MECH 498/898 (Spring 2013)
Micro and Nanoscale Thermal-Fluids Science and Engineering

Instructor Sidy Ndao, Assistant Professor
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Schedule TR 2:00 – 3:15 PM

Office hours Wed. 1:00 – 3:00 PM in my office (W317.4C)

Prerequisites MECH 420 or equivalent or the instructor's permission

Course Description This course is an introduction to heat transfer and fluid flow at the micro- and nanoscale. Emphasis will be put on the physics and engineering aspect though mathematical derivations will be presented when necessary. Topics to be covered include a review of macroscopic thermal sciences, Thermal transport at the nanoscale, microfluidics and microscale convection (single-phase & two-phase) heat transfer, and thermal radiation. Materials selection and micro/nanofabrication processes relevant to micro- and nanosystems will be briefly covered. Specific engineering applications such as thermal management, energy conversion, and microfluidics will be also discussed.

Textbooks No required textbook, materials will be provided by instructor

References

Macroscopic thermal-fluids:

- Theodore L. Bergman, Adrienne S. Lavine, Frank P. Incropera, David P. DeWitt, "**Fundamentals of Heat and Mass Transfer**" 7th Edition, John Wiley, 2011
- Frank White , "**Fluid Mechanics**" 7th Edition, McGraw Hill, 2011

Micro- & Nanoscale thermal-fluids:

- Zhuomin M. Zhang, "**Nano/Microscale Heat Transfer**" McGraw Hill, 2007
- Brian Kirby, "**Micro- and Nanoscale Fluid Mechanics: Transport in Microfluidic Devices**" Cambridge University Press, 2010

Two-Phase Heat Transfer:

- Van P. Carey, "**Liquid-Vapor Phase-Change Phenomena**" 2nd Edition, Taylor & Francis, 2008

Micro- & Nanoscale Fabrication:

- Stephen A. Campbell, "**Fabrication Engineering at the Micro- and Nanoscale**" 4th Edition, Oxford University Press, 2013

Student Evaluation

Four (4) homework assignments - 60% (15% each)
Final term project - 40%

Homework assignments are accepted during class time **only** on the date they are due. No late homework will be accepted.

Late final project reports will be penalized 10% of the points available for each 24-hour interval that they are late.

The Final term project consists of a written report and presentation based on the analysis (numerical or analytical) of a physical problem related to at least one of the topics covered in class. Project proposals, consisting of a brief description of the problem and an outline, are due Feb 7th. Students are encouraged to select problems relevant to their own thesis research but need to discuss them with the instructor prior to proposals submission. Final reports are due **April 11th** while project presentations will be scheduled during the last week of classes.

TENTATIVE COURSE SCHEDULE (SUBJECT TO CHANGES)

Date	Sessions	Topics
8 – Jan	1	Introduction & motivations – There is plenty of room at the bottom
10 – Jan	2	Overview of Macroscopic Thermal sciences – Thermodynamics & conduction
15 – Jan	3	Overview of Macroscopic Thermal sciences – Convection
17 – Jan	4	Overview of Macroscopic Thermal sciences – Radiation
22 – Jan	5	Basic statistical thermodynamics, quantum theory, and kinetic theory
24 – Jan	6	Phonon and electron transport processes
29 – Jan	7	Thermal properties at the nanoscale – heat capacity & thermal conductivity
31 – Jan	8	Thermoelectricity and applications
5 – Feb	9	Macroscopic fluid mechanics
7 – Feb	10	Wetting and contact angles
12 – Feb	11	Theory of micro/nanofluidics
14 – Feb	12	Electrokinetic flows
19 – Feb	13	Microfluidic - Devices and applications
21 – Feb	14	Convection heat transfer – Fundamentals
26 – Feb	15	Laminar convection – Internal flow
28 – Feb	16	Boiling and condensation
5 – Mar	17	Boiling and condensation continued
7 – Mar	18	Single-phase heat transfer in microchannels
12 – Mar	19	Two-phase flow heat transfer in microchannels
14 – Mar	20	Two-phase flow heat transfer in microchannels continued
19 – Mar	**SPRING VACATION**	
21 – Mar		
26 – Mar	21	Fundamentals of thermal radiation
28 – Mar	22	Fundamentals of thermal radiation continued
2 – Apr	23	Radiative properties of nanomaterials
4 – Apr	24	Near-field radiative heat transfer

9 – Apr	25	Nanophotonics and applications
11 – Apr	26	Silicon microfabrication
16 – Apr	27	Silicon microfabrication continued
18 – Apr	28	Soft fabrication and polymers
23 – Apr	29	**Student Presentation**
25 - Apr	30	**Student Presentation**