The Hong Kong University of Science and Technology

UG Course Syllabus

Course Title: Heat Transfer

Course Code: MECH 3310

Number of Credits: 3

Pre-requisites: MECH 2210 and MECH 2310

Terms Offered: Fall

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Course Description

This course teaches the basic physics and practical calculation methods for conduction, convection, and radiation heat transfer. Students will encounter problems involving the flow of heat from nearly every aspect of life. The course covers the science behind heat flow and introduces the engineering of it, including rule-of-thumb approximations, empirical correlations, and rigorous solutions applied to practical heat-transfer processes.

Intended Learning Outcomes (ILOs)

By the end of this course, students should be able to:

1. Explain the basic concepts of conduction, convection, and radiation heat transfer.
2. Formulate and solve simple conduction heat transfer problems, using techniques including both closed-form and numerical methods.
3. Apply empirical correlations for both forced and natural convection to determine values for the convection heat transfer coefficient.
4. Examine blackbody and gray surface radiation, and evaluate radiation exchange between surfaces.
5. Apply the principles of conduction, convection, and radiation heat transfer to analyze natural phenomena and practical systems.

Assessment and Grading

This course will be assessed using criterion-referencing. Student performance will be evaluated according to their demonstrated achievement of the intended learning outcomes (ILOs) via homework assignments, class participation, a midterm examination, and a final examination.

Assessment Task	Contribution to Overall Course grade (%)	Due date
Homework assignments	15%	Throughout the term
Class participation and quiz	10%	Throughout the term
Midterm examination	35%	Around week 7-9
Final examination	40%	Final examination period

Mapping of Course ILOs to Assessment Tasks

Assessed Task	Mapped ILOs	Explanation
Homework assignments	ILO 1, ILO 2, ILO 3, ILO 4, ILO 5	Homework assignments assess students' ability to apply theoretical and analytical tools introduced in lectures and tutorials. Students solve problems on conduction, convection, and radiation heat transfer, including formulating and solving heat transfer problems using both closed-form and numerical methods.
Class participation and quiz	ILO 1, ILO 2, ILO 3, ILO 4, ILO 5	Class participation and quizzes assess students' engagement with course material and ability to explain and apply fundamental heat transfer concepts in real time.
Midterm examination	ILO 1, ILO 2, ILO 3	The midterm examination assesses individual understanding of conduction and early convection topics, including fundamental concepts, steady-state and transient conduction, and basic forced convection analysis.
Final examination	ILO 1, ILO 2, ILO 3, ILO 4, ILO 5	The final examination is cumulative and assesses individual achievement of all core conceptual and analytical learning outcomes, including conduction, convection, radiation, and multimode heat transfer.

Grading Rubrics

The following rubrics describe the general criteria used to assess the major assessment components in this course. More detailed task-specific marking schemes may be provided for individual homework assignments and examination questions.

Rubric for Homework Assignments

Criteria	Excellent	Good	Satisfactory	Marginal	Fail	Map to Course ILOs
Conceptual understanding	Demonstrates clear and accurate understanding of the relevant heat transfer concepts and physical mechanisms. Correctly explains assumptions and limitations of the models used.	Shows good understanding of the main concepts, with only minor omissions or imprecision.	Shows adequate understanding of basic concepts but may lack depth or contain some conceptual gaps.	Shows limited understanding; explanations are incomplete or partially incorrect.	Shows little or no understanding of the relevant heat transfer concepts.	ILO 1, ILO 2, ILO 3, ILO 4, ILO 5
Application of heat transfer theory	Selects and applies appropriate heat transfer theories and equations correctly and efficiently, including conduction, convection correlations, and radiation exchange relations where relevant.	Applies appropriate methods with mostly correct reasoning and only minor errors.	Applies standard methods to familiar problems but may require clearer justification or contain some procedural errors.	Attempts to apply relevant methods but with significant errors or weak justification.	Fails to apply appropriate heat transfer methods or uses irrelevant approaches.	ILO 1, ILO 2, ILO 3, ILO 4, ILO 5
Mathematical accuracy and problem solving	Solutions are mathematically sound, logically organized, and lead to correct results with appropriate units and notation.	Solutions are generally correct, with minor algebraic, numerical, or unit errors.	Solutions show reasonable effort and partial correctness but include some significant errors.	Solutions are incomplete or contain major mathematical errors.	Solutions are largely absent, incorrect, or not submitted.	ILO 1, ILO 2, ILO 3, ILO 4, ILO 5
Physical interpretation of results	Provides clear interpretation of results, including heat transfer trends, limiting cases, model assumptions,	Provides reasonable interpretation, though some details may be missing.	Provides basic interpretation but may not fully connect results to physical heat transfer behavior.	Provides limited or superficial interpretation.	Provides no meaningful interpretation of results.	ILO 1, ILO 2, ILO 3, ILO 4, ILO 5

Criteria	Excellent	Good	Satisfactory	Marginal	Fail	Map to Course ILOs
	and engineering significance.					
Clarity of presentation	Work is clear, well structured, legible, and easy to follow, with appropriate equations, diagrams, and explanations.	Work is mostly clear and organized.	Work is understandable but may be disorganized or difficult to follow in places.	Work is poorly organized or hard to follow.	Work is illegible, incoherent, or missing.	ILO 1, ILO 2, ILO 3, ILO 4, ILO 5

Final Grade Descriptors

Grade	Short Description	Elaboration on Subject Grading Description
A	Excellent Performance	Demonstrates excellent command of heat transfer fundamentals. Clearly explains and quantifies all three modes of heat transfer. Formulates and solves conduction, convection, and radiation problems with accuracy and insight. Applies empirical correlations and radiation exchange methods confidently. Work is accurate, well organized, and shows strong physical understanding and engineering judgement.
B	Good Performance	Demonstrates good understanding of the main heat transfer concepts. Applies methods for conduction, convection, and radiation correctly in most situations. Solves standard and moderately challenging problems with generally sound reasoning. Homework submissions are clear and technically competent, with only minor weaknesses.
C	Satisfactory Performance	Demonstrates adequate understanding of core heat transfer concepts and can apply standard methods to familiar problems. Some errors or gaps in reasoning may be present, and physical interpretation may lack depth, but the main learning outcomes are achieved at an acceptable level.
D	Marginal Pass	Demonstrates threshold understanding of basic heat transfer concepts but has difficulty applying theories consistently or accurately. Can attempt standard calculations but work may contain significant errors, incomplete reasoning, or weak physical interpretation. There is sufficient evidence of partial achievement of learning outcomes, but performance is limited.
F	Fail	Demonstrates insufficient understanding of fundamental heat transfer concepts. Unable to apply basic conduction, convection, or radiation methods to standard problems. Work contains major conceptual and mathematical errors, is incomplete, or does not demonstrate achievement of the intended learning outcomes.

Course AI Policy

The use of artificial intelligence (AI) tools is permitted in this course for learning support, brainstorming, checking understanding, improving writing clarity, and assisting with coding or software-related tasks. However, students remain fully responsible for the accuracy, originality, and integrity of all submitted work.

For homework submissions, students may use AI tools to support their learning, but they must ensure that the final submitted work reflects their own understanding and reasoning. Students should not submit AI-generated solutions without verification, explanation, and independent judgement. Any use of AI that contributes substantively to submitted work should be acknowledged where appropriate.

During examinations, the use of AI tools is not permitted.

Communication and Feedback

Assessment marks for individual assessed tasks will normally be communicated via Canvas within two weeks of submission. Feedback may include written comments, annotated solutions, marking rubrics, sample solutions, in-class or tutorial discussion, or verbal feedback.

Homework feedback will focus on the correctness of methods, mathematical execution, physical interpretation, and clarity of presentation.

Students who have questions about feedback or marks should contact the instructor or teaching assistants within two weeks after the feedback is released.

Resubmission Policy

Assessment marks for individual assessed tasks will normally be communicated via Canvas within two weeks of submission. Feedback may include written comments, annotated solutions, marking rubrics, sample solutions, in-class or tutorial discussion, or verbal feedback.

Homework feedback will focus on the correctness of methods, mathematical execution, physical interpretation, and clarity of presentation.

Students who have questions about feedback or marks should contact the instructor or teaching assistants within two weeks after the feedback is released.

Required Texts and Materials

To ensure fairness to students who submit work on time, late submissions for homework will not be accepted unless prior approval has been granted by the instructor or valid supporting documentation is provided. Students are encouraged to contact the instructor in advance if they anticipate difficulty meeting a deadline.

Academic Integrity

Students are expected to adhere to the university's academic integrity policy. Students are expected to uphold HKUST's Academic Honor Code and to maintain the highest standards of academic integrity. The University has zero tolerance of academic misconduct. Please refer to [Academic Integrity | HKUST – Academic Registry] for the University's definition of plagiarism and ways to avoid cheating and plagiarism.

Required Texts and Materials

The main textbook for this course is:

- Principles of Heat Mass Transfer (Ebook), Incropera et al.

Other materials, including lecture slides, tutorial handouts, homework assignments, and datasets, will be provided via Canvas.

Course Outline

1. Introduction and Basic Concepts [Week 1]
    - Definition and modes of heat transfer (conduction, convection, radiation)
    - Conservation of energy and relationship to thermodynamics
2. Conduction Fundamentals [Week 2]
    - Governing equations for heat conduction
    - 1-D steady conduction without heat generation: thermal circuits
3. 1-D Steady Conduction [Weeks 2–4]
    - Radial systems (cylinders and spheres)
    - Conduction with internal heat generation
    - Extended surfaces (fins)
4. Transient Conduction [Weeks 4–5]
    - Lumped capacitance model
    - Semi-infinite solid approximation
5. Multi-Dimensional Conduction and Numerical Methods [Week 6]
    - 2-D conduction and numerical methods
    - Midterm review
6. Convection Fundamentals and External Convection [Week 7]
    - Boundary layers, similarity, and analogies
    - External convection: flat plate and bluff bodies
7. Internal Convection [Weeks 8–10]
    - Hydrodynamic and thermal entry length
    - Energy balance for internal flows
    - Heat transfer correlations for internal flows
8. Natural Convection [Week 10]
    - Governing equations and scaling analysis
    - Empirical correlations for natural convection
9. Radiation Fundamentals [Weeks 11–12]
    - Radiation intensity and spectral quantities
    - Blackbody radiation and gray surface approximation
    - Kirchhoff's law and environmental radiation

10. Radiative Transfer [Weeks 12–13]

    - View factors and radiation exchange between two surfaces
    - Radiation exchange between three surfaces and radiation shields
    - Multimode heat transfer analysis