

North Dakota State University
Department of Mechanical Engineering
ME 755 “Fluid Mechanics for Bio/Nanotechnologies” (3 credits)

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Class Time: MWF 9 – 9:50 pm, Dolve 202

Office Hours: Fridays 2-2:50 pm

Prerequisites: Admission to the graduate program; Knowledge in Fluid Dynamics and Thermodynamics would be helpful.

Course (Bulletin) Description:

Fundamental principles of fluid dynamics in micro- and nano-scales, with applications to nanotechnology and biotechnology.

Course Objectives:

Novel manufacturing processes and biotechnologies that can create small devices have been developed in recent years. The technology is progressing at a rate that far exceeds our understanding of the conventional physics involved in the manufacturing and operation of those miniaturized devices. The primary objective of this course is to critically review the status of the modern understanding of the fluid flow phenomena particular to micro- and nano-sized devices. Fundamentals of fluid dynamics in micro- and nano-scales will be studied. At the conclusion of the course students will be able to actively contribute to research projects that involve fluid handling in micro- and/or nano-scales. In addition, students will demonstrate growth and proficiency in professional skills and mindset development. Students will select a sub-set of learning objectives (see attached) tailored to their particular research project with guidance from their project’s faculty mentor.

Student Resources:

Materials will be taken from various sources and will be presented in class. Some materials will be shared on Black Board. Please make sure you have access to this course on the Black Board website. Suggested books or review papers are as follows:

1. “Micro- and Nanoscale Fluid Mechanics” by B. J. Kirby, Cambridge University Press, 2010.
2. “Microfluidics for Biotechnology” by J. Berthier and P. Silberzan, Library of Congress Cataloging-in-Publication Data, 2005.
3. “Analysis of Transport Phenomena” by W. M. Deen, Oxford University Press, 1998
4. “Transport Phenomena” by R. B. Bird, W. E. Stewart, and E. N. Lightfoot, John Wiley & Sons, Inc, 2002

Tentative Class Schedule:

<u>Week / Date</u>	<u>Objectives</u>	<u>Assignments</u>
1	Introduction to Discovery-Based-Learning, Incompressible Flow	
2	Viscosity, Boundary Conditions, Unidirectional Flow, Surface Tension	
3	Project Presentations	Eval 1
4	Dimensionless Analysis, Dispersing, Patterning, Mixing	
5	Project Presentations	Eval 2
6	Stokes Flow, Species Transport	
7	Project Presentations	Eval 3
8	Electroosmosis, Particle Electrophoresis	
9	Presentation Projects	Eval 4
10	Zeta Potential in Microchannels, Particle and Droplet Actuation	
11	Project Presentations	Eval 5
12	Microchip Chemical Separations	

13	Project Presentations	Eval 6
14	Nanofluidics	
15	Projects	
16	Projects	Eval 7

Evaluation Procedures and Criteria

Items	Weights
Evals	50%
Projects	40%
Homework	10%

Grading Policy

A ≥ 90%, 90% > B ≥ 80% 80% > C ≥ 70%, 70% > D ≥ 60%, and 60% > F.

Academic Honesty Statement

The academic community is operated on the basis of honesty, integrity, and fair play. All work in this course must be completed in a manner consistent with Code of Academic Responsibility and Conduct, 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.

Americans with Disabilities Act for Students with Special Needs

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 Accessibility and Disability Services Office (www.ndsu.edu/disabilityservices) as soon as possible.

Attendance Expectations

According to NDSU Policy 333 (www.ndsu.edu/fileadmin/policy/333.pdf), participation in all classes is expected. Students are expected to attend every class and remain in class for the duration of the session when it is safe to do so. Please do not come to class if you are feeling ill, particularly if you are experiencing COVID-19 symptoms. You will still need to complete the assignments, quizzes, exams, etc. necessary to meet class learning objectives. I will be flexible regarding deadlines for students who are experiencing illness or other challenges related to illness. Please contact me as early as possible if you think you may not be able to complete an assignment in time or participate in the course due to illness.

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.

If uncontrollable challenges appear, such as isolation, with instructor’s permission, virtual participation of classes is possible at <https://ndsu.zoom.us/j/95919081337>, **passcode: ME755**.

Copyright of Course Materials

In this course recording the lectures is prohibited with your own personal devices without prior express approval from the instructor. In this course recording the lectures for anything other than personal use is prohibited. Please refer to NDSU Policy 190 on Intellectual property.

Additional Resources for Students

As a member of the NDSU community, resources are available for you should you need help in dealing with adverse reactions to things happening in the world today. A variety of resources are listed below:

For students on campus and remotely (telehealth):

- Counseling Services: 701-231-7671; <https://www.ndsu.edu/counseling/>
- Disability Services: 701-231-8463; <https://www.ndsu.edu/disabilityservices/>
- Student Health Service: 701-231-7331; <https://www.ndsu.edu/studenthealthservice/>
- Dean of Students Office: 701-231-7701; <https://www.ndsu.edu/deanofstudents/>

In a crisis or emergency situation:

- Call University Police: 701-231-8998
- Call 9-1-1
- Go to a Hospital Emergency Room
- Go to Prairie St. Johns for a Needs Assessment: 701-476-7216 (510 4th St. S.)
- Call the FirstLink Help Line: 1-800-273- TALK (8255) or 2-1-1
- Call Rape and Abuse Crisis Center: 701-293-7273

DISCOVERY-BASED-LEARNING LEARNING REQUIREMENTS: Discipline Specific Knowledge

Requirement DSK1, Student will define the anticipated topics that they will learn. These have to be detailed and measurable. (1 pts)

Requirement DSK2, Lower level learning: Student will describe which of the elements of DSK1 that will be learned at the memorization, comprehension and application level. Student will indicate the forms of evidence to provide evidence of learning. (1 pts)

Requirement DSK3, Higher level learning: Student will describe which of the elements of DSK1 that will be learned at the analysis, evaluation and creation level. These have to be detailed and measurable. Student will indicate the forms of evidence to provide evidence of learning. The research project is the likely venue for demonstrating this knowledge. (1 pts)

Requirement DSK4, Freeform learning: Sometime opportunities will appear that cannot be planned. Provide evidence and level of learning to the faculty mentor and if appropriate to the class. (1 pts)

Note: Alterations to these requirements may be made throughout the semester after approval by the faculty mentor.

DISCOVERY-BASED-LEARNING LEARNING REQUIREMENTS: Fundamental Research Skills

Requirement FR1, Research method: Student will demonstrate growth and proficiency understanding the elements of the scientific method and apply it to their research project. Frequent peer review of their application of the scientific method is required. (1 pts)

Requirement FR2, Literature Review: Student will demonstrate growth and proficiency in reviewing literature in their research. Frequent peer review of the literature and how it relates to the research project is required. (1 pts)

Requirement FR3, Experimental Design: Student will demonstrate growth and proficiency in the development of the experiment or numerical method(s) used to solve their research problem. Frequent engagement in peer review is required. (1 pts)

Requirement FR4, Experimental equipment: Student will demonstrate growth and proficiency in understanding and implementing error analysis. Frequent peer review is required. (1 pts)

Requirement FR5, Intellectual merit: Student will demonstrate growth and proficiency in understanding the intellectual merit of their research. Frequent engagement in peer review is required. (1 pts)

Requirement FR6, Broader impact: Student will demonstrate growth and proficiency in understanding the broader impacts of their research. Frequent peer review is required (1 pts)

Requirement FR7, IRB/IACUC: Student will demonstrate growth and proficiency in understanding and certification for human and animal research. Frequent peer review of the ethical considerations involved in the student's research is required. (1 pts)

Requirement FR8, Lab Safety: Student will demonstrate growth and proficiency in obtaining proper lab safety considerations. (1 pts)

DISCOVERY-BASED-LEARNING LEARNING REQUIREMENTS: Mechanisms of Research Skills

Requirement MR1, Statistics: Student will demonstrate growth and proficiency the foundational statistical methods needed in their experiment. Frequent peer review of the statistical approach is required. (2 pts)

Requirement MR2, Experimental controls: Student will demonstrate growth and proficiency in understanding the nature of experiment controls. Frequent peer review of the experimental controls is required. (2 pts)

Requirement MR3, Data collection: Student will demonstrate growth and proficiency in the collection process needed in the experiment. Frequent peer review is required. (2 pts)

Requirement MR4, Data Analysis: Student will demonstrate growth and proficiency analyzing data using modern software tools. Frequent peer review is required. (2 pts)

Requirement MR5, Drawing Conclusions: Student will demonstrate growth and proficiency in the evaluation of results. Frequent peer review is required. (2 pts)

Requirement MR6, Knowing Nature of results: Student will demonstrate growth and proficiency in how the results relate to the field and across other fields. Frequent peer review is required. (2 pts)

DISCOVERY-BASED-LEARNING LEARNING REQUIREMENTS: Professional Communication Skills

Requirement PC1, Conference Abstract: Student will demonstrate growth and proficiency preparing an abstract and submission to a conference. Frequent peer review of the abstract is required. (1 pts)

Requirement PC2, Conference Poster: Student will demonstrate growth and proficiency in preparing a poster for presentation at a conference. Frequent peer review of the poster is required. (2 pts)

Requirement PC3, Conference Presentation: Student will demonstrate growth and proficiency in the preparation and delivery of a conference presentation. Frequent engagement in peer review is required. (3 pts)

Requirement PC4, Proposal Preparation: Student will demonstrate growth and proficiency preparing a research proposal for a fellowship, scholarship, or for assisting with a proposal preparation with their faculty mentor. Frequent peer review is required. (5 pts)

Requirement PC5, Journal manuscript: Student will demonstrate growth and proficiency in preparing a manuscript for submission to a referred journal. Frequent peer review of the manuscript is required. (5 pts)

Requirement PC6, Standard Operating procedure: Student will demonstrate growth and proficiency writing standard operating procedures or developing mathematical models for their faculty mentor's lab related to their research effort. Review of the SOP is required by a naive reviewer. (2 pts)

Requirement PC7, Outreach communication: Student will demonstrate growth and proficiency in communicating their research to a non-scientific/engineering audience such as K-12, development of learning session for underclassmen, and public dissemination. (1 pts)

Requirement PC8, Invention Disclosure: Student will demonstrate growth and proficiency in preparing invention disclosures and patents. (5 pts)

DISCOVERY-BASED-LEARNING LEARNING REQUIREMENTS: Research Mindset

Requirement RM1, Receiving Critique: Student will demonstrate growth and proficiency in receiving frequent constructive criticism of their work from peers and outside professionals. Frequent peer review is required. (1 pts)

Requirement RM2, Providing Critique: Student will demonstrate growth and proficiency in providing frequent constructive criticism of their peers' work. Frequent engagement in peer review is required. (1 pts)

Requirement RM3, Establishing Learning Requirements: Student will demonstrate growth and proficiency in designing their own learning requirements and correlating these with cognitive development taxonomy. Learning requirements will require feedback from a subject expert and refinement of their personalized learning model. (1 pts)

Requirement RM4, Team Conduct: Student will demonstrate growth and proficiency in contributing to the synergy of their team. Frequent peer review is necessary to improve team synergy. A team contract is necessary, where roles and responsibilities will be defined. (1 pts)

Requirement RM5, Mindset: Student will demonstrate growth and proficiency in their curiosity, ability to connect their work to the broader global context, and create value for themselves and others in their evidence of learning and their creative work. (1 pts)