterials, natural nanomaterials, nanobiometrics, preparation of nanomaterials, properties of nanomaterials, applications of nanomaterials mainly in materials technology mediums, energy, electronics and chemical engineering, preparation of carbon nanomaterials and its applications.

2105679   Bioactive Compounds   3(3-0-9)
Physical, chemical and biological properties of bioactive compounds from plants, animals and microorganisms with significant biological activity and important uses in pharmaceuticals, agriculture, cosmetic industries, including synthesis, extraction techniques and development of bioactive properties by bio/chemical/genetic engineering treatment.

2105680   Multifunctional Reactor   3(3-0-9)
Basic concepts and knowledge of different multifunctional reactors and their applications; mathematical modelling and simulation to understand effects of various operating parameters on the multifunctional reactors performance.

2105681   Catalyst Deactivation   3(3-0-9)
Physical and chemical knowledge of catalyst deactivation by fouling, poisoning and sintering, regeneration of fixed beds.

2105682   Surface Technology   3(3-0-9)
Basic concepts and surface chemistry; and inorganic chemistry, absorption and various techniques for surface analysis.

2105683   Bioenergy Technology   3(3-0-9)
Fundamental concepts for biofuel/bioenergy technology. Renewable feedstocks, availability and attributes for biofuel/bioenergy production, Thermochemical conversion of biomass to heat, power, and fuel. Thermal gasification of biomass, Biochemical engineering for conversion of biomass to fuel; ethanol, butanol, methane, hydrogen and biodiesel production, environmental impacts of biofuel production; value-added processing of biofuel residues; case studies on biofuel production.

**2105684   Chemical Analysis for Chemical
        Process Control I   3(3-0-9)**
Principles of chromatograph (gas and liquid) and spectroscopy, signal charactyeristic, factors affecting signal interpretation, appliaction in real-time process control.

**2105685   Selected Topics in Transport Phenomena
        3(3-0-9)**
Study of specialized topics of interest in transport phenomena assigned by the lecturer with the consent of the head of the department. Written report and oral examination are required.

**2105686   Selected Topics in Chemical Engineering
        Thermodynamics   3(3-0-9)**
Study of specialized topics of interest in chemical engineering thermodynamics assigned by the lecturer with the consent of the head of the department. Written report and oral examination are required.

**2105687   Advanced Chemical Kinetics and
        Catalysis   3(3-0-9)**
Thermodynamics of chemical reaction; determination of rate expressions; reaction mechanisms; molecular theories of chemical kinetics; chemical systems involving multiple reactions; elements of heterogeneous catalysis; liquid phase reactions and homogeneous catalysis; mass and heat transport process in porous catalysts.

**2105688   Selected Topics in Chemical Engineering
        Kinetics   3(3-0-9)**
Study of specialized topics of interest in chemical engineering kinetics assigned by the lecturer with the consent of the head of the department. Written report and oral examination are required.

**2105689   Safe Process Operation and Design
        3(3-0-9)**
Design and operate chemical process with safety consideration. Preventive measures: control system design for safe operation. Emergency Planning.

2105690   Independent study I   3(3-0-9)
Independent studies course provides the platform for students to be involved in a research or industrial project. Students will need to work closely with a faculty member with the consent of the head of the department and external mentor who can guide them through the process of conducting a research study.

2105691   Independent study II   3(3-0-9)
Independent studies course provides the platform for students to be involved in a research or industrial project. Students will need to work closely with a faculty member with the consent of the head of the department and external mentor who can guide them through the process of conducting a research study.

2105692   Independent study III   3(3-0-9)
Independent studies course provides the platform for students to be involved in a research or industrial project. Students will need to work closely with a faculty member with the consent of the head of the department and external mentor who can guide them through the process of conducting a research study.

**2105693   Special Problems in process control
        Engineering   3(3-0-9)**
Study of investigation of special problems in process control engineering assigned by the instructor with the consent of the head of department. The work must be completed within one semester and an examination taken.

2105694   **Special Problems in Petrochemical Engineering**   **3(3-0-9)**

Study of investigation of special problems in petrochemical engineering assigned by the instructor with the consent of the head of department. The work must be completed within one semester and an examination taken.

2105695   **Special Problems in Polymer Engineering**   **3(3-0-9)**

Study of investigation of special problems in polymer engineering assigned by the instructor with the consent of the head of department. The work must be completed within one semester and an examination taken.

2105696   **Special Problems in Biochemical Engineering**   **3(3-0-9)**

Study of investigation of special problems in biochemical engineering assigned by the instructor with the consent of the head of department. The work must be completed within one semester and an examination taken.

2105697   **Special Problems in Cleaner Production Engineering**   **3(3-0-9)**

Study of investigation of special problems in cleaner production engineering assigned by the instructor with the consent of the head of department. The work must be completed within one semester and an examination taken.

2105698   **Special Problems in Particle Technology**   **3(3-0-9)**

Study of investigation of special problems in particle technology assigned by the instructor with the consent of the head of department. The work must be completed within one semester and an examination taken.

2105699   **Multifunctional Reactor**   **3(3-0-9)**

Basic concepts and knowledge of different multifunctional reactors and their applications; mathematical modeling and simulation to understand effects of various operating parameters on the multifunctional reactors performance.

2105717   **Seminar in Chemical Engineering III**   **3(3-0-9)**

Review and presentation of specialized topic of modern progress in Chemical Engineering assigned by program committee. Written report presentation and oral examination are required.

2105718   **Seminar in Chemical Engineering IV**   **3(3-0-9)**

Study and discussion of specialized topics of modern progress in Chemical Engineering assigned by program committee. Written report, presentation and oral examination are required.

2105897   **Qualifying Examination**   **0(0-0-0)**

2105811   **Thesis**   **12 Credits**

2105816   **Thesis**   **36 Credits**

2105828   **Dissertation**   **48 Credits**

2105829 * Dissertation   **60 Credits**

2105830*   Dissertation   **72 Credits**

2105894   **Doctoral Dissertation Seminar**   **0(0-0-0)**

Study and discussion of dissertation and present the progress of doctoral dissertation.