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# MEC 512 Mechanics of Viscous Fluids

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**Spring 2022**

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**Lectures (in-person):** Thursdays 4:45-7:35 PM @ FREY222

**Office Hours (online):** Tuesdays 12PM - 1:15PM & Thursday: 3PM – 4:45 PM

Join Zoom Meeting

<https://stonybrook.zoom.us/j/6532557377>

Meeting ID: 653 255 7377

**Instructions:**

Lectures will be delivered in person, slides with lecture content and the reading materials will be provided via email before each lecture.

Homework assignments will be posted on SBU Blackboard and each student must upload their solutions in Blackboard before the deadline.

**Course Topics:** Fundamentals of microscopic physics of fluids. The origin and role of viscous forces in fluid flows. Physical and mathematical derivation of the Navier-Stokes equations and analytical solutions for static and dynamic problems. Newtonian and Non-Newtonian fluids. Capillary flows and wetting phenomena. Creeping flows and low Reynolds number behavior including Stokes flow, lubrication theory, imbibition, Darcy's law for porous media, and Brownian particles in fluids. Introduction to turbulent flows and high-Reynolds number behavior including steady and unsteady external flows and boundary layers. Special topics in micro/nanofluidics and complex fluids covered if time permits. **Emphasis will be placed on the connection between macroscopic descriptions and microscopic physical phenomena.**

**Credits:** 3

**Grade:** A-F; Final exam 40% + Midterm exam 30% + Homework assignments 30%

The final exam is administered on the date assigned by the registrar office without exemptions

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## Tentative Lecture Schedule

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week	Topic
1	<b>Viscous fluids: Introduction/Basic Concepts</b>
2	<b>The Navier-Stokes equations</b>
3	<b>Static equilibrium of fluids and fluid interfaces</b>
4	<b>Unidirectional flows</b>
5	<b>Laminar boundary layers &amp; Lubrication flows</b>
6	<b>Creeping flows I</b>
7	<b>Creeping flows II</b>
8	<b>Creeping flows III</b>
9	<b>Analytical methods for fluid flow</b>
10	<b>Basic numerical solutions for fluid flow</b>
11	<b>Turbulent flows I</b>
12	<b>Turbulent flows II</b>
13	<b>Special Topics: Micro/Nanoscale flows</b>
14	<b>Special Topics: Complex fluids</b>

### **Course Learning Outcomes/Objectives**

Upon completion of this course, students will be able to:

1. Understand macroscopic fluid properties such as viscosity, density, and pressure from a microscopic (atomistic) description
2. Understand the limitations of constitutive laws based on the Newtonian fluid assumption
3. Understand assumptions involved in deriving continuum-based descriptions for fluid motion
4. Understand the derivation of the Navier-Stokes equations (conservation laws for mass, momentum, and energy) for simple fluids.
5. Model and solve analytically static fluid problems involving wetting and liquid-fluid interfaces.
6. Model and solve analytically fluid flow problems for different geometries for low Reynolds numbers
7. Model fluid flow problems for simple geometries for high Reynolds numbers

### **Learning Objectives**

The objective of this course is to (1) learn the fundamentals physics involved in modelling fluids and hydrodynamic phenomena and (2) learn analytical techniques required to solve fluid flow equations for different geometries and flow conditions. The student will learn analytical solution techniques for diverse fluid problems, including lubrication flows, boundary layers, and Stokes flow, in steady and unsteady conditions. Through learned analytical methods and basic numerical techniques presented in this course the students will be able to determine volumetric flow rates, shear and pressure drag, and lift forces for different geometric configurations. The course provides fundamental tools for professional engineers working in fluid mechanics.

## **Grading, Attendance, and Late Work Policies**

### **Assessment & Grading:**

- *30% Homework assignments*
- *30% Midterm Exam*
- *40% Final project*

**Letter Grades:**

Final grades assigned for this course will be based on the percentage of total points earned and are assigned as follows:

Letter Grade	GPA/Points	Performance
A	4.0	Excellent Work
A-	3.7	Nearly Excellent Work
B+	3.3	Very Good Work
B	3.0	Good Work
B-	2.7	Mostly Good Work
C+	2.3	Above Average Work
C	2.0	Average Work
C-	1.7	Mostly Average Work
D+	1.3	Below Average Work
D	1.0	Poor Work
F	0.0	Failing Work

**Late Work Policy:**

Late work submitted after the deadline will not be graded. You will be able to request via email up to 2 deadlines extensions for homework assignments during the semester. The extension request must be made before the deadline.

**Course and University Policies****Disability Support Services (DSS) Statement:**

If you have a physical, psychological, medical or learning disability that may impact your course work, please contact Disability Support Services, ECC (Educational Communications Center) Building, Room 128, (631)632-6748. They will determine with you what accommodations, if any, are necessary and appropriate. All information and documentation is confidential.

**Academic Integrity Statement:**

Each student must pursue his or her academic goals honestly and be personally accountable for all submitted work. Representing another person's work as your own is always wrong. Faculty are required to report any suspected instances of academic dishonesty to the Academic Judiciary. Faculty in the Health Sciences Center (School of Health Technology & Management, Nursing, Social Welfare, Dental Medicine) and School of Medicine are required to follow their school-specific procedures. For more comprehensive information on academic integrity, including categories of academic dishonesty please refer to the academic judiciary website at [http://www.stonybrook.edu/commcms/academic\\_integrity/index.html](http://www.stonybrook.edu/commcms/academic_integrity/index.html) **Important Note:** Any form of academic dishonesty, including cheating and plagiarism, will be reported to the Academic Judiciary.

**Critical Incident Management:**

Stony Brook University expects students to respect the rights, privileges, and property of other people. Faculty are required to report to the Office of University Community Standards any disruptive behavior that interrupts their ability to teach, compromises the safety of the learning environment, or inhibits students' ability to learn. Faculty in the HSC Schools and the School of Medicine are required to follow their school-specific procedures. Further information about most academic matters can be found in the Undergraduate Bulletin, the Undergraduate Class Schedule, and the Faculty-Employee Handbook.

**Understand When You May Drop This Course:**

It is the student's responsibility to understand when they need to consider disenrolling from a course. Refer to the Stony Brook Academic Schedule for dates and deadlines for registration:

[http://www.stonybrook.edu/commcms/registrar/calendars/academic\\_calendars](http://www.stonybrook.edu/commcms/registrar/calendars/academic_calendars)

**Incomplete Policy:**

Under emergency/special circumstances, students may petition for an incomplete grade. Circumstances must be documented and significant enough to merit an Incomplete. If you need to request an incomplete for this course, contact me for approval as far in advance as possible.

**Course Materials and Copyright Statement:**

Course material accessed from Blackboard, SB Connect, SB Capture or a Stony Brook Course website is for the exclusive use of students who are currently enrolled in the course. Content from these systems cannot be reused or distributed without written permission of the instructor and/or the copyright holder. Duplication of materials protected by copyright, without permission of the copyright holder is a violation of the Federal copyright law, as well as a violation of Stony Brook's Academic Integrity.

## **Online Communication Guidelines and Learning Resources:**

**Maintain Professional Conduct Both in the Classroom and Online:** The classroom is a professional environment where academic debate and learning take place. I will make every effort to make this environment safe for you to share your opinions, ideas, and beliefs. In return, you are expected to respect the opinions, ideas, and beliefs of other students—both in the face-to-face classroom and online communication. Students have the right and privilege to learn in the class, free from harassment and disruption. The course follows the standards set in the Student Code of Conduct, and students are subject to disciplinary action for violation of that code. If your behavior does not follow the course etiquette standards stated below, the grade you receive for a posting may suffer. I reserve the right to remove any discussion messages that display inappropriate language or content.

### **Online Post Etiquette:**

- Offensive language or rudeness will not be tolerated. Discuss ideas, not the person.
- Avoid cluttering your messages with excessive emphasis (stars, arrows, exclamations).
- If you are responding to a message, include the relevant part of the original message in your reply, or make sure to refer to the original's contents so as to avoid confusion;
- Be specific and clear, especially when asking questions.
- Use standard punctuation and capitalization. Using all UPPERCASE characters gives the appearance of shouting and makes the message less legible;
- Remember that not all readers have English as their native language, so make allowances for possible misunderstandings and unintended discourtesies.

**Online Classes Require Better Communication:** It is important to remember that we will not have the non-verbal cues that occur in a face-to-face classroom. I cannot see the confused, frustrated, or unhappy expressions on your face if you encounter problems. **You MUST communicate with me so that I can help.** To make the experience go smoothly, remember that you're responsible for initiating more contact, and being direct, persistent, and vocal when you don't understand something.

**My Role as the Instructor:** As the instructor, I will serve as a "guide" in terms of the Discussion Board. While I will not respond to every post, I will read what is posted, and reply when necessary. Expect instructor posts in the following situations:

- To assist each of you when it comes to making connections between discussion, lectures, and textbook material.
- To fill in important things that may have been missed.
- To re-direct discussion when it gets "out of hand".
- To point out key points or to identify valuable posts.

### **Student Learning Resources:**

- **Academic and Transfer Advising Services:** Have questions about choosing the right course? Contact an advisor today. Phone: (631) 632-7082 (option 2); email: [advising@stonybrook.edu](mailto:advising@stonybrook.edu); website: <http://www.stonybrook.edu/commcms/advising/>
- **Amazon @ Stony Brook:** Order your books before classes begin. Phone: (631) 632-9828; email: [Bookstore.Liaison@stonybrook.edu](mailto:Bookstore.Liaison@stonybrook.edu); website: <http://www.stonybrook.edu/commcms/bookstore/>
- **Bursar:** For help with billing and payment. Phone: (631) 632-9316; email: [bursar@stonybrook.edu](mailto:bursar@stonybrook.edu); website: <http://www.stonybrook.edu/bursar/>
- **Career Center** The Career Center's mission is to support the academic mission of Stony Brook University by educating students about the career decision-making process, helping them plan and attain their career goals, and assisting with their smooth transition to the workplace or further education. Phone: (631) 632-6810; email: [sbucareercenter@stonybrook.edu](mailto:sbucareercenter@stonybrook.edu); Website: <http://www.stonybrook.edu/career-center/>
- **Counseling and Psychological Services:** CAPS staff are available by phone, day or night. <http://studentaffairs.stonybrook.edu/caps/>
- **Disability Support Services:** Students in need of special accommodations should contact DSS. Phone: (631) 632-6748; email: [dss@stonybrook.edu](mailto:dss@stonybrook.edu); <http://www.stonybrook.edu/commcms/studentaffairs/dss/>
- **Library:** Access to online databases, electronic journals, eBooks, and more!
  - **Library Instruction Website** - <http://library.stonybrook.edu/workshops-this-week-citation-skills-worldcat-and-endnote-the-hsc/>
  - **SBU Library Research Guides and Tutorials** <http://library.stonybrook.edu/research/research-basics/>
- **Registrar:** Having a registration issue? Let them know. Phone: (631) 632-6175; email: [registrar\\_office@stonybrook.edu](mailto:registrar_office@stonybrook.edu); <http://www.stonybrook.edu/commcms/registrar/>
- **Writing Center:** Students are able to schedule face-to-face and online appointments. <https://www.stonybrook.edu/writingcenter/>
- **Support for Online Learning** <http://www.stonybrook.edu/commcms/onlineed/student.html>
- **Ombuds Office** The Stony Brook University Ombuds Office provides an alternative channel for confidential, impartial, independent and informal dispute resolution services for the entire University community. We provide a safe place to voice your concerns and explore options for productive conflict management and resolution. The Ombuds Office is a source of confidential advice and information about University policies and procedures and helps individuals and groups address university-related conflicts and concerns. <http://www.stonybrook.edu/ombuds/>

**Critical Incident Management and COVID**

Stony Brook University expects students to respect the rights, privileges, and property of other people. Faculty are required to report to the Office of Student Conduct and Community Standards any disruptive behavior that interrupts their ability to teach, compromises the safety of the learning environment, or inhibits students' ability to learn. Until/unless the latest COVID guidance is explicitly amended by SBU, during Spring 2022 "disruptive behavior" will include refusal to wear a mask during classes.

For the latest COVID guidance, please refer to:

<https://www.stonybrook.edu/commcms/strongertogether/latest.php>