16.540 CLASS FORMAT AND STRUCTURE

16.540 Notes
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MESSAGE

• Active learning (active engagement of students with the material during class) is helpful and useful in the learning process

• The conduct of the class is built around this idea
OVERALL VIEW OF 16.540

• Grad-H subject
• “Industrial strength fluid mechanics done in a rigorous manner”
• Strong emphasis on concepts, attributes, features of internal flow
• Modeling of real flows
  – Loss generation mechanisms
  – Unsteady flow
  – Rotating flow
• Most of these are topics students have not seen before
OVERALL COURSE LEARNING OBJECTIVES

• Development of “physical insight” into the phenomena which characterize internal flow in fluid machinery
  – Not just what happened, but why it happened

• Ability to define, in a rigorous manner, the levels of modeling needed for useful descriptions of a number of internal flow situations

• Ability to interpret numerical simulations and experimental results in terms of concepts and principles (as enumerated below)
IMPETUS FOR PEDAGOGY

• In the past, subject was taught:
  – From notes, on blackboard (initially)
  – Using viewgraphs and handouts
  – Using draft book sections, viewgraphs, and handouts

• Book (*Internal Flow: Concepts and Applications*) Spring 2004

• Main point: Students had equations, basic ideas, applications

• **What value does the instructor have?**
APPROACH

• We will emphasize concepts
• We will not “lecture”
• We will engage students in defining explicitly what they know and what they don’t
• We will engage students in helping define their own learning path
STRUCTURE

• Material will be assigned to be read before class
• “Concept questions” on material will be assigned before class
• You are urged to raise issues that are difficult
• We (students and instructors) will discuss concept questions in class
• There will be a number of “concept quizzes” to probe understanding
DIAGNOSTICS FOR STUDENT LEARNING

• Concept questions

• Concept quizzes

• Oral mid-term and oral final exam
  – Oral exams provide excellent insight into the degree to which concepts have been internalized

• Projects
SYLLABUS DESCRIPTION OF CONCEPT QUESTIONS

• In presenting the material from a different perspective, it is useful to pose Concept Questions which illustrate the points

• You will be asked to provide some of these

• You can work in groups of 3-4 so that there can be interchange and sharing of ideas

• Concept Questions (one per group per week) should be sent to us the week before we discuss the material in class
  – Questions to be submitted by 6pm on the Friday before the week in which the material is discussed
WHAT IS A CONCEPT QUESTION?
WHAT IS A CONCEPT QUESTION?

• Examples are given in the next slides

• General attributes are:
  – The question is based on the direct application of a fluid dynamic principle or characteristic
  – The question has an answer which can be stated simply
  – The answer can be reasoned without calculation
  – The question and its answer serve as analogies, or springboards, to other situations or classes of fluid motions
  – The arguments (train of logic) by which you came to the answer involve some approximations so their validity has limitations
  – You can articulate these approximations and the limits clearly
  – YOU CAN DEFINE THE CONCEPT(S) WHICH THE QUESTION ILLUSTRATES
CONCEPT QUESTION CONCERNING FLOW AROUND SHARP EDGES

• Will a “real fluid” follow the geometry at a sharp edge (will the fluid flow round the sharp edge?)

• Why or why not?

• What implications might this have for modeling such a flow using an inviscid (ideal fluid) description

• Have you seen such a description?

• Have you seen such a description for an internal flow? (Give an example)
CONCEPT QUESTION CONCERNING FLOW THROUGH A BENT TUBE

• Freely rotating bent tube, constant area $A$, volume rate of flow $Q$

• Flow entering at center $0$ and exiting through bent part

• What determines the rotation rate $\Omega$?

• What happens if there is inflow instead of outflow through bent tube?

• Does the device rotate? Why or why not?
WHAT IS NOT A CONCEPT QUESTION?

• How do I go from Equation (2.A) to Equation (2.B)?

• Is there a sign error in Equation (4.C)?

• Is there a $\rho$ missing in Equation (4.D)?

• Should there be a subscript on the velocity, $u$?

• I read a paper and there is something in there about vorticity. The figure looks interesting. I’ll put the figure in as a concept question.

• Here is a fluid phenomena that I don’t understand, but it looks as if it has something to do with upstream influence. I’ll get the answer when we discuss it in class.
TAYLOR-PROUDMAN THEOREM

- An amazing result for strongly rotating flow
- Any steady motion is two-dimensional!

- Rotating container of fluid
- Moving object takes with it a Taylor column extending the height of the container
POSSIBLE CONCEPT QUESTION

• You are responsible for training a fish to swim in the Olympics

• Would it be helpful to train him/her in a rapidly rotating container?

• Why or why not?
Concept Question: The picture is a top view of a fish swimming in a rotating water channel. The water is moving radially outward with a uniform relative velocity, \( w \). The fish has the same density as the surrounding fluid.

1. What does the fish need to do in order to swim upstream to location B, along the centerline, at a velocity \( w \) relative to the walls? When can rotation be neglected? (Non-dimensional criterion?)

2. Will this fish beat Prof. Greitzer's fish in the Olympics?
BLOOM’S TAXONOMY OF EDUCATIONAL OBJECTIVES

1. Knowledge
   - list, recite

2. Comprehension
   - explain, paraphrase

3. Application
   - calculate, solve

4. Analysis
   - predict, model, derive

5. Synthesis
   - design, invent, propose

6. Evaluation
   - judge, critique, justify

HOW DO WE DEVELOP CONCEPT QUESTIONS?

• The comment made in previous classes is that finding good questions is hard. *Tan and Greitzer totally agree.*

• You can approach the problem several ways
  – One is to start with a fluid dynamic situation that *calls out to you* that here is an illustration of concept X or concept Y or even, concept x, concept Y and the linking between them
  – Another is to start with a concept and try to find an instructive illustration of this (I want to find an illustration of baroclinic torque and the creation of vorticity in an industrial situation--I know, velocity field exiting a combustor)

• This is not an exact science
THE BOTTOM LINE

• This is not about the number of questions submitted per student

• It is not necessarily about finding an interesting fluid dynamic “wrinkle” (although that might be helpful in making a concept stick

• It is about helping you be able to make an explicit statement (to yourself) about what and how well you have learned, and can use, the material

• It is about helping you define (for yourself) what you have and have not mastered

• It is about making the subject material your own