ENSC 3233: FLUID MECHANICS
OKLAHOMA STATE UNIVERSITY
Spring 2009

INSTRUCTOR

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Email: gbrown@okstate.edu, *If you email me please put "**ENSC 3233**:" at the start of the subject line.*

OFFICE HOURS

Please use the TA help hours for homework assistance. For any other problem, I have an open door policy. Drop in anytime, or contact me by phone or email if you want a specific appointment time.

TIME AND PLACE

Lectures and examinations: MWF 9:30 to 10:20 a.m., EN 108
Discussion sessions: **Mondays** at the following times and places:

Section	Time	Room
1	10:30 a.m. - 11:20 a.m.	PS 121
2	11:30 a.m. - 12:20 p.m.	EN 107
3	12:30 p.m. - 1:20 p.m.	EN 107
4	3:30 p.m. - 4:20 p.m.	EN 514
5	4:30 p.m. - 5:30 p.m.	EN 514
6	2:30 p.m. -3:20 p.m.	closed

TA Help Hours: Tuesday and Thursday (location TBA). You can get help from any TA, not just your own. TA schedules will be announced within one week.

PREREQUISITES

ENSC 2113 and MATH 2233 or concurrent enrollment

COURSE OBJECTIVES

1. Introduce the student to the fundamental theories and principles of fluid mechanics.
2. Develop practical problem solving skills in fluid mechanics.
3. Meet ABET Objectives as itemized in the ABET Addendum attached.

INSTRUCTION METHODS

1. Lectures
2. Problem discussion sessions with example problem solving
3. Individual instruction by TA

TEXTBOOK

Fundamentals of Fluid Mechanics, 6 ed., by Munson, Young, Okiishi and Huebsch. *4^{th} and 5^{th} editions are acceptable also.*

SCHEDULE

A tentative schedule is attached. Any significant changes will be announced in class.

LECTURE NOTES

Notes will be posted on the web at: biosystems.okstate.edu/home/gbrown/ENSC_3233

HOMEWORK

1. Assignments will be made in class at the beginning of lecture periods, usually each Wednesday.
2. Homework will be due ***before*** class on the specified due date, usually the next Wednesday.
3. Late homework will ***not*** be accepted.
4. Note the attached illustration problem:
   a) Problem done on ***engineering paper***.
   b) Start a **new page** for each problem.
   c) Students name at the top of the sheet.
   d) Problem number at the top of the sheet.

e) The equation or method of solution is given at the beginning.
f) Where appropriate, a suitable sketch should be drawn.
g) Note any assumptions or decisions needed for the solution.
h) Each numerical value used has an accompanying set of units.
i) The final answer is set apart by "**boxing in**".
j) The final answer is reported to the appropriate number of significant figures (usually two or three).

5. All sheets in a given assignment will be stapled and folded vertically, with the student's *name, date, discussion section number and problem numbers.*
6. Turn in assignments before class at the ENSC 3233 box in the NE entranceway to Eng. North.
7. You will be graded on organization, neatness, clarity of your solution and correct answer.
8. Your graded homework will be returned at the next discussion session.
9. Discuss any grading disparity with *your* discussion section TA.
10. Homework will be reviewed if needed in the discussion sessions and solutions will be posted on the due date on the bulletin board near the ENSC 3233 box.

EXAMINATIONS

1. There will be **three one-hour examinations** and a **comprehensive final**.
2. Exams will be given on the dates shown on the attached schedule. Any date changes will be officially announced one week ahead of time.
3. All exams will be **closed book**. However, for each hour exam, there will be detailed equation sheet for your use.
4. Students must supply their own pencils and calculator. **Calculators must conform to the NCESS specifications for the FE exam.** (Currently, Casio fx-115, HP 33, HP 35, TI-30X and TI-36X) During the exam, borrowing or sharing of anything - paper, calculators, etc. - is strictly prohibited.
5. As with homework, neatness and organization are an absolute must on exam problem solutions. If your work and logic cannot be easily followed, very often no credit can be given.
6. Graded exams will be returned and discussed during discussion sessions.
7. Questions on grading should be discussed with the teaching assistant during the session. If you feel your exam should be regraded, write the reasons why you think so and return this explanation to the teaching assistant with your exam. No exams will be regraded if they are not returned to the teaching assistant during the class hour in which they were distributed.

EXAM ABSENCES

1. You must take the exams as scheduled.
2. In exceptional circumstances such as a documented serious illness or an important school sponsored trip, an absence from a scheduled hour exam *may* be excused.
3. In order to be excused from a one-hour exam, the student must submit, as early as possible, a written explanation and justification for the absence, together with any documentation (physician's note, Athletic department request, etc.). This note should also have the student's name and ID number and the date submitted. The student must also sign it. It may be given to either professor, but not a TA.
4. **THE FINAL EXAM MUST NOT BE MISSED!**
5. I reserve the right to give *either* a make-up exam or to use instead the average of the student's other in-class exams adjusted relative to the class averages.
6. If a student has been excused from an hour exam and no make up exam is given, an estimated grade based on the student's other hour exams and the average class performance will be assigned. An example of this calculation is given below.

	Exam 1	Exam 2	Exam 3
Class Average	76	71	75
Student Score	86	Excused absence	73
Difference	10	-	-2

Average difference between student and class average = (10–2) / 2 = 4

Student score on Exam 2 = 71 + 4 = **75**

GRADING

Grading is based on a 600 points system as follows.

	Points
Exam 1	100
Exam 2	100
Exam 3	100
Final	200
Homework and Quizzes	100
Total Points	600

In order to allow you to put your performance into perspective as you progress through the course, note that grades are normally assigned with the following breaks.

A	85 to 100%
B	75 to 84.9%
C	65 to 74.9%
D	55 to 64.9%
F	0 to 54.9%

On occasion, the instructor has lowered one or more grade-breaks after the final. In no case will the grade-breaks be raised. In recent years the final class GPA has been about 2.9.

ATTENDANCE

The lectures are important. They are the best means we have to convey to you the qualitative knowledge and art of engineering. Students are expected to attend every class session and will be responsible for all material, announcements, schedule changes, etc., discussed in class. In class quizzes will be given on a regular basis.

I will make reasonable accommodation for students who are involved in sponsored activities of the University. Students that will be absent from class should provide reasonable notification of their planned absence to me, with written documentation from the designated University sponsor for that activity. I may require homework to be turned in ahead of the missed classes, and for examinations to be taken before the planned absence.

ACADEMIC INTEGRITY

I know most students are responsible and honest, and I will treat each of you accordingly. However, any act of dishonesty will result in disciplinary action up to and including assigning a semester grade of “F!".

I encourage students to work together on the homework, but direct copying from another's work is dishonest. Likewise, allowing someone to copy your work or test is dishonest. Use of a solution manual or old class notes for homework is prohibited and is considered plagiarism in this class. All cases of academic misconduct will be handled in accordance with University policies and regulations.

DROP POLICY

University policy regarding dropping this course during the semester will be followed. Look at the enclosed *Syllabus Attachment* for a list of important dates and policy.

SPECIAL PROBLEMS

If you have any special problems, such as health or learning disabilities, please let me know as soon as possible. Every effort will be made to make your learning experience reasonable and straightforward. See the enclosed *Syllabus Attachment* for additional information. *The earlier you tell me about a problem, the more and better solutions we will have at our disposal to solve it.*

ENSC 3233: Fluid Mechanics
Tentative Schedule
Spring 2009

Date	Topic	Chapter
January 12	Introduction	1
14	Systems of units	1
16	Properties of fluids	1
19	***Martin Luther King Day (Student Holiday)***	-
21	Pressure and the hydrostatic equation	2
23	Pressure gauges and manometers	2
26	Forces on submerged and floating objects	2
28	Bernoulli Equation	3
30	Fluid Kinematics	4
February 2	Reynolds Transport Theory	4
4	Conservation of mass	5
6	Conservation of momentum	5
9	Momentum applications	5
11	Conservation of energy	5
13	**EXAM 1**	**1 to 5**
16	Energy applications	5
18	Dimensional analysis	7
20	Similitude	7
23	Modeling	7
25	Viscous flow in pipes	8
27	Friction factors	8
March 2	Laminar flow	8
4	Turbulent flow, Moody chart	8
6	Minor losses	8
9	Piping systems	8
11	Flow measurement	8
13	**EXAM 2**	**5, 7 and 8**
14-22	***Spring Break***	9
23	Flow over immersed bodies, Lift and drag	9
25	Boundary layers	9
27	Drag on 2 & 3 D shapes	-
30	Drag applications	9
April 1	Compressible flow	11
3	Mach number and compressible flow	11
6	Isentropic flow	11
8	Isentropic flow Applications	11
10	**EXAM 3**	**9 & 11**
13	Open-channel geometry	10
15	Energy and critical flow	10
17	Uniform flow	10
20	Contractions and weirs	10
22	Pumps	12
24	Pump curves and operation	12
27	Pump cavitation	12
29	Review of course	
May 1	Review of course and Instructor Evaluation	
Monday May 4	**FINAL EXAM, 8:00 – 9:50 A.M.**	**All**

As long as most engineering calculations were done on slide rules, the question of numbers of significant figures seldom arose because the slide rule could only be read to three or four figures under the best of conditions. The introduction of computers and hand-held calculators has altered this. One can generate digits quite independently of whether these numbers have any meaning or not. *However, it is misleading, confusing, unprofessional and unpleasant to the eye to report answers to a greater degree of accuracy than is consistent with the input information and the basic equations.*

There is a limit to the accuracy of any engineering calculation. This limit arises from the uncertainties in the basic equations, differences between the design and actual operating conditions, and uncertainties in physical properties. Very few calculations in fluid flow are valid beyond the third "significant figure." Typically, inputs are just not measured or known more accurately than 1%.

"Significant figure" means a number that is likely to be correct. Thus, if we write 2.52 (three significant figures), we mean that the correct answer is more likely to be 2.52 than 2.53 or 2.51. It implies that the correct answer is less than 2.5205 and greater than 2.5195.

Rules for determination of significant figures in numbers

Normal Numbers: Any digit given, except as noted in the following paragraphs, may be assumed to be significant. Thus, 12.3 has *three* significant figures, while 12.3456789 has *nine*.

Leading Zeros: In the number 0.00702, none of the *leading* 0's are significant. They only serve to set the decimal point and imply nothing about the accuracy of the number. The first significant figure is the 7, and the entire number has only three significant figures.

Trailing Zeros: In the number 0.002020, the use of a trailing zero implies it is a significant figure. If a trailing zero is not significant, don't write it down. One exception occurs with trailing zeros. In practice, the number 1230 may have either three or four significant figures. In those cases, it is assumed the reader will know from experience, which it is.

Natural Numbers: Numbers such as π or the natural base *e* have as many significant figures as you enter.

Unit conversations: Most unit conversations, such as pounds to kilograms, are published to eight or more significant figures. Be sure to enter one significant digit more than your least significant real input to maintain accuracy.

Pure Numbers: The 1/2 used in the calculation of the area of a triangle (A=1/2*b*h) and other pure numbers arising from mathematical theory have an infinite number of significant figures. Usually, you may assume the reader knows they are pure numbers, and you need not write down trailing zeros.

Counting: When counting objects, significant figures may not strictly apply and you must use your engineering judgement. For example if you have six apples, there are 6 apples, not 6.00 apples.

Math operations with inputs having different numbers of significant figures

The result of a math operation may have a different number of significant figures than the inputs. In general, it may require a detailed error analysis to determine the number of significant figures. *However, we will assume the following rules of thumb.*

- The result of any multiplication, division, trigonometric, exponentiation, or logarithmic operation will have a number of significant figures equal to the *least* significant digits of the input. *(This rule is a little sloppy.)*

  Example: 12.3 * 1.234 = 15.2 (three significant figures)
  Example: sin(123.0) = 0.8387 (four significant figures)

- The result of an addition or subtraction will have significant figures equal to the *magnitude* of the least significant figure of the inputs.

  Example: 1.23 + 1.234 = 2.46 (three significant figures at 0.01 digit)
  Example: 12.34 + 1.234 = 13.57 (four significant figures at 0.01digit)
  Example: 1.23 - 1.234 = 0.00 (two significant figures at 0.01 digit)

Rules of thumbs for doing problems in this class

- Any number given in a problem has at least two significant figures.

Example: "A ball with a mass of 2 kg..." Assume the mass is 2.0 kg.

- Graphs can be read to the precision of ½ the axis divisions.

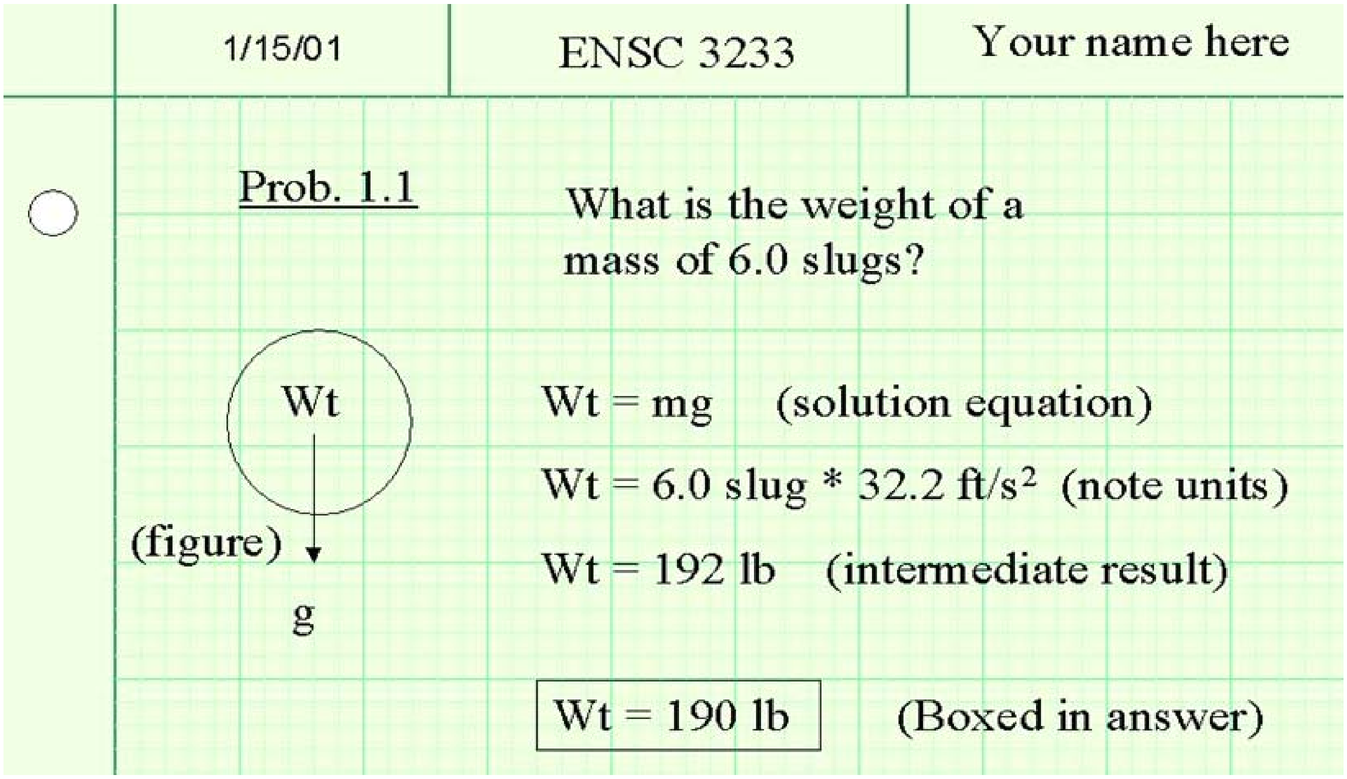
  Example: On Figure 8.20, page 413, *f* between 0.02 and 0.025 can be read to a precision of 0.0005.
  Example: On Figure 8.27, page 419, *K* can be read to a precision of 0.1.

- In almost all problems the results will have 2 or 3 significant figures.

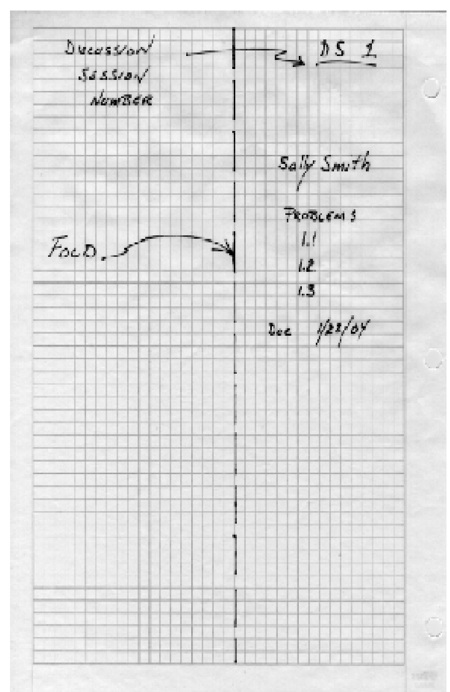
- *Do not assume that the textbook has used significant figures correctly.*

Common Steel Pipe Sizes

Nominal Size (in)	Outside diameter (in)	Schedule	Inside diameter (in)	Inside diameter (ft)	Area (ft^2)
1/8	0.405	40	0.269	0.0224	0.000395
		80	0.215	0.0179	0.000252
1/4	0.540	40	0.364	0.0303	0.000723
		80	0.302	0.0252	0.000497
3/8	0.675	40	0.493	0.0411	0.001326
		80	0.423	0.0353	0.000976
1/2	0.840	40	0.622	0.0518	0.00211
		80	0.546	0.0455	0.00163
3/4	1.050	40	0.824	0.0687	0.00370
		80	0.742	0.0618	0.00300
1	1.315	40	1.049	0.0874	0.00600
		80	0.957	0.0798	0.00500
1-1/4	1.660	40	1.38	0.115	0.0104
		80	1.28	0.107	0.0089
1-1/2	1.900	40	1.61	0.134	0.0141
		80	1.50	0.125	0.0123
2	2.375	40	2.07	0.172	0.0233
		80	1.94	0.162	0.0205
2-1/2	2.875	40	2.47	0.206	0.0332
		80	2.32	0.194	0.0294
3	3.500	40	3.07	0.256	0.0513
		80	2.90	0.242	0.0459
3 1/2	4.000	40	3.55	0.296	0.0687
		80	3.36	0.280	0.0617
4	4.500	40	4.03	0.336	0.0884
		80	3.83	0.319	0.0798
5	5.563	40	5.05	0.421	0.139
		80	4.81	0.401	0.126
6	6.625	40	6.07	0.505	0.201
		80	5.76	0.480	0.181
8	8.625	40	7.98	0.665	0.347
		80	7.63	0.635	0.317
10	10.75	40	10.02	0.835	0.548
		80	9.56	0.797	0.499
12	12.75	40	11.94	0.995	0.777
		80	11.37	0.948	0.706



Fold sheets lengthwise, and write your name, discussion section number problem numbers and due date. Turn in at box in Engineering North hallway, *before class on the due date*.



When you get your engineering degree from OSU, you will have a degree that is recognized nationally in both the private and public domain. Your degree is from an accredited program. The Accreditation Board for Engineering and Technology (ABET) is recognized in the U.S.A. as the sole agency responsible for accreditation of engineering programs leading to degrees. All programs are evaluated every 6 years or less. The ABET board is comprised of representatives from the professional engineering societies:

AAEE	American Academy of Environmental Engineers
ACSM	American Congress on Surveying and Mapping
AIAA	American Institute of Aeronautics and Astronautics
AIChE	American Institute of Chemical Engineers
ANS	American Nuclear Society
ASAE	American Society of Agricultural Engineers
ASCE	American Society of Civil Engineers
ASEE	American Society for Engineering Education
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASME	American Society of Mechanical Engineers
IEEE	Institute of Electrical and Electronic Engineers
IIE	Institute of Industrial Engineers
ISA	The International Society for Measurement and Control
NCEES	National Council of Examiners for Engineering and Surveying
NICE	National Institute of Ceramic Engineers
NSPE	National Society of Professional Engineers
SAE	Society of Automotive Engineers
SME	Society of Manufacturing Engineers
SME-AIME	Society for Mining, Metallurgy and Exploration, Inc.
SNAME	Society of Naval Architects and Marine Engineers
SPE	Society of Petroleum Engineers
TMS	The Minerals, Metals and Materials Society

You can learn more about ABET from the Internet, www.abet.org.

ABET requires the following program outcomes in the mechanical and aerospace disciplines. Other programs will have similar requirements. The bulleted segment indicates the relevance to this course (ENSC 3233 – Fluid Mechanics).

A. An ability to apply knowledge of mathematics, science and engineering appropriate to the mechanical and aerospace engineering disciplines.
- *This is largely what the course is about.*

B. An ability to design and conduct experiments, analyze and interpret data.
- *Some assigned homework problems require data interpretation.*

C. An ability to design a system, component, or process to meet desired needs.

D. An ability to function on teams, some of which require consideration of multiple disciplines.

E. An ability to identify, formulate and solve engineering problems.
- *In majority of homework problems you are being asked to solve engineering problems.*

F. An understanding of professional and ethical responsibility.
- *This course contributes. Professionalism and ethics are societal issues. You will be expected to behave appropriately.*

G. An ability to communicate effectively (written and oral).

H. The broad education necessary to understand the impact of engineering solutions in a societal context.

I. A recognition of the need for, and an ability to engage in, life-long learning.

J. A knowledge of contemporary issues.

K. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
- *You will use pertinent analytical techniques.*

L. A knowledge of chemistry and calculus-based physics with depth in at least one.

M. The ability to apply advanced mathematics through multivariate calculus and differential equations.
- *Some homework problems will require this ability.*

N. A familiarity with statistics and linear algebra.
- *Some homework problems may require this ability.*

O. The ability to work professionally in both thermal and mechanical systems areas including the design and realization of such systems.