North Dakota State University
Department of Mechanical Engineering
ME 763 "Advanced Transport Phenomena" (3 credits)

Spring 2023

Instructor: Dr. Yechun Wang, Dolve 210, Phone: 701-231-6732, Email: yechun.wang@ndsu.edu

Class Time: MWF 11 – 11:50 am, **Class Location**: Dolve 202

Office Hours: Fridays 2-3 pm

Prerequisites: Admission to the graduate program

Course (Bulletin) Description:

Advanced topics in combined heat, mass and momentum transport, with applications to energy and biomedical systems.

Course Objectives:

Advances in energy and biomedical engineering require the development and operation of complex devices that involve multi-physical phenomena. This course leads discussions in heat, mass, and momentum transfer theory, and their combinations, from the viewpoint of transport phenomena. Besides a review of the fundamentals of fluid mechanics, this course will focus on conservations of heat and mass transfer, conduction and diffusion problems, forced-convection heat and mass transfer problems, multicomponent energy and mass transfer, surface tension driven motion such as Marangoni effect, with applications to complex situations in traditional or alternative energy systems, pharmaceutical or biomedical systems.

Student Resources:

Textbook is not required for this course. Materials will be taken from various sources and will be presented in class. Some materials will be shared on BlackBoard. Please make sure you have access to this course on the Black Board website. Suggested reference books are as follows:

1. "Analysis of Transport Phenomena" by W. M. Deen, Oxford University Press, 1998
2. "Transport Phenomena" by R. B. Bird, W. E. Stewart, and E. N. Lightfoot, John Wiley & Sons, Inc, 2002

Evaluation Procedures and Criteria:

Your level of success in attaining the anticipated course outcomes will be assessed during the semester by homework assignments, a midterm exam, project, and a final exam. The format of your solutions in the afore-mentioned work should be in acceptable engineering form including labeled drawings of the system considered.

(a) Homework

Homework is due at the beginning of the class. There will be a 30% grade deduction if the homework is submitted after the due time and before the solution is posted, unless arrangements are made in advance (at least 24 hours prior to the beginning of the class when the homework is due). After the solution is posted on NDSU blackboard or discussed in class, no homework will be accepted. Copying homework solutions is forbidden. Students involved in copying homework or projects will be penalized.

(b) Examinations

All examinations will be comprehensive of covered materials. Students who fall ill, or who know they will be missing an exam for a valid reason (e.g. Family emergency) are encouraged to notify the instructor by email prior to the exam, if at all possible, and then make arrangement for making up the exam. Students missing an exam without prior notification and a valid excuse will receive a grade of zero for that exam.

(c) Course Project

A list of course project options and instructions will be provided for students. Projects will be applications of transport phenomena in energy or biomedical systems. A group of 2-3 students will select a single topic to work on and inform the instructor their choice by the 3rd week of the semester. Student groups are welcome to propose and work on their own projects outside of provided project list, with the approval of the instructor. Each project group is expected to deliver progress reports in the form of presentations in classes during the semester, a final presentation and a project paper at the end of the semester.

Grading Policy:

Items	Weights
Homework	30%
Mid-term Exam	20%
Final Exam	20%
Project	30%

The final course grade will be assigned per the following absolute scale:

$A \geq 90\%$, $90\% > B \geq 80\%$ $80\% > C \geq 70\%$, $70\% > D \geq 60\%$, and $60\% > F$.

Additional Information:

- **Attendance**

According to NDSU Policy 333 (www.ndsu.edu/fileadmin/policy/333.pdf), attendance in classes (in-person) is expected. Veterans and student service members with special circumstances or who are activated are encouraged to notify the instructor as soon as possible and are encouraged to provide Activation Orders.

- **Auditing of Graded Work:**

Students are welcome to discuss their evaluations. Auditing of a work must be made within **one week** after the evaluation result has been provided to the student. Contact the instructor during office hours to discuss grade problems.

- **Americans with Disabilities Act for Students with Special Needs Statement**

Any students with disabilities or other special needs, who need special accommodations in this course, are invited to share these concerns or requests with the instructor and contact the Disability Services Office (www.ndsu.edu/disabilityservices) as soon as possible.

- **Veterans and Student Soldiers**

Veterans and student service members with special circumstances or who are activated are encouraged to notify the instructor as soon as possible and are encouraged to provide Activation Orders.

- **Academic Dishonesty:**

The academic community is operated on the basis of honesty, integrity, and fair play. NDSU Policy 335: Code of Academic Responsibility and Conduct applies to cases in which cheating, plagiarism, or other academic misconduct have occurred in an instructional context. Students found guilty of academic misconduct are subject to penalties, up to and possibly including suspension and/or expulsion. Student academic misconduct records are maintained by the Office of Registration and Records. Informational resources about academic honesty for students and instructional staff members can be found at www.ndsu.edu/academichonesty.

Tentative Class Schedule (Very Tentative):

Topics	# Weeks
Overview and Introduction to Transport Phenomena	0.5
Momentum Transport / Review of Fluid Dynamics • Basic constitutive equations • Unidirectional flow and creeping flow • Laminar flow at high Reynolds number • Fluid mechanics at interfaces • Nondimensionalization and simplification of the Navier-Stokes equation	2
Project Selection	
Conservation equations of Heat and Mass Transfer • Basic constitutive equations • Conservation of mass • Conservation of energy • Heat transfer at interfaces • Mass transfer at interfaces	3
Project Report (Presentations)	1
Midterm Exam on 3/6/2023 (Tentative)	
Forced-Convection Heat and Mass Transfer • Peclet number, Nusselt and Sherwood numbers • Scaling laws • Taylor dispersion • Heat and mass transfer in creeping flow	3
Project Report (Presentations)	1
Multicomponent Energy and Mass Transfer • Conservation of energy in multicomponent systems • Couple fluxes • Diffusion in dilute mixtures • Transport in electrolyte solutions	3
Project Paper Due on 4/21/2023	
Project Final Report (Presentations)	1
Interface Transport • Mass transfer to drops and bubbles • Effects of interfacial forces on heat and mass transfer	1
Final Exam on May 11, 8 am – 10 am	