THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY
Approval of Undergraduate Course

Section 1: Academic Administration [1]

1.1 Catalog

a) Course to be effective from: Academic Year 2020/2021 Term Spring

b) Department Code[3]: SUSEE Subject Area[3]: ENEG Course Number [4]: 4210

Previous Course Code[5]: N/A

c) Full Title[6] *(max. 100 characters)*: Optimization of Energy Systems

d) Abbreviated Title[7] *(max. 30 characters)*:

e) Course Credits[8]: ◉ Fixed: 3 ○ Range: From ____ To ____

f) Catalog Description[9] *(word limit = 150)*:

Optimization practice, theory, and implementation with applications in energy. Topics include: foundations of linear and nonlinear programming; constrained and multiobjective optimization; optimization under uncertainty; multidisciplinary optimization; discrete optimization. The focus is on the application of optimization methods to solve energy engineering problems.

g) Grading Type[10]: ■ Letter Grades ○ Distinction/Credit/Pass/Fail ○ Pass/ Fail ○ Distinction/Pass/Fail ☐ Others *(please specify)*: ____

h) ■ Prerequisites[11]:

Course Code / Public Exam	Course Title / Exam Subject and Level / Grade attained
CENG 2210 or MECH 2310	Chemical and Biological Engineering Thermodynamics or Thermodynamics

i) ☐ Corequisites[12]:

Course Code	Course Title

j) ☐ Exclusions[13]:

Course Code / Public Exam	Course Title / Exam Subject and Level / Grade attained

k) ☐ Co-listing[14]: ☐ Multi-coding[14]:

Course Code	Course Title

l) Other Enrollment Restrictions[15] ■ No ○ Yes

☐ Instructor's approval required

☐ Restricted to specified student group(s) ____

☐

(please specify, e.g. year and program of study): _____

Others *(please specify):* _____

m) Medium of Instruction/Materials[16]: ■ English ○ Others, (Pls specify and provide a justification in Section 1.3): _____

n) Allow course repetition for credit[17]: ■ No ○ Yes

1.2 *Contribution of course to Programs of Study [Check all appropriate boxes below]*

■ Major

Program of Study	As		
SUSEE CENG, CEEV	☐ Required Course	■ Elective	☐ Prerequisite
	☐ Required Course	☐ Elective (for Energy Option)	☐ Prerequisite

☐ Minor

Program of Study	As		
	☐ Required Course	☐ Elective	☐ Prerequisite

☐ Common Core

☐ Others (pls specify):

Program of Study	As		
	☐ Required Course	☐ Elective	☐ Prerequisite

1.3 *Rationale for Introducing this course and other relevant information [18]*

Optimization is needed in engineering to find the best or optimal designs. Therefore, it is critical to optimize processes so that a chosen quantity, the objective function, is maximized or minimized. For example, energy efficiency or profit may be maximized, while energy inputs or costs may be minimized. In turn, the energy industry's success and growth are strongly tied to the optimization of systems and processes.

Optimization in energy is particularly important as engineers need to find optimal design and operation leading to minimizing costs and maximizing efficiencies. In that context, it is critical that engineers formulate and solve optimization problems. To do that, the objective functions and constraints need to be formulated and understood not only in the context of a single optimization but also within the framework of large multidisciplinary teams that operate under uncertainty. In that context, multidisciplinary optimization and optimization under uncertainty play a critical role.

In short, the course aims to introduce techniques for the optimization modeling and the economic evaluation of industrial process and energy systems and to develop the skills required to identify the opportunity and implement optimization-based decision support tools in energy processes and systems. It covers the problem statement, modeling process and systems, solving methods for the simulation, and the single and multiobjective optimization strategies. Topics cover process systems engineering, process and system modeling and simulation, economic evaluation, optimization strategies, and data reconciliation.

Textbooks:

1. M.J. Kochenderfer, and T.A. Wheeler, Algorithms for Optimization, The MIT Press (2019)
2. I. Dincer, M.A. Rosen, and P. Ahmadi, Optimization of Energy Systems, Wiley, 1st Edition (2017).
3. O. Erdinc, Optimization in Renewable Energy Systems, Butterworth-Heinemann (2017)
4. L.T. Bielger, Nonlinear Programming: Concepts, Algorithms, and Applications to Chemical Processes, Society for Industrial and Applied Mathematics (2010)

2.1 *Key Course Intended Learning Outcomes (Should not normally exceed six or eight outcomes)*

Upon completion of this course, students are expected to be able to do the following:

	Course ILOs	**Nature of the learning outcomes** *(A - Knowledge/Content Related; B - Academic Skills/Competencies; C - Others)*
1	Formulate optimization problems related to energy	A, B
2	Solve optimization problems	B
3	Visualize and present optimization results	B
4	Analyze heat and power production optimization	A, B
5	Optimize storage systems under uncertainty	A, B
6		
7		
8		

2.2 *Contribution of Learning Outcomes to Programs of Study identified in Section 1.2*

(Please also complete Section 4.1)

	Program of study 1: _____SUSEE_____ **Program ILOs**	**To be achieved through these course ILOs** *(Write CILO-1, CILO-2, etc.)*
1	Apply sustainable energy engineering principles in a wide range of settings;	CILO-1, CILO-4, CILO-5
2	Design processes and products in the realm of energy engineering to meet societal needs;	CILO-4, CILO-5
3	Develop an awareness of contemporary issues as they relate to engineering;	CILO-1, CILO-3
4	Solve energy and related problems critically and creatively;	CILO-1, CILO-2
5	Communicate clearly and concisely both in writing and orally;	CILO-3
6	Function effectively in multi-cultural and multidisciplinary teams;	
7	Pursue lifelong learning as self-regulated learners;	
8	Exercise integrity, high ethical standards, and care in their personal and professional lives; and	
9	Select and use appropriate engineering tools and data effectively.	CILO-1, CILO-2, CILO-3

	Program of study 1: _____CENG_____ **Program ILOs**	**To be achieved through these course ILOs** *(Write CILO-1, CILO-2, etc.)*
1	Apply chemical engineering principles in a wide range of settings;	CILO-1, CILO-4, CILO-5
2	Design processes and products in the realm of chemical engineering to meet societal needs;	CILO-4, CILO-5
3	Develop an awareness of contemporary issues as they relate to engineering	CILO-1, CILO-3
4	Solve chemical engineering and related problems critically and creatively;	CILO-1, CILO-2
5	Communicate clearly and concisely both in writing and orally;	CILO-3
6	Function effectively in multi-cultural and multidisciplinary teams;	

7	Pursue lifelong learning as self-regulated learners;	
8	Exercise integrity, high ethical standards, and care in their personal and professional lives; and	
9	Select and use appropriate engineering tools and data effectively.	CILO-1, CILO-2, CILO-3

	Program of study 1: _____CEEV_____ **Program ILOs**	**To be achieved through these course ILOs** *(Write CILO-1, CILO-2, etc.)*
1	Apply chemical and environmental engineering principles in a wide range of settings;	CILO-1, CILO-4, CILO-5
2	Design processes and products in the realm of chemical and environmental engineering to meet societal needs;	CILO-4, CILO-5
3	Develop an awareness of contemporary issues as they relate to engineering;	CILO-1, CILO-3
4	Solve chemical and environmental engineering and related problems critically and creatively;	CILO-1, CILO-2
5	Communicate clearly and concisely both in writing and orally;	CILO-3
6	Function effectively in multi-cultural and multidisciplinary teams;	
7	Pursue lifelong learning as self-regulated learners;	
8	Exercise integrity, high ethical standards, and care in their personal and professional lives; and	
9	Select and use appropriate engineering tools and data effectively.	CILO-1, CILO-2, CILO-3

Section 2B: Additional Information[2] *(for courses not proposed to be Common Core Courses)*

2.3 *Planned Teaching & Learning Arrangement*

	Teaching & Learning Arrangement	Weekly Scheduled Hours/ Estimated Weekly Learning Hours	Indicate which course ILOs this activity serves to achieve *(Write CILO-1, CILO-2, etc.)*	Additional Information *(optional)*
Face-to face activities	■ Lecture*	3	CILO-1, CILO-2, CILO-3, CILO-4, CILO-5	Activities will include frontal lectures and in-class coding exercises
	☐ Tutorial*			
	☐ Seminar/Small-class*			
	☐ Laboratory*			
	*Does the above scheduled component(s) involve structured active learning activities?[19] ◉ No ○ Yes *If yes, please specify for each scheduled component, the percentage and the type of active learning involved in the "Additional Information" column.*			
	☐ Others (e.g. fieldtrip, visit, etc.), *pls specify:* _____			
Online activities	☐ Online lecture videos			
	☐ Other online learning tasks, *pls specify:* _____			
	The total learning hours of the course# is equivalent to ____135_____ hours[8] *# including both scheduled instructional hours and hours for self-study activities & assessment*			

- *For course adopting a pedagogic approach other than lecture, tutorial and laboratory, please indicate the pedagogy used:*

○ Blended learning[20] ○ Pure online delivery[21]

○ Experiential learning[22] ○ Others, *pls specify:*_____

2.4 *Planned Assessment Weightings*

Assessment Task	Proportion of Final Grade (%)	Indicate which course ILOs this task is to assess *(Write CILO-1, CILO-2, etc.)*	Additional Information *(optional)*
☐ In-class test			
☐ Mid-term test			
☐ Final exam			
■ Written assignment	**40%**	CILO-1, CILO-2, CILO-4, CILO-5	**Individual project among those assigned**
■ Project report	**30%**	CILO-1, CILO-2, CILO-3, CILO-4, CILO-5	**Individual project among those assigned**
■ Presentation	**30%**	CILO-1, CILO-2, CILO-3, CILO-4, CILO-5	
☐ Learning portfolio			
☐ Course participation			
☐ Peer evaluation			
☐ Others (e.g. proctored online exam, etc.), *pls specify:* _____			

2.5 *Course Duration*

(■) 1 term ( ) 2 terms ( ) Others, *pls specify:* _____

2.6 *Planned Frequency of Offerings* *[Check all appropriate boxes]:*

[ ] Every Fall
[ ] Every Winter
[■] Every Spring
[ ] Every Summer
[ ] No fixed pattern
[ ] Other *(pls specify):* _____

2.7 *Course outline attached* ( ) No (■) Yes

- **Internationalization:**

Internationalization in a course refers to course content and/or pedagogic approaches which incorporate an intercultural and international perspective. Examples may include:

- Collaboration with overseas institutions to develop and adopt international course content, or to arrange international field trip
- Insertion of international theme as part of the course
- Integrating the course content with international material as examples or case studies
- Elements to provide global diversified perspectives and/or practices around the world

Please briefly list or summarize any component(s) in the course that contributes to internationalizing the curriculum:

2.8 *Resources*

Request extra resources for teaching this course? (■) No ( ) Yes

Course Outline:

Week	Topic
1	Introduction to Modeling and Optimization of Thermal Systems
2	Introduction to Basic Optimization Concepts and Numerical Optimization Code
3	Bracketing and Local Descent
4	First- and Second-Order Methods
5	Direct Methods: Pattern Search and the Symplex
6	Stochastic Methods - Adam
7	Population Methods
8	Linear Constrained Optimization and Multiobjective Optimization – Concurrent Optimization of Battery Parameters
9	Optimization under Uncertainty
10	Bayesian Optimization and Probabilistic Methods
11	Discrete Optimization
12	Multidisciplinary Optimization in Engineering Design
13	Optimal Design of Hybrid Renewable Energy Systems

Section 4: Development, Concurrence and Approval

4.1 *Contribution to the Program Learning Outcomes*

(To be completed by EACH of the program(s) of study noted under Section 1.2)

■ The course contributes to this Major/~~Minor~~* Program: CENG, CEEV

(Delete as appropriate)*

■ The relevant **program learning outcomes are attached**.

■ On behalf of this program of study, I confirm that the course will contribute appropriately to overall program learning outcomes.

	Position / Name:	Signature	Date
Program Director / Head of Department:	Program Director Ying Chau		23 OCT 2020

■ The course contributes to this Major/ * Program: SUSEE

(Delete as appropriate)*

■ The relevant **program learning outcomes are attached**.

■ On behalf of this program of study, I confirm that the course will contribute appropriately to overall program learning outcomes.

	Position / Name:	Signature	Date
Program Director / Head of Department:	Minhua Shao		23 OCT 2020

☐ The course contributes to this Major/ ~~Minor~~* Program:

(Delete as appropriate)*

☐ The relevant **program learning outcomes are attached**.

☐ On behalf of this program of study, I confirm that the course will contribute appropriately to overall program learning outcomes.

	Position / Name:	Signature	Date
Program Director / Head of Department:			

4.2 *Approvals*

Department/Program unit level Recommendation

	Position / Name:	Signature	Date
■ Offering Department/Program Unit: *(Please specify unit): SUSEE*	Program Director Minhua Shao		23 OCT 2020
☐ Offering Department/Program Unit: *(Please specify unit): ~~MECH TBC~~*			
[X] Recommending School/IPO: *(Please specify):* SENG	Prof. Philip K. T. MOK Assoc. Dean of Engineering		14 Dec 2020

School-level Concurrence

	Name of School/Unit	Position / Name	Signature	Date
■	DDP	UGC / Betty Lin		30 Oct 2020
☐				
☐				

Section 4: Development, Concurrence and Approval

4.1 *Contribution to the Program Learning Outcomes*

(To be completed by EACH of the program(s) of study noted under Section 1.2)

■ The course contributes to this Major/~~Minor~~* Program: CENG, CEEV

(Delete as appropriate)*

■ The relevant **program learning outcomes are attached.**

■ On behalf of this program of study, I confirm that the course will contribute appropriately to overall program learning outcomes.

	Position / Name:	Signature	Date
Program Director / Head of Department:	Program Director Ying Chau		23 OCT 2020

■ The course contributes to this Major/ * Program: SUSEE

(Delete as appropriate)*

■ The relevant **program learning outcomes are attached.**

■ On behalf of this program of study, I confirm that the course will contribute appropriately to overall program learning outcomes.

	Position / Name:	Signature	Date
Program Director / Head of Department:	Minhua Shao		23 OCT 2020

☐ The course contributes to this Major/ ~~Minor~~* Program: MECH

(Delete as appropriate)*

☐ The relevant **program learning outcomes are attached.**

☐ On behalf of this program of study, I confirm that the course will contribute appropriately to overall program learning outcomes.

	Position / Name:	Signature	Date
Program Director / Head of Department:			

4.2 *Approvals*

Department/Program unit level Recommendation

	Position / Name:	Signature	Date
■ Offering Department/Program Unit: *(Please specify unit): SUSEE*	Program Director Minhua Shao		23 OCT 2020
☐ Offering Department/Program Unit: *(Please specify unit): ~~MECH~~ ~~TBC~~*			
☐ Recommending School/IPO: *(Please specify):*			

School-level Concurrence

	Name of School/Unit	Position / Name	Signature	Date
■	DDP			
☐	MECH	Prof. Baoling Huang/UG Coordinator		3 Nov 2020
☐				