CVEN 678-600
Fluid Dynamics for Ocean and Environmental Engineering
Fall 2006, MWF 1:50-2:40 in CE 219

Instructor : Dr. Scott A. Socolofsky
Office : Wisenbaker 235-F
Office hours : To be announced...check the website for an update
Telephone : (979) 845-4517
E-mail : socolofs@tamu.edu

Fluid Dynamics for Ocean and Environmental Engineering. (3-0). Credit 3. Central conservation laws; Navier-Stokes equations; steady and unsteady Bernoulli’s equation; potential flow theory and basics of panel methods; laminar and turbulent boundary layer; dispersion and diffusion processes in laminar and turbulent flow; flow past a body of any shape. Prerequisite: CVEN 462 or approval of instructor.

The objective of this course is to develop an understanding of the principles of hydrodynamics, especially intuition and ingenuity, and to apply these principles to solve problems in

- The study of hydrodynamic forces applied on a moving body in an unbounded flow by application of viscous and potential flow theories (surface wave effects ignored).
- The study of diffusion and dispersion effects on mass transport.

1 Textbooks and Other Resources

There is one required textbook for this course:


There will also be a number of handouts during the semester. Two important online resources will also be helpful for studying the material. The first is an online book by the instructor on the topic of Environmental Fluid Mechanics. We will cover the first three chapters in the book, and it can be downloaded from


The second important online resource is a set of lecture notes put together by Prof. C. C. Mei at the Massachusetts Institute of Technology. These notes are available at
Among the many other good textbooks on this subject, the following books are also recommended:


2 Tentative course calendar

The following table presents a tentative course calendar. In addition to the weekly class meeting times, two important dates should be noted:

- Midterm Exam 1: Friday, October 27, 1:50–2:40 p.m.
- Final Exam: Tuesday, December 12, 3:30–5:30 p.m.

During the semester, a few lectures will be cancelled because of my travel or to accommodate activities where many students will be absent. These days will be made up by a few 75 minute lectures that will be scheduled so that all students can attend.

In the following table, the sections in the Reading column are from Currie (2003) except for those sections preceded by an “S,” which are from Socolofsky & Jirka (2005). Reading should be completed before the relevant lecture.

<table>
<thead>
<tr>
<th>Date</th>
<th>Lec.</th>
<th>Topic</th>
<th>Reading</th>
<th>HW Due</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td><strong>Introduction and Governing Equations</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8/28</td>
<td>1</td>
<td>Introduction and tensor algebra review</td>
<td>handout</td>
<td></td>
</tr>
<tr>
<td>8/30</td>
<td>2</td>
<td>Continuum hypothesis and Eulerian/Lagrangian viewpoints</td>
<td>1.1-1.3</td>
<td></td>
</tr>
<tr>
<td>9/1</td>
<td>3</td>
<td>Physical meaning of vorticity and Reynolds transport theorem</td>
<td>3.4, 1.5</td>
<td></td>
</tr>
<tr>
<td>9/4</td>
<td>4</td>
<td>Conservation of Mass and Momentum</td>
<td>1.6-1.7</td>
<td></td>
</tr>
<tr>
<td>9/6</td>
<td>5</td>
<td>Stress tensor constitutive equations; relation between stress and strain rate</td>
<td>1.9-1.12</td>
<td></td>
</tr>
<tr>
<td>9/8</td>
<td>6</td>
<td>Navier-Stokes equations</td>
<td>1.13, 1.15-1.16</td>
<td>HW1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>Lec.</th>
<th>Topic</th>
<th>Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/11</td>
<td>7</td>
<td>Exact solutions: Couette and Poiseuille flow</td>
<td>7.1-7.2</td>
</tr>
<tr>
<td>9/13</td>
<td>8</td>
<td>Viscous thin film on an incline: exact equations</td>
<td>handout</td>
</tr>
<tr>
<td>9/15</td>
<td>9</td>
<td>Viscous thin film on an incline: Thin film approximation</td>
<td>handout</td>
</tr>
<tr>
<td>9/18</td>
<td>10</td>
<td>Introduction to boundary layer theory</td>
<td>9.1</td>
</tr>
<tr>
<td>9/20</td>
<td>11</td>
<td>Boundary layer equations and Blasius solution</td>
<td>9.2-9.3</td>
</tr>
<tr>
<td>9/22</td>
<td>12</td>
<td>Von Karman’s momentum integral approximation</td>
<td>9.8-9.9</td>
</tr>
</tbody>
</table>

(continued)
<table>
<thead>
<tr>
<th>Date</th>
<th>Lec.</th>
<th>Topic</th>
<th>Reading</th>
<th>HW Due</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/25</td>
<td>13</td>
<td>Properties and measures of turbulence</td>
<td>handout</td>
<td></td>
</tr>
<tr>
<td>9/27</td>
<td>14</td>
<td>Reynolds average Navier-Stokes equations; Reynolds</td>
<td>handout</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>stresses</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9/29</td>
<td>15</td>
<td>Turbulent boundary layer on a flat plate</td>
<td>handout</td>
<td></td>
</tr>
<tr>
<td>10/2</td>
<td>16</td>
<td>Law of the wall</td>
<td>handout</td>
<td></td>
</tr>
<tr>
<td>10/4</td>
<td>17</td>
<td>Velocity defect law</td>
<td>handout</td>
<td></td>
</tr>
<tr>
<td>10/6</td>
<td>18</td>
<td>Turbulent drag on a flat plate</td>
<td>handout</td>
<td>HW3</td>
</tr>
<tr>
<td>10/9</td>
<td>19</td>
<td>Effect of an external pressure gradient and tendency</td>
<td>handout</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>for separation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10/11</td>
<td>20</td>
<td>Friction drag on an immersed body</td>
<td>handout</td>
<td></td>
</tr>
<tr>
<td>10/13</td>
<td>21</td>
<td>Impulsive motion of a blunt body and tendency for</td>
<td>handout</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>separation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Environmental Fluid Transport

<table>
<thead>
<tr>
<th>Date</th>
<th>Lec.</th>
<th>Topic</th>
<th>Reading</th>
<th>HW Due</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/16</td>
<td>22</td>
<td>Transport equation: Conservation of heat and passive</td>
<td>S1.1-1.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>tracer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10/18</td>
<td>23</td>
<td>Fourier and Fick’s Law constitutive equations</td>
<td>S1.2</td>
<td></td>
</tr>
<tr>
<td>10/20</td>
<td>24</td>
<td>Instantaneous point source solution to the advective</td>
<td>S1.3-2.1</td>
<td>HW4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>diffusion equation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10/23</td>
<td>25</td>
<td>Initial concentration distribution and fixed</td>
<td>S2.2-2.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>concentration solutions to the advective diffusion</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>equation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10/25</td>
<td>26</td>
<td>Turbulent diffusion and dye tracer studies</td>
<td>S3.1-3.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>and viscous flows</td>
<td></td>
<td></td>
</tr>
<tr>
<td>makeup</td>
<td>27</td>
<td>Introduction to shear flow dispersion</td>
<td>S3.3</td>
<td></td>
</tr>
<tr>
<td>makeup</td>
<td>28</td>
<td>Advective dispersion equation and dispersion coefficients</td>
<td>S3.3-3.4</td>
<td></td>
</tr>
</tbody>
</table>

### Potential Flows

<table>
<thead>
<tr>
<th>Date</th>
<th>Lec.</th>
<th>Topic</th>
<th>Reading</th>
<th>HW Due</th>
</tr>
</thead>
<tbody>
<tr>
<td>makeup</td>
<td>29</td>
<td>Kelvin’s theorem, irrotational flows, and the velocity</td>
<td>5.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>potential</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11/6</td>
<td>30</td>
<td>Bernoulli’s theorem</td>
<td>3.2</td>
<td></td>
</tr>
<tr>
<td>11/8</td>
<td>31</td>
<td>3D solutions to the velocity potential</td>
<td>5.3-5.6</td>
<td></td>
</tr>
<tr>
<td>11/10</td>
<td>32</td>
<td>Stream function and 2D potential flows</td>
<td>4.1-4.4</td>
<td>HW5</td>
</tr>
<tr>
<td>11/13</td>
<td>33</td>
<td>Conformal mapping and additional 2D potential flow</td>
<td>4.7, 4.12</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>solutions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11/15</td>
<td>34</td>
<td>Green’s function and Green’s theorem</td>
<td>handout</td>
<td></td>
</tr>
<tr>
<td>11/17</td>
<td>35</td>
<td>Forces on a 2D body: Blasius integral laws</td>
<td>4.10</td>
<td></td>
</tr>
<tr>
<td>11/20</td>
<td>36</td>
<td>Forces on a 3D body and D’Alembert’s paradox</td>
<td>5.12</td>
<td></td>
</tr>
<tr>
<td>makeup</td>
<td>37</td>
<td>Forces induced by singularities</td>
<td>5.13</td>
<td></td>
</tr>
<tr>
<td>11/24</td>
<td>—</td>
<td>Thanksgiving day, no classes</td>
<td>5.13</td>
<td></td>
</tr>
<tr>
<td>11/27</td>
<td>38</td>
<td>Kinetic energy of a moving fluid</td>
<td>5.14</td>
<td></td>
</tr>
<tr>
<td>11/29</td>
<td>39</td>
<td>Added mass coefficients</td>
<td>5.15</td>
<td></td>
</tr>
<tr>
<td>12/1</td>
<td>40</td>
<td>Properties of added mass coefficients</td>
<td>handout</td>
<td>HW6</td>
</tr>
<tr>
<td>12/4</td>
<td>41</td>
<td>Review</td>
<td>handout</td>
<td></td>
</tr>
</tbody>
</table>

12/12/  | —    | **Final Exam**: Comprehensive final exam from 3:30–5:30 p.m. |
3 Homework Assignments

Homework assignments, designated above as HW in the course calendar, will be problem sets. These will be hand-written assignments solving problems related to the lecture material. These assignments will be graded by the instructor and returned in a timely manner. The problems in the homework will be similar to exam problems, but often with more details than can be covered in a one-hour exam.

You may ask others for help at places where you have made diligent attempts and have become stumped. You may ask others for confirmation of results at significant milestones in the problem. However, homework submissions are to be as individuals; please do not copy (see Plagiarism below).

Homework due dates will be announced when the homework assignment is distributed. No late homework will be accepted.

4 Grading

Your final grade for the course will be calculated as follows:

- Homework : 30 %
- Midterm exam : 30 %
- Final exam : 40 %

Late homework assignments will not be accepted without a University Excused Absence. For absence policies, please read Part I, Rule 7 of the Texas A&M University Student Rules at

- http://student-rules.tamu.edu/

5 Class Participation and Quizzes

You are expected to attend all classes, turn in all assignments, and complete all exams at their scheduled times. Exceptions are only permitted for University Excused Absences as described above in Grading.

Classes will start on time, and pointers for the homework assignments and last-minute changes to the schedule may be announced in class. It is your responsibility to be in class to receive this information or to get the information from another student.

6 Exams

One 50-minute midterm exam and one two-hour final exam are scheduled (see Course Calendar above for scheduling). The grading of the exams will be based on both the approach and the final answer. Exams will be closed book and closed notes.

7 Plagiarism and Cheating

Please read Section 20 of the Texas A&M University Student Rules at

No form of scholastic dishonesty (cheating, plagiarism, etc.) will be tolerated. As commonly defined, plagiarism consists of passing off as one's own the ideas, words, writings, etc., which belong to another. In accordance with this definition, you are committing plagiarism if you copy the work of another person and turn it in as your own, even if you should have permission of that person. Since the homework grade for this course is a high percentage of your total grade, no plagiarism or cheating will be permitted in the homework.

8 Absences

The university views class attendance as an individual student responsibility. Students are expected to attend class and to complete all assignments. Please read Part I, Rule 7 of the Texas A&M University Student Rules at


Please contact me as soon as you know you will miss a class or an exam so that a reasonable alternative can be accommodated. Unexcused absences will result in a grade of zero for the missed work.

9 Americans with Disabilities Act (ADA)

The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation, please contact the Department of student Life, Services for Students with Disabilities in Room 126 of the Koldus Building, or call 845-1637.
OCEN 678-600 Fall, 2006
Student Information Card

Name: ____________________________________________
UIN: ____________________________________________
E-mail: ____________________________________________

List previous Fluids courses you have taken:
________________________________________________________________________
________________________________________________________________________

What topic(s) do you most want to learn in this course:
________________________________________________________________________
________________________________________________________________________

You are a (circle one): Ph.D. Student   M.S. Student   M.E. Student

What degree major have you declared:
________________________________________________________________________

Please fill out the following table by marking through any times below in which you are NOT available for a make-up lecture period.

Table 2: Schedule for Fall, 2006

<table>
<thead>
<tr>
<th>Time</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>