MAT309 – Transport Phenomena in Materials Processing
3 credits (3 hr lecture +1 hr recitation)

Objective

This course intends to introduce materials science and engineering students to the transport phenomena in materials processing. Transport phenomena is concerned with the subjects of momentum transport (fluid mechanics), energy transport (heat transfer with conduction, convection, and radiation), and mass transport (molecular and convective diffusion in fluids, and solid state diffusion in solids). The course is composed of two parts. Part I will provides an introduction to fluid flow, heat transfer, and mass transfer. It includes governing equations and boundary conditions for studying materials processing. Part II covers the several specific applications to materials processing with a brief description of various materials processing technologies polymer processing, rheology, and bulk and surface heat treating. Students will also be exposed very briefly to the numerical simulation of transport equations through finite difference formulations and coding with MATLAB. By the end of the course, students will gain mathematical modeling skill that is fundamentally important to have a better understanding of engineering problems involving momentum, heat and mass transport.

Teaching Staff

	Instructor	**Teaching Assistant**
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Course Schedule

Lectures:
- Thursday 11.40 – 13.30
- Friday 14.40 – 15.30

Recitation:
- Tuesday 17.40 – 18.30

Textbook and Reference Materials

I will use my own lecture notes compiled from different resources.
Textbook:
- R. Byron Bird, Warren E. Stewart, Edwin N. Lightfoot, Transport Phenomena, 2nd Edition, Wiley

Reference Materials:
- James Welty, Charles E. Wicks, Robert E. Wilson, Gregory L. Rorrer, Fundamentals of Momentum, Heat, and Mass Transfer, Wiley; 4 edition (November 2, 2000)
- Anthony F. Mills, Mass Transfer, Prentice Hall
- Sindo Kou, Transport Phenomena and Materials Processing, Wiley

Exams

- Midterm exam and final exam will be classical paper-and-pencil type will be proctored via zoom.
- Date is announced at the tentative outline section
- Make-up exams will be given only to students with valid excuses. To take a make-up exam you need to present a document about your excuse such as a medical report or a letter taken from the department/university administration.

Assignments

- There will be 8 homework assignments.
- Assignments should be written clearly. Diagrams or graphs should be given when necessary. They should be clearly labeled and contain enough information so that they can stand-alone.

Project

- You will be assigned a project on finite-difference formulations and coding to numerically solve a transport problem.
- MATLAB is suggested as the coding platform but you can use any platform for coding after talking to the instructor.
- You will submit your source code and a report to state your formulations, discrete form of equations, knowns, unknowns, etc.

Grading

Following is the list of items that will contribute to your final grade. Percentages are up to change and will be finalized at the end of the semester.

- Midterm 25 %
- Final 35 %
- Assignment 20 %
- Project 10 %
- Quiz 10 %

Course Policies

- Classes will be synchronous via zoom live sessions and will be recorded and videos will be shared.
- Attendance to live sessions is required for your own benefit. It is imperative that you review the coverage of previous weeks prior to coming to class to increase your understanding of the materials to be covered in the class.
- Working with others to learn the material is strongly encouraged. However, it is strictly forbidden to copy answers from one another without putting your efforts to solve them. All graded materials (assignments and project) are intended to be solved or prepared individually. Any instance of giving or receiving aid on these issues will be viewed as a serious offence, which may result in a failing grade for the course and/or referral to the University disciplinary system
- Plagiarism
  - Definition: the practice of taking someone else's work or ideas and passing them off as one's own.
  - Proper citing is suggested to avoid plagiarism

Tentative Outline

Week 1 – Oct. 8th, Oct 9th

A brief introduction to transport phenomena
Mathematical preliminaries

Week 2 – Oct. 15th, Oct 16th

Mathematical preliminaries
HW1

Week 3 – Oct. 22nd, Oct 23th

Introduction to Fluid Flow
Newton's law of viscosity
Convective momentum transport
HW2

Week 4 – Oct 30th

Shell momentum balances: Flow of a falling film
Shell momentum balances: Flow through a circular tube
Multiphase flow

HW3

Week 5 – Nov. 5th, Nov. 6th

Equation of continuity
Equation of motion
Flow equations in integral form: Reynolds Transport Theorem
HW4

Week 6 – Nov. 12th, Nov. 13th

Introduction to Energy balance
Shell energy balance

Week 7 – Nov. 19th, Nov. 20th

Midterm exam
Shell energy balance
HW5

Week 8 – Nov. 26th, Nov. 27th

Heat diffusion equation
Heat conduction in a cooling fin
HW6

Week 9 – Dec. 3rd, Dec. 4th

Finite difference form of the heat equation: Energy balance method
Project 1 assignment

Week 10 – Dec. 10th, Dec. 11th

Applications of Transport Phenomena in Materials Processing: injection molding

Week 11 – Dec. 17th, Dec. 18th

Applications of transport Phenomena in Materials Processing: resin transfer molding
HW7

Week 12 – Dec. 24th, Dec. 25th

Introduction to mass transport

Week 13 – Dec. 31st

Applications of Transport Phenomena in Materials Processing
Mathematical Models for Selected Materials Processing Technologies
HW8

Week 14 – Jan. 7th, Jan. 8th

Applications of Transport Phenomena in Materials Processing: transport equations for biosensors