CHE 514 (4 Cr.) – Fluid Flow

Winter Quarter 2015
School of Chemical, Biological, and Environmental Engineering
Oregon State University
2015.01.05

COURSE SYLLABUS

Instructor: Travis Walker
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Dates: 2015.01.05-2015.03.13
Lectures: CRN 33488: M 1100-1250
Classroom: Furman 202
Recitation: WF 1400-1550
Classroom: Furman 202

Course Description: (CRN: 33488) CHE 514. FLUID FLOW (4). Fundamentals of fluid dynamics with an emphasis on transport phenomena on small-length scales appropriate to applications in microfluidics, complex fluids, and biology. The basic equations of mass, momentum, and energy are derived for incompressible fluids and simplified to the slow-flow limit. Topics include solution techniques utilizing expansions of harmonic and Green's functions; perturbation theory (regular and singular); singularity solutions; flows involving rigid particles and fluid droplets; applications to suspensions; lubrication theory for flows in confined geometries; slender body theory; and capillarity and wetting. Lec/rec. **PREREQS:** CHE 525.

CHE 514 is the required fluid mechanics course for first-year graduate students in the OSU chemical engineering program. The course content focuses on the fundamentals of viscous fluid flow. Major lecture topics are detailed in the Lecture Outline.

Students are expected to have completed some undergraduate coursework in the transport phenomena, including fluid flow. Students are also expected to be proficient in calculus and differential equations, particularly analytical solution of ordinary differential equations (e.g., MTH 256), and to have successfully completed CHE 525 (Chemical Engineering Analysis).

Website: `https://oregonstate.instructure.com/`
(Please make sure you have access to the Oregon State Instructure website, since all course materials and announcements will be available there.)

Prerequisites: CHE 525

Required Textbook:

Leal, L.G. *Advanced Transport Phenomena: Fluid Mechanics and Convective Transport Processes*. Cambridge University Press (2010). ISBN 978-0521179089.

Recommended Textbook:

Bird, R.B., Stewart, W.E., Lightfoot, E.N. *Transport Phenomena*, 2nd ed. John Wiley & Sons, New York (1999). ISBN 0-47011-539-4.

Other Textbooks:

Abramowitz, M., I.A. Stegun. *Handbook of Mathematical Functions: with Formulas, Graphs, and Mathematical Tables.* Dover (1965). Web Link.
Batchelor, G.K. *An Introduction to Fluid Dynamics.* Cambridge University Press (2000).
Berg, J.C. *An Introduction to Interfaces and Colloids: The Bridge to Nanoscience.* World Scientific (2009).
Boyce, W.E., R.C. DiPrima. *Elementary Differential Equations and Boundary Value Problems.* Wiley (2009).
de Gennes, P-G., F. Brochard-Wyar, D. Quere. *Capillarity and Wetting Phenomena: Drops, Bubbles, Pearls, Waves.* Springer (2004).
Greenberg, M.D. *Foundations of Applied Mathematics*. Dover (2013).
Happel, J., Brenner, H. *Low Reynolds Number Hydrodynamics*. Prentice-Hall, Englewood Cliffs, NJ (1965).
Hinch, E.J. *Perturbation Methods*. Cambridge University Press (2002).
Lamb, H. *Hydrodynamics*, 6th ed. Cambridge University Press (1932).
Kim, S., Karrila, S.J. *Microhydrodynamics: Principles and Selected Applications*. Buttersworth-Heinemann, Boston (1991).
Slattery, J.C. *Advanced Transport Phenomena*. Cambridge University Press (1999).
Varma, A., Morbidelli, M. *Mathematical Methods in Chemical Engineering*. Oxford University Press (1997).

Course Grading:

Homework	20%
Group Project	20%
Midterm Examination I	15%
Midterm Examination II	15%
Final Examination	30%

Grade Policy: Homework received up to 24-hours late will receive 50% credit. Homework received beyond 24-hours late will receive 0% credit. Group work on homework is permitted, but each student must turn in his or her own individual assignment with a list of contributors.

Grading: If you determine that a regrade is necessary, the entire assignment will be regraded.

Final performance percentage will be assigned a minimum letter grade by the following scale (implying that the percentage requirements for a particular grade may be decreased at the instructors' sole discretion but will not be increased):

90-100	A
80-90	B
70-80	C
60-70	D
0-60	F

Course Overview & Objectives: By the end of the course, a student will be able to do the following:

- Develop a fundamental knowledge base for using vectors and tensors while being introduced to Einstein notation.
- Derive the conservation laws including the Reynolds transport equation, develop constitutive equations, and understand the boundary conditions necessary to solve transport systems.
- Experience the usefulness of dimensional analysis (Buckingham Π), similarity solutions, perturbation theory, boundary layer theory, and stability theory.
- Obtain a fundamental understanding of unidirectional and one-dimensional flow, asymptotic approximations, thin-gap (lubrication) approximations, and creeping flow.

Course Structure:

Communication:

The Canvas announcement tab (CRN 53577) will be used to distribute information, while email to ONID addresses will be used for course communication. All scores will be posted in the Canvas grade center.

Lectures:

Lectures will be used for the following:

- Content instruction,
- Project presentations,
- Two midterm exams, and
- Exam feedback and questions.

Attendance in lectures is expected. You are expected to be punctual and to minimize disruptions. Cell-phones need to be off during class. Also, no use of laptops or other electronic

devices for activity outside of its use in this class will be tolerated. If you miss a class, you are responsible for obtaining lecture notes from other students.

While the University is a place where the free exchange of ideas and concepts allows for debate and disagreement, all classroom behavior and discourse should reflect the values of respect and civility. Behaviors that are disruptive to the learning environment will not be tolerated. As your instructor, I am dedicated to establishing a learning environment that promotes diversity of race, culture, gender, sexual orientation, and physical disability. Anyone noticing discriminatory behavior, or who feels discriminated against, should bring it to the attention of the instructor or other University personnel as appropriate.

Recitations:

Recitations will be used for the following:

- Content instruction,
- Project presentations,
- Homework feedback and questions,
- Exam feedback and questions.

Homework:

Homework will be due on Fridays at 1400. Homework will be assigned every other week. To increase efficiency in the grading process, homework will be graded in the following manner.

✓+	excellent
✓	satisfactory
✓-	unsatisfactory
0	not submitted

To aid in the understanding of the information, complete solutions will be posted to Canvas following the submission of the homework. Inquiries will be directed to these solutions for comparison to the returned homework, while further discussion will be saved for office hours and recitations.

Group Project:

A course project will be completed by groups of one, two, or three (1, 2, 3) students depending on the number of students in the course. The project will be used as an overall assessment of the students' understanding of key concepts described throughout the course. The deliverable will consist of an oral presentation during Week 10 of the course. Further information will be distributed in a separate document entitled Project Description.

Exams:

Three exams will exist for this course: two in-class midterms during a lecture period and one take-home final during the last week of class. The tentative dates of the exams are the following:

- Midterm I: Week 4, Monday, 2015.01.26 from 1100-1250 in class
- Midterm II: Week 7, Monday, 2015.02.16 from 1100-1250 in class
- Final: Week 10 & 11, from Friday, 2015.03.06 to Wednesday, 2015.03.16 at 2000

During exams you may only use your copy of the required textbook and any materials provided during the course. You cannot "share" a textbook during an exam or use copies of pages from the book. Laptops, calculators, or phones are not allowed during exams.

Make-up exams will only be allowed in the case of documented emergencies or with prior authorization from the instructor. If you must miss one of the exams for an emergency situation, please let the instructor know as soon as possible (travis.walker@oregonstate.edu). You will not have an opportunity to make up the exam without an approved reason.

Dates:

- **Classes:**
  January 05, 07, 12, 14, 21, 23
  February 02, 04, 09, 11, 16, 18, 23, 25
  March 02, 04, 09, 11
- **No Classes:**
  January 19 (Martin Luther King, Jr., Day)
- **Recitations:**
  January 09, 16, 30
  February 06, 13, 20, 27
  March 06, 13
- **Important Dates:**

Add/Drop Deadline	2015.01.16
Midterm I	2015.01.26 1100-1250
Midterm II	2015.02.16 1100-1250
Withdraw Deadline	2015.02.20
Final Exam	2015.03.06 – 2015.03.16 2000

Tentative Course Outline (2015.01.05):

Lecture Topic	Reading*
0. Cartesian vectors and tensors & Einstein (indicial or index) notation	BSL App A V&M Ch 1.1-12
1. Conservation laws, constitutive equations, and boundary conditions	LGL Ch 2
HW Set #1 due 2015.01.16	
Midterm Exam I (Topics 0 & 1) on 2015.01.26	
2. Unidirectional and one-dimensional flow problems	LGL Ch 3
HW Set #2 due 2015.01.30	
3. Introduction to asymptotic approximations	LGL Ch 4
HW Set #3 due 2015.02.13	
Midterm Exam II (Topics 2 & 3) on 2015.02.16	
4. Thin-gap approximation – Lubrication problems	LGL Ch 5 (& 6)
HW Set #4 due 2015.02.27	
5. Creeping flow – two-dimensions and axisymmetric problems	LGL Ch 7
Final Exam (Topics 0 – 5) due 2014.06.06	

*BSL: Bird, Stewart, & Lightfoot; LGL: Leal; V&M: Varma & Morbidelli

OSU STATEMENTS:

From the Office of the Dean of Students (1995.12.13): Behaviors which are disruptive to the learning environment will not be tolerated, and will be referred to the Office of the Dean of Students for disciplinary action. Behaviors which create a hostile, offensive or intimidating environment based on gender, race, ethnicity, color, religion, age, disability, marital status or sexual orientation will be referred to the Affirmative Action Office.

Web link : `http://oregonstate.edu/admin/stucon/index.htm`

Statement Regarding Students with Disabilities Accommodations are collaborative efforts between students, faculty and Disability Access Services (DAS). Students with accommodations approved through DAS are responsible for contacting the faculty member in charge of the course prior to or during the first week of the term to discuss accommodations. Students who believe they are eligible for accommodations but who have not yet obtained approval through DAS should contact DAS immediately at 737-4098.

Web link: `http://ds.oregonstate.edu/prospective/`

Academic Honesty Any instances of dishonesty in academic work will be treated according to OSU Academic Regulations. The Statement of Expectations for Student Conduct is given in the OUS OAR #576-015-0020, accessible at the following link:

Web link: `http://oregonstate.edu/studentconduct/home/`.

The policy is stated below:

> Academic or Scholarly Dishonesty is defined as an act of deception in which a Student seeks to claim credit for the work or effort of another person, or uses unauthorized materials or fabricated information in any academic work or research, either through the Student's own efforts or the efforts of another.
>
> It includes:
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> (i) CHEATING - use or attempted use of unauthorized materials, information or study aids, or an act of deceit by which a Student attempts to misrepresent mastery of academic effort or information. This includes but is not limited to unauthorized copying or collaboration on a test or assignment, using prohibited materials and texts, any misuse of an electronic device, or using any deceptive means to gain academic credit.
> (ii) FABRICATION - falsification or invention of any information including but not limited to falsifying research, inventing or exaggerating data, or listing incorrect or fictitious references.
> (iii) ASSISTING - helping another commit an act of academic dishonesty. This includes but is not limited to paying or bribing someone to acquire a test or assignment, changing someone's grades or academic records, taking a test/doing an assignment for someone else by any means, including misuse of an electronic device. It is a violation of Oregon state law to create and offer to sell part or all of an educational assignment to another person (ORS 165.114).
> (iv) TAMPERING - altering or interfering with evaluation instruments or documents.
> (v) PLAGIARISM - representing the words or ideas of another person or presenting someone else's words, ideas, artistry or data as one's own, or using one's own previously submitted work. Plagiarism includes but is not limited to copying another person's work (including unpublished material) without appropriate referencing, presenting someone else's opinions and theories as one's own, or working jointly on a project and then submitting it as one's own.

ACCESSING COE PROGRAMS AND DOCUMENTS 2015.01.05:

1. **Verify that you have a valid OSU ONID and ENGR computing account.** More information on getting access to and using ENGR computing resources is available here:
   `http://engineering.oregonstate.edu/computing/gettingstarted/224`
   To create an ENGR computing account (if you have not done so already),
   (a) go to `https://secure.engr.oregonstate.edu:8000/teach.php`
   (b) select "Create a new account" at the bottom of the screen.
   (c) follow the prompts to create your ENGR account.
   It is strongly suggested that you immediately log in and verify that you can access the Web, printers, etc. from your ENGR account.
   If you are working from off-campus, you will need to access COE systems through the secure Virtual Private Network (VPN).
   For more information and to download software to set up the VPN, please visit `http://oregonstate.edu/helpdocs/network/vpn-campus-access`
2. **You must have a laptop computer with access to wireless networks and which is capable of running Microsoft Excel and MATLAB.** You will lose points for any lab section that you do not have a laptop with access to Excel and MATLAB.
   Access to a laptop computer is a requirement for students in the OSU College of Engineering (c.f., `http://engineering.oregonstate.edu/laptop-requirements`).
   For general information about OSU COE computing resources, visit `http://engineering.oregonstate.edu/computing/personal`.
   If you need help with your ENGR account, setting up your laptop, installing software, or access to the ENGR wireless network, please contact the COE Wireless Helpdesk. The Helpdesk is located in Dearborn 120A and is open from 9AM - 11PM, 7 days a week. `http://engineering.oregonstate.edu/computing/personal/155`
3. **MATLAB can only be installed on your personal laptop by the COE Wireless Helpdesk in Dearborn.**
4. **Microsoft Office is made available for free by OSU.** Obtain installation access using the following URL.
   `http://oregonstate.edu/office365`
5. **Accessing MATLAB and MS Office through Citrix/XenApp Web (no need to purchase Microsoft Office)**
   Both MATLAB and Microsoft Office (including Excel) can be accessed remotely, at no cost, from COE servers using the Citrix or XenApp Web mechanisms.
   Citrix and XenApp allow you to run a wide variety of software applications on your PC or Mac system, as well as some iOS, Android and Chrome-based devices. A convenient Web-based interface makes access to the applications simple and can be accessed at `https://apps.engr.oregonstate.edu/Citrix/EngineeringWeb/`.
   You will need to install the Citrix Receiver software to use applications on the Citrix servers. Follow the directions at the site below to get started with Citrix: `http://engineering.oregonstate.edu/computing/citrix/`

If you need help with any of these steps, please contact the OSU College of Engineering Helpdesk: `http://engineering.oregonstate.edu/computing/policies/155` or `https://secure.engr.oregonstate.edu/forms/contact.php?to=support`