Subject Guide – Heat Transfer

Shortened Name	HT	**Semester**	2-2022
Class Time (weekly)	Fri, 13-16	**Lecture hours**	3h x 15w
Subject Code	090125214	**Assignment and self-study**	5h x 15w
ECTS credits	6	**Preparation for exams**	30
KMUTNB Credits	3(3-0-6)	**Total working hours/semester**	150

1 Revision date of this document, reasons for revision

- 04.01.2023

2 Course description

1D and 2D steady-state conduction, transient conduction, heat transfer by forced convection in external and internal flows, heat transfer by free convection, boiling and condensation, usage of heat transfer correlations, basic surface radiation, heat exchangers.

3 Lecturer

- Dr. Ampol Likitchatchawankun

4 Expected learning outcomes (in accordance with the MAE program ELOs)

Primary LOs (primary content of class, knowledge is explicitly evaluated (for example, by exams), larger share of overall grade)

- Ability to define a technical task or problem, to analyze/structure it and formulate a strategy to solve it (GELO 1)
- Knowledge and understanding of scientific fundamentals relevant for the understanding of the behavior of solid body and fluids in engineering applications (SELO 2)

Secondary LOs (not primary content of class, but implicitly taught and evaluated by application (for example, by project work or assignments), lower share of overall grade)

- Ability to independently conduct a literature study on a given topic, identify and acquire relevant sources, extract and sum up the essence in writing (GELO 5)
- Ability to present a project in front of a professional audience (GELO 6)

Note: These ELOs correspond to the Program ELOs (referenced in parentheses).

5 Assessment

Each student will be individually assessed based on the performance on homework assignments, written exams/quizzes, and seminar, with the overall grade resulting from the shares in the table below:

Evaluated items*	**shares**
Homework submission	10%
Quiz 1 (Midterm exam 1)	20%
Quiz 2 (Midterm exam 2)	20%
Quiz 3 (Pre-final exam)	20%
Quiz 4 (Final exam)	20%
Seminar: Current research in Heat Transfer	10%
Total	**100%**

*I reserve the right to make small changes to the grading breakdown

- All quizzes are closed-book and paper-based
- Each quiz consists of *Part A* (5 conceptual questions with short answers, drawing graphs, and simple mathematical derivation) and *Part B* (1 problem with multiple parts to assess the problem-solving skills. Necessary information such as tables for some properties)
- Each student has to propose one journal paper (to be presented in seminar) for approval by week 10.

6 Teaching materials

- Power-point presentation of each lecture is handed over (before each class)
- E-books are provided by email before the first day of the class
- The links of relevant VDOs from youtube are also given

7 Books and references

1) *Fundamentals of Heat and Mass Transfer, 8th Edition, T. L. Bergman and A. S. Lavine, John Wiley & Sons, Publishers, 2017.* **(MAIN TEXTBOOK)**

*Important note: Earlier editions of this book will work just as well.

** For the reference to homework and discussion, I use the 8th edition.

8 Course schedule

Week	Date/Month	Activity, Class Title (Book Chapter)	Evalu-ation %	Class Hours
1	06/01	Introduction to heat transfer (Ch1) and introduction to conduction (Ch2)		3
2	13/01	1D steady-state conduction (Ch3)		3
3	20/01	Extended surface-fins (Ch3)		3
4	27/01	**Quiz I (1D conductive heat transfer)**	20%	3
5	03/02	2D steady-state conduction (Ch4)		3
6	10/02	Finite Different Equation in 2D steady-state conduction (Ch4)		3
7	17/02	Transient conduction (Ch5)		3
8	24/02	Finite Different Equation in 1D transient conduction (Ch5)		3
9	03/03	**Quiz II (2D steady-state and 1D transient conduction)**	20%	3
10	10/03	Introduction to convection (Ch6)		3
11	17/03	External Flow (Ch7)		3
12	24/03	Internal Flow (Ch8)		3
13	31/03	**Quiz III (Convective heat transfer, external and internal)**	20%	3
14	**Wed** 05/04	Free convection (Ch9)		3
15	07/04	Boiling and condensation		3
16	**Wed** 19/04	Heat Exchanger		3
17	21/04	**Quiz IV (Free convection, 2 phase flow, and heat exchanger)**	20%	3
18	**Wed** 26/04	****Seminar-Current Research in Heat Transfer****	10%	3
	Throughout the semester	**Nine (9) homework submissions**	10%	-
		Sum	100%	45

9 Content details

Chapter	Title	Lesson (L) Contents
1	Introduction	• Physical Origins and Rate Equations • Relationship to Thermodynamics • Analysis of Heat Transfer Problems: Methodology • Relevance of Heat Transfer
2	Introduction to Conduction	• The Conduction Rate Equation • The Thermal Properties of Matter • The Heat Diffusion Equation • Boundary and Initial Conditions
3	One-Dimensional, Steady-State Conduction	• The Plane Wall and Radial Systems • Conduction with Thermal Energy Generation • Summary of One-Dimensional Conduction Results • Heat Transfer from Extended Surfaces
4	Two-Dimensional, Steady-State Conduction	• The Method of Separation of Variables • The Conduction Shape Factor and the Dimensionless Conduction Heat Rate • Finite-Difference Equations • Solving the Finite-Difference Equations
5	Transient Conduction	• The Lumped Capacitance Method and its validity • Exact and Approximate solutions for The Plane Wall and Radial Systemes with Convection considering Spatial Effects • The Semi-Infinite Solid • Finite-Difference Methods (Explicit and Implicit)
6	Introduction to Convection	• Convection Boundary Layers • Local and Average Convection Coefficients • Laminar and Turbulent Flow • The Boundary Layer Equations • The Heat and Mass Transfer Analogy
7	External Flow	• The Flat Plate in Parallel Flow • Methodology for a Convection Calculation • The Cylinder and Sphere in Cross Flow • Flow Across Banks of Tubes
8	Internal Flow	• Hydrodynamic and Thermal Considerations • Laminar and Turbulent Flows in Circular Tubes • Noncircular Tubes and the Concentric Tube Annulus • Convection Correlations
9	Free Convection	• The Governing Equations for Laminar Boundary Layers • Laminar Free Convection on a Vertical Surface • External Free Convection Flows for Inclined and Horizontal plates, Long Horizontal Cylinder, and Sphere • Combined Free and Forced Convection
10	Boiling and Condensation	• Boiling Modes and The Boiling Curves • Pool Boiling and its Correlations • Forced Convection Boiling • Condensation
11	Heat Exchangers	• The Overall Heat Transfer Coefficient • HX analysis using ΔT_{lm} and ε -NTU Method • Heat Exchanger Design and Performance Calculations
12	Radiation: Processes and Properties	• Radiation Heat Fluxes and Intensity • Blackbody Radiation • Emission, Absorption, Reflection, and Transmission by Real Surfaces

13	Radiation Exchange Between Surfaces	• The View Factor • Blackbody Radiation Exchange • Radiation Exchange Between Opaque, Diffuse, Gray Surfaces in an enclosure

10 Details on Evaluation of Expected Learning Outcomes

		Quiz 1	Quiz 2	Quiz 3	Quiz 4	Seminar	Homework	Sums
		20%	20%	20%	20%	10%	10%	
GELO1	Ability to define a design task or problem, to analyze/structure it and formulate a strategy to solve it	10%	10%	10%	10%		10%	**50%**
SELO2	Knowledge and understanding of scientific fundamentals relevant for the understanding of the behavior of solid bodies and fluids in engineering applications	10%	10%	10%	10%			**40%**
GELO5	Ability to independently conduct a literature study on a given topic, identify and acquire relevant sources, extract and sum up the essence in writing					5%		**5%**
GELO6	Ability to present a project in front of a professional audience					5%		**5%**