FUNDAMENTALS
OF
MULTIPHASE FLOW
AND
HEAT TRANSFER

Lectured by
Sun Park

Spring 2003
Energy Technology
Royal Institute of Technology
Sweden
# Participant Information

**Sun Park** (sun@egi.kth.se)

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<thead>
<tr>
<th>Name</th>
<th>Personal number</th>
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<tbody>
<tr>
<td>Email address</td>
<td>Telephone</td>
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<td>Your advisor</td>
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<tr>
<td>Department/Division</td>
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<tr>
<td>Project title</td>
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<td>Project description</td>
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**How long in your project?**

**Any courses taken similar to this course? If yes, please list them here.**

**What is your special interest on this course?**

**If you have any comments, suggestion or request on this course, please list them here.**
Multiphase flows and heat transfer is an area of fluid flow and heat transfer in which several different phases of fluids are co-existed. Obviously, this type of transport phenomena can be seen in everywhere nearby us, for examples, from water boiling for cooking and blood streaming in a body to the operation of the huge power plants. Although the physical understanding of the phenomena is extremely challenging, better understanding of the phenomena is an essence of not only developing most industrial processes but also understanding nature itself.

For the first time at EGI/KTH, the very subject is dealt in a new introductory course that gives students a rudimentary exposure to the thermo-fluid transport phenomena in multiphase system as well as guides students to formulate and solve problems associated with the phenomena. This introductory course is intended for the final year undergraduates and the beginning graduate students who have not been exposed to the subject of interests or already involved in the subject during their own research works. The course will be designed for students to develop their heuristic learning process based on the first principle of the modern physics, which involves technical problem solving, presenting and reporting techniques.

This course basically deals with three parts of the subject; fluid mechanics, heat transfer and applications of multiphase transport phenomena. The first part of the course starts with a short review of the basics of fluid flow and heat transfer in single-phase and comparison between the single and multiphase problems. Basic analytical models for the two-phase flow will also be introduced. The second part of the course extends to the heat transfer with phase changes including natural/forced convective boiling, critical and post-critical heat fluxes and condensation. Finally the course will be summarized by brief introduction of the interesting fundamental phenomena encountered in many applications; e.g., flooding, chocking, two-phase instability, interfacial instabilities, cavitation, bubble dynamics, and two-phase heat transfer enhancement.

The students taking this course are assumed to have taken the elementary courses on the fluid mechanics, thermodynamics, and the heat transfer. The class instruction will be delivered in English in a free, discussion-friendly atmosphere.
Course General Information

Instructor:  
Hyun Sun Park and Bal Raj Sehgal
Office: Drottning Kristinas Väg 33A, 2nd floor Room 227
Office Hours: Monday through Friday 9:00 ~ 18:00
Office Phone: 08-790-9256 (Office), 9234 (Lab)
Email: sun@egi.kth.se

Class hours & Class Room:  
Three-hour-long lecture per each (See Lecture Schedule),
M42, Brinellvägen 60, KTH

Language:  
English

Credits:  
4 credits

Prerequisites:  
1. Knowledge on elementary thermodynamics, heat transfer and fluid dynamics.
2. Fundamental numerical analysis.
3. Computer programming with Fortran, C or Matlab

Textbooks:  

Selected Reference  
L. Passman.


Thermo-fluid Dynamics Theory of Two-phase Flow, Eyrolles, Paris (1975), by M. Ishii


**Grading:**

**PhD Student**

1. **Homework** 50%
2. **Project Seminar** 25%
   - Topic Selection & formulation: 25% of 25% Total
   - Problem Solving: 25% of 25% Total
   - Presentation (10min Presentation/5min Q&A): 25% of 25% Total
   - Report: 25% of 25% Total
3. **Final Exam** 25%

† Ph.D. Student with 70% of the total scores will pass the course.

**Undergraduate Student**

1. **Homework** 2 Credit
2. **Project Seminar** 1 Credit
   - Topic Selection & formulation: 25%
   - Problem Solving: 25%
   - Presentation (10min Presentation/5min Q&A): 25%
   - Report: 25%
3. **Final Exam** 1 Credit

**Note**  **Homework** will be corrected and given to the students at the end of each lecture. The set of homework problems consists of two parts; basic problems and advanced problems. The Ph.D. students require solving both sets of problems, e.g., basic and advanced problems. However, the undergraduate students only require solving the basic problems.

**Project** will be any problem solving related to the contents of the course during the students’ own project for the Ph.D. students. For the undergraduate students, a set of advanced problems will be given.

**Final Exam** will be the extended set of the homework problems. For the undergraduate students, the level equivalent to the basic homework problem sets will be provided. The Ph.D. students will be asked to solve additional problems including the basics given to the undergraduates.
<table>
<thead>
<tr>
<th>Date/Time</th>
<th>Topics</th>
<th>Homework</th>
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<tbody>
<tr>
<td>Feb. 10 (M) 09:00~12:00</td>
<td>Introduction to Multiphase Flow and Heat transfer</td>
<td>HW01</td>
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<tr>
<td>Feb. 17 (M) 09:00~12:00</td>
<td>Two-phase Flow Patterns and Flow Pattern Maps</td>
<td>HW02</td>
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<td>Feb. 24 (M) 09:00~12:00</td>
<td>Basic Analytical Models; Homogeneous Equilibrium Model</td>
<td>HW03</td>
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<td>Mar. 03 (M) 09:00~12:00</td>
<td>Basic Analytical Models: Separated Fluid Model</td>
<td>HW04</td>
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<tr>
<td>Mar. 10 (M) 09:00~12:00</td>
<td>Basic Analytical Models: Drift Flux Model</td>
<td>HW05</td>
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<td>Mar. 17 (M) 09:00~12:00</td>
<td>Applications: Pressure Drop, Flooding and Critical Flow</td>
<td>HW06</td>
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<td>Mar. 24 (M) 09:00~12:00</td>
<td>Phase Change Fundamentals of Phase Change</td>
<td>HW07 Discussions on Project</td>
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<td>Apr. 14 (M) 09:00~12:00</td>
<td>Pool Boiling</td>
<td>HW08</td>
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<td>Apr. 22 (T) 09:00~12:00</td>
<td>Flow Boiling</td>
<td>HW10</td>
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<td>Apr. 28 (M) 09:00~12:00</td>
<td>Critical Heat Flux in Pool and Flow Boiling</td>
<td>HW11</td>
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<td>May. 5 (M) 09:00~12:00</td>
<td>Condensation Heat Transfer</td>
<td>HW12</td>
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<td>May. 12 (M) 09:00~12:00</td>
<td>Applications: Steady State Single Heated Channel Analysis</td>
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<td>May. 19 (M) 09:00~12:00</td>
<td>Project Seminar</td>
<td>Seminar</td>
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<td>May. 19 (M) 09:00~12:00</td>
<td>5 Min Presentation</td>
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<td>May. 19 (M) 09:00~12:00</td>
<td>Project Report</td>
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<td>Jun. 2 (M) 09:00~12:00</td>
<td>Final Exam</td>
<td>Final</td>
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<td>The basic level (Undergraduates and Ph.D. students)</td>
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<td>The advanced Level (Ph.D. Students)</td>
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