Course Syllabus

2105623 Optimization of Chemical Processes

Semester 1, Academic Year 2026 | Student copy, English

English student copy. It is a faithful rendering of the syllabus registered in myCourseVille for 2105623 (2026/1); where the registered record is in Thai, the English wording here is a translation for reference and the registered Thai text governs. The course is taught in Thai and English, and every written course document, notebook, workbook, assignment and examination is in English.

Course Information

Field	Entry
Course no.	2105623
Course credits	3.0 (3.0-0.0-9.0)
Course title	Optimization of Chemical Processes
Responsible unit	Faculty of Engineering, Department of Chemical Engineering
Field of study	-
Type of course	Semester Course (Regular course)
Semester	1st semester
Academic year	2026
Course co-ordinator	Soorathep Kheawhom
Instructors / staffs	Soorathep Kheawhom
Enrollment conditions	-
Degree level	Master and Doctoral
Related curricula	Master of Engineering in Chemical Engineering (2020) Doctor of Engineering in Chemical Engineering (2023) Master of Engineering in Chemical Engineering (2025)
Status	Required elective courses

Course Description

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. Applications of optimization to chemical processes.

Curriculum Mapping

Programme learning outcomes to which this course contributes. The official statements are registered in Thai; the English wording below is provided for reference.

PLO code	Programme learning outcome
ENG-1	Knowledge of mathematics, science and engineering
ENG-2	Application of knowledge of mathematics, science and engineering
ENG-3	Problem analysis
ENG-4	Design and development of solutions
ENG-5	Investigation and verification of facts
ENG-7	Individual work and teamwork
MENG_ChE-1	Identify the principles and theories that matter in advanced chemical engineering, and select appropriate tools to produce research or create new knowledge
MENG_ChE-2	Lead a team, working with others and across disciplines
MENG_ChE-3	Analyze and solve advanced engineering problems through a research process
MENG_ChE-4	Plan and manage work effectively

Course Learning Outcomes

Translated from the registered Thai statements. CLO 1 carries the greatest weight in this offering, because the model construction block runs for five of the fifteen weeks.

#	Course learning outcome (CLO)	Related PLO
1	Construct optimization problems in order to solve chemical engineering problems	ENG-1, ENG-4
2	Solve linear programming problems	ENG-2, ENG-3
3	Solve convex optimization problems	ENG-2, ENG-3
4	Solve non-convex optimization problems	ENG-2, ENG-3
5	Apply optimization in order to solve chemical engineering problems	ENG-3, ENG-5, ENG-7

Learning Contents

Fifteen Monday sessions, 10 August to 16 November 2026. The 2026 revision expands model construction from three weeks to five, adds a hands-on workshop on AI-assisted modeling in Week 6, and replaces the standalone global optimization week with data-driven and AI-based optimization in Week 13.

#	Date	Learning content	Method	CLO
1	2026-08-10	Introduction, the Optimization Workflow and the Tool Stack - What optimization is and where it is used in process engineering - Decision variables, parameters, objectives, constraints - Classification: LP, NLP, IP, MILP, stochastic, global - Feasibility and boundedness; reading solver status - The tool stack: Excel Solver, OpenSolver, Pyomo, the solver layer Activity: First product mix LP in Excel Solver; software installation clinic	Lecture and laboratory	CLO 1, CLO 5
2	2026-08-17	Modeling I: Linear Models, Product Mix, Multiperiod Planning and Inventory - Time-indexed formulation and inventory balance	Lecture and laboratory	CLO 1, CLO 2, CLO 5

#	Date	Learning content	Method	CLO
		- Multi-product capacity allocation - Reusable modeling patterns: index sets, balances, capacity, linking constraints - Why an LP optimum lies at a vertex Activity: Multiperiod production planning in OpenSolver, then the same model in Pyomo		
3	2026-08-24	Modeling II: Networks, Flows and Process Superstructures - Transportation, transshipment, shortest path, maximum flow - Node balances and network structure - Process superstructures and route selection Activity: Transportation and transshipment in OpenSolver; graph models in Pyomo	Lecture and laboratory	CLO 1, CLO 2, CLO 5
4	2026-08-31	Modeling III: Blending, Pooling and Quality Specifications - Linear blending with quality specifications - Linearizing ratio and quality constraints - The pooling problem and the origin of bilinear terms - Local versus global solutions in a nonconvex blend plan Activity: Blending in OpenSolver, then pooling in Pyomo with Ipopt and multistart	Lecture and laboratory	CLO 1, CLO 4, CLO 5
5	2026-09-07	Modeling IV: Logical and Discrete Decisions - Binary variables, fixed charges, minimum run rates, semicontinuous variables - Translating logical propositions into linear constraints - Big-M selection and its numerical consequences - Convex hull versus big-M, and formulation strength Activity: Fixed-charge MILP in OpenSolver with CBC; relaxation bound comparison in Pyomo	Lecture and laboratory	CLO 1, CLO 5
6	2026-09-14	AI-Assisted Modeling and Model Debugging (workshop) - Structured specification of an optimization problem - Prompt patterns for drafting models with a language model - Auditing a generated model: sign errors, missing constraints, unit inconsistencies - A verification toolkit: dimensional audit, degenerate-instance tests, monotonicity checks, shadow-price plausibility - Diagnosing infeasible and unbounded models - Disclosure and reproducibility in engineering deliverables Activity: Three-hour hands-on workshop auditing and repairing defective models in Pyomo	Workshop	CLO 1, CLO 5
7	2026-09-21	Linear Programming Theory and Solver Behavior - Standard form and the geometry of the feasible region - The simplex method and one full tableau pass - Infeasible, unbounded, degenerate and alternative optimal cases - What a modern solver does: presolve, scaling, anti-cycling, interior point Activity: Simplex implemented from scratch and cross-checked against a solver	Lecture and laboratory	CLO 2
8	2026-09-28	Duality and Sensitivity Analysis - Dual construction, weak and strong duality - Shadow prices, reduced costs and complementary slackness	Lecture and laboratory	CLO 2, CLO 5

#	Date	Learning content	Method	CLO
		- Right-hand-side and objective coefficient ranging - Writing an economic interpretation as an engineering recommendation Activity: Sensitivity report in Excel Solver compared against Pyomo dual values		
9	2026-10-05	Unconstrained Nonlinear Programming - Convexity, Hessian tests, local versus global optima - One-dimensional search: golden section and quadratic interpolation - Steepest descent, Newton, conjugate gradient and quasi-Newton methods - Conditioning, scaling and stopping criteria Activity: Gradient methods implemented from scratch; nonlinear curve fitting	Lecture and laboratory	CLO 3, CLO 4
10	2026-10-12	Constrained Nonlinear Programming - Equality constraints and Lagrange multipliers as shadow prices - KKT conditions, complementary slackness, constraint qualifications - Penalty and barrier methods and the central path - Augmented Lagrangian, sequential quadratic programming, interior point Activity: Constrained NLP in Pyomo with Ipopt; SQP subproblems worked explicitly	Lecture and laboratory	CLO 3, CLO 4, CLO 5
11	2026-10-19	Integer and Mixed-Integer Programming - LP relaxation and integrality gap - Branch and bound with a worked search tree - Cutting planes and branch and cut - Solver tuning and reading a MILP log - Applications: batch scheduling and capital investment Activity: Branch and bound from scratch; scheduling and facility location in Pyomo	Lecture and laboratory	CLO 4, CLO 5
12	2026-10-26	Optimization under Uncertainty - Multistage decisions and the principle of optimality - Backward recursion and dynamic programming - Two-stage stochastic programming with recourse; EVPI and VSS - Robust optimization and chance constraints Activity: Dynamic programming and a two-stage stochastic program in Pyomo	Lecture and laboratory	CLO 4, CLO 5
13	2026-11-02	Data-Driven and AI-Based Optimization - Metaheuristics as a baseline: multistart, simulated annealing, genetic algorithms - Surrogate models, Gaussian processes and Bayesian optimization - Design of experiments and the exploration versus exploitation trade-off - Training a machine learning model as an unconstrained optimization problem: SGD, momentum, Adam, automatic differentiation - Reinforcement learning as sequential decision making, compared against exact dynamic programming	Lecture and laboratory	CLO 4, CLO 5

#	Date	Learning content	Method	CLO
		- Method selection: when data-driven methods beat mathematical programming and when they do not Activity: Surrogate-based optimization and tabular Q-learning benchmarked against the exact optimum		
14	2026-11-09	Project Presentations I - Group project presentations - Peer review and question session Activity: Presentations and peer evaluation	Presentation	CLO 5
15	2026-11-16	Project Presentations II and Wrap-up - Remaining group project presentations - Review of modeling principles and solution algorithms - Trends in process optimization Activity: Presentations and synthesis discussion	Presentation	CLO 1, CLO 5

> *The class meets on Mondays. The first session is 10 August 2026 and the last is 16 November 2026. No Thai public holiday falls on a Monday within this range: Mother's Day (12 August) is a Wednesday, the anniversary of the passing of King Rama IX (13 October) is a Tuesday, and Chulalongkorn Day (23 October) is a Friday. The final examination is held in the university examination period following Week 15.*

Key Dates, Semester 1/2026

Every deadline below is anchored to the Monday session of the stated week. All fifteen sessions and every deadline fall on a Monday.

Week	Date	Event	Notes
1	Mon 10 Aug 2026	First session. Software installation clinic.	Students must have a working environment by Week 2
2	Mon 17 Aug 2026	HW1 released	Linear and network model construction
3	Mon 24 Aug 2026	Project groups formed and registered	Groups of two or three
4	Mon 31 Aug 2026	HW1 due. HW2 released.	HW2: blending, pooling, logical modeling, model audit
5	Mon 7 Sep 2026		
6	Mon 14 Sep 2026	HW2 due. Project proposal due.	Proposal in the Week 6 structured specification format
7	Mon 21 Sep 2026	HW3 released	LP theory, simplex, duality, sensitivity
8	Mon 28 Sep 2026	MIDTERM EXAMINATION	Covers Weeks 1 to 8. Three hours, 25 percent. No nonlinear programming.
9	Mon 5 Oct 2026	HW3 due. Project formulation checkpoint.	Complete algebraic model, units audit, one passing degenerate test
10	Mon 12 Oct 2026	HW4 released	Unconstrained and constrained NLP, MILP
11	Mon 19 Oct 2026		

Week	Date	Event	Notes
12	Mon 26 Oct 2026	HW4 due. Project preliminary results due.	A model that solves, first results, complete test suite
13	Mon 2 Nov 2026		Last lecture session
14	Mon 9 Nov 2026	Project presentations, part 1	Twelve minutes plus three minutes of questions per group
15	Mon 16 Nov 2026	Project presentations, part 2. Final report due.	Report, code, test suite, reproducibility and AI-use disclosure
-	Examination period	FINAL EXAMINATION	Cumulative, emphasis on Weeks 9 to 13. Three hours, 35 percent.

> *No Thai public holiday falls on a Monday between 10 August and 16 November 2026, so no session needs to be rescheduled. Mother's Day, 12 August, is a Wednesday. The anniversary of the passing of King Rama IX, 13 October, is a Tuesday. Chulalongkorn Day, 23 October, is a Friday.*

Teaching and Learning Media

- Lecture slides for every week
- Fourteen Jupyter notebooks in Python with Pyomo, one per week plus a tools appendix
- Ten Excel and OpenSolver workbooks for Weeks 1 to 5, in student and solution versions
- Handouts: an OpenSolver setup guide, a project brief with topic menu and rubric, and a report template
- Problem sets and past examination papers with full solutions

Communication Channels

Type	Channel
Learning Management System	myCourseVille. Announcements, material distribution and submissions.
Weekly feedback	A short anonymous form, about 45 seconds, posted after every session. One link for the whole term.
E-mail	soorathep.k@chula.ac.th, for individual questions and consultations.

Assessments

The computational project is listed separately from the problem sets, because it carries its own deliverables and its own rubric.

Assessment method	Level of assessment	Related CLO	Percentage
Midterm Examination	Bloom's Taxonomy (Creating)	Construct optimization models to solve chemical engineering problems Solve linear programming problems	25.00
Final Examination	Bloom's Taxonomy (Evaluating)	Solve convex optimization problems Solve non-convex optimization problems Construct optimization models to solve chemical engineering problems	35.00

Assessment method	Level of assessment	Related CLO	Percentage
Assignments / Problem Sets	Bloom's Taxonomy (Analyzing)	Construct optimization models to solve chemical engineering problems Solve linear programming problems Solve convex optimization problems Solve non-convex optimization problems	15.00
Computational Project	Bloom's Taxonomy (Creating)	Construct optimization models to solve chemical engineering problems Apply optimization to solve real-world chemical engineering problems	15.00
Class Participation and Quizzes	Bloom's Taxonomy (Understanding)	All five course learning outcomes	10.00
Total			100.00

Grading

Field	Entry
Grading system	Letter Grade (A-F)
Grading method	Criterion-referenced grading
Minimum Passing Level (MPL)	0

A	B+	B	C+	C	D+	D	F
80 or above	75 or above	70 or above	65 or above	60 or above	55 or above	50 or above	otherwise

Reading List

As registered. The principal text is Rao; Williams supports the model construction block in Weeks 2 to 5.

Type	Title
Text book	Engineering Optimization: Theory and Practice, 4th edition. Singiresu S. Rao
Text book	Model Building in Mathematical Programming, 5th edition. H. P. Williams
Electronic media	Pyomo Documentation, current release, and Pyomo: Optimization Modeling in Python, 3rd edition
Electronic media	OpenSolver for Excel documentation

Course Evaluation and Improvement

Course evaluation system

Faculty online evaluation, supplemented by a Microsoft Form issued in Week 15 covering material clarity, the balance between modeling and theory, the usefulness of the computational sessions, and the workload of the project.

Details of improvement from the previous evaluation

UPDATED.

Student feedback and the instructor's own review of the 2025 offering indicated that model construction, which is the skill graduates most often need, occupied only three of fifteen weeks, while classical one-dimensional search methods occupied a full week despite being of limited practical use. The 2026 offering therefore makes four changes. First, the model construction block is expanded from three weeks to five, so that networks, blending and pooling, and logical and discrete decisions each receive a full session. Second, a three-hour workshop on AI-assisted modeling is introduced in Week 6, which teaches students to draft models with the assistance of language models and, more importantly, to verify them; students audit deliberately defective models and build a reusable test suite. Third, the computational sessions now alternate deliberately between OpenSolver in Excel and Python with Pyomo, so students learn to judge which tool a problem calls for, with the pooling problem in Week 4 serving as the designed point at which a spreadsheet becomes inadequate. Fourth, the standalone global optimization week is replaced by data-driven and AI-based optimization, covering surrogate modeling, Bayesian optimization, training as optimization, and reinforcement learning, with classical metaheuristics retained as the comparison baseline. One-dimensional search methods and constrained optimization methods are compressed to make room, without removing any topic entirely.

Course quality control and responses to complaints

Course quality is maintained through continuous revision of instructional materials. Every computational notebook is executed end to end before distribution, and every numerical answer in the solution documents is verified by independent computation, so that students never work against an erroneous reference. Student feedback is collected through formal evaluations and informal channels during the laboratory sessions. Complaints or petitions are addressed promptly by direct communication or through the academic advisory process.

Delivery of AI Content in the Course

AI content increases from 6 hours in 2025 to 15 hours in 2026, and now appears in two distinct roles.

Field	Entry
Topics related to AI covered in this course	Two distinct roles are taught, and the distinction is explicit. (1) AI as a modeling instrument, Week 6: using large language models to draft optimization models from a structured specification, and the verification discipline that must accompany them. Students audit generated models containing sign errors, missing constraints and unit inconsistencies, quantify the resulting error, and build a reusable verification suite. The governing message is that an incorrect model can be perfectly feasible and return an optimal solution to the wrong problem. (2) AI and data as method, Week 13: surrogate modeling and Gaussian processes, Bayesian optimization and expected improvement, design of experiments, training a machine learning model viewed as an unconstrained optimization problem including stochastic gradient descent, momentum, Adam and automatic differentiation, reinforcement learning framed as sequential decision making and compared against exact dynamic programming, and the classical metaheuristics of genetic algorithms and simulated annealing retained as a baseline. Method selection is taught explicitly: data-driven methods are appropriate where the model is expensive, unknown or available only as data, while mathematical programming is superior where the model is known and its structure can be exploited.
Total hours	15 hours (Week 6 workshop 3 hours, Week 13 3 hours, plus approximately 9 hours distributed across the project, the AI-assisted modeling component of Homework 2, and the model verification requirements of the computational project)
Learning strategies used to teach AI-related topics	A three-hour hands-on workshop in which students audit and repair defective generated models; lectures with worked numerical examples; executable notebooks implementing surrogate optimization, gradient-based training and Q-learning from scratch; a model-audit exercise in Homework 2; and a computational project that

Field	Entry
	requires a documented model test suite and a disclosure of AI assistance.
Assessment strategies used for AI-related topics	A model-verification question on the midterm examination; a dedicated data-driven and AI optimization section worth 14 points on the final examination, combining conceptual questions with one hand calculation; a model-audit problem in Homework 2 in which students locate and correct defects in a supplied model; and a rubric row worth 12 points in the computational project awarded for the model test suite and the verification evidence, with an explicit rule that an unverified generated model scores zero on the model correctness row.

Alignment with the Sustainable Development Goals

SDG 9, Industry, Innovation and Infrastructure. The course develops quantitative methods for the efficient design and operation of chemical processes. Several project topics and worked examples address energy storage, hydrogen production and resource efficiency, which additionally support SDG 7, Affordable and Clean Energy, and SDG 12, Responsible Consumption and Production.

Additional Remarks

The generative AI policy is expanded to match what Week 6 teaches.

- Students may use generative AI tools for assignments and for the computational project. Their use in drafting optimization models is not merely permitted but expected, and the workflow is taught in Week 6.
- What is assessed is verification. Every AI-assisted deliverable must disclose which parts were AI-drafted and which tests were run to validate them.
- An unverified generated model receives no credit on the model correctness criterion, regardless of how plausible its numerical results appear.
- Students take full responsibility for the content they submit, including any error introduced by a tool.
- The use of generative AI is strictly prohibited during all examinations.