16.540 CLASS FORMAT AND STRUCTURE

16.540 Notes
Spring 2006

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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?

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- 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

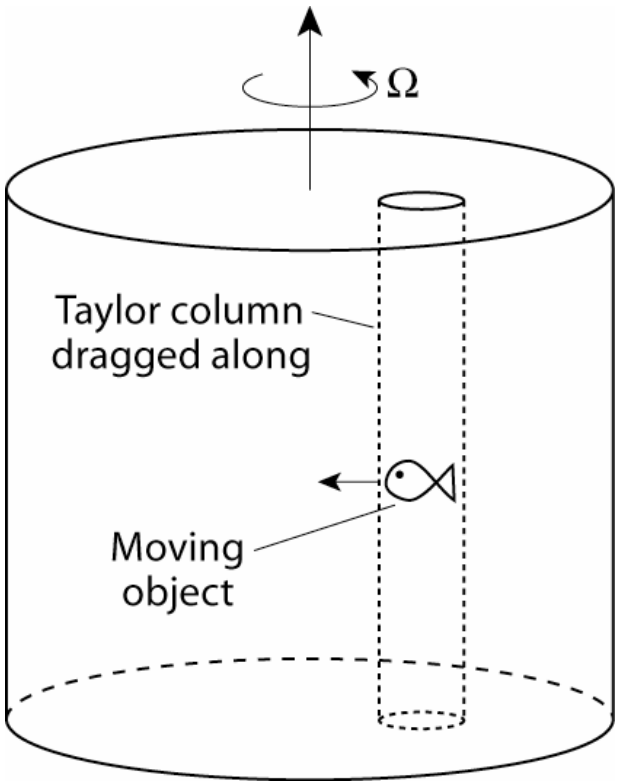
- What determines the rotation rate Ω?
- What happens if there is inflow instead of outflow through bent tube?
- Does the device rotate? Why or why not?

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 ρ 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

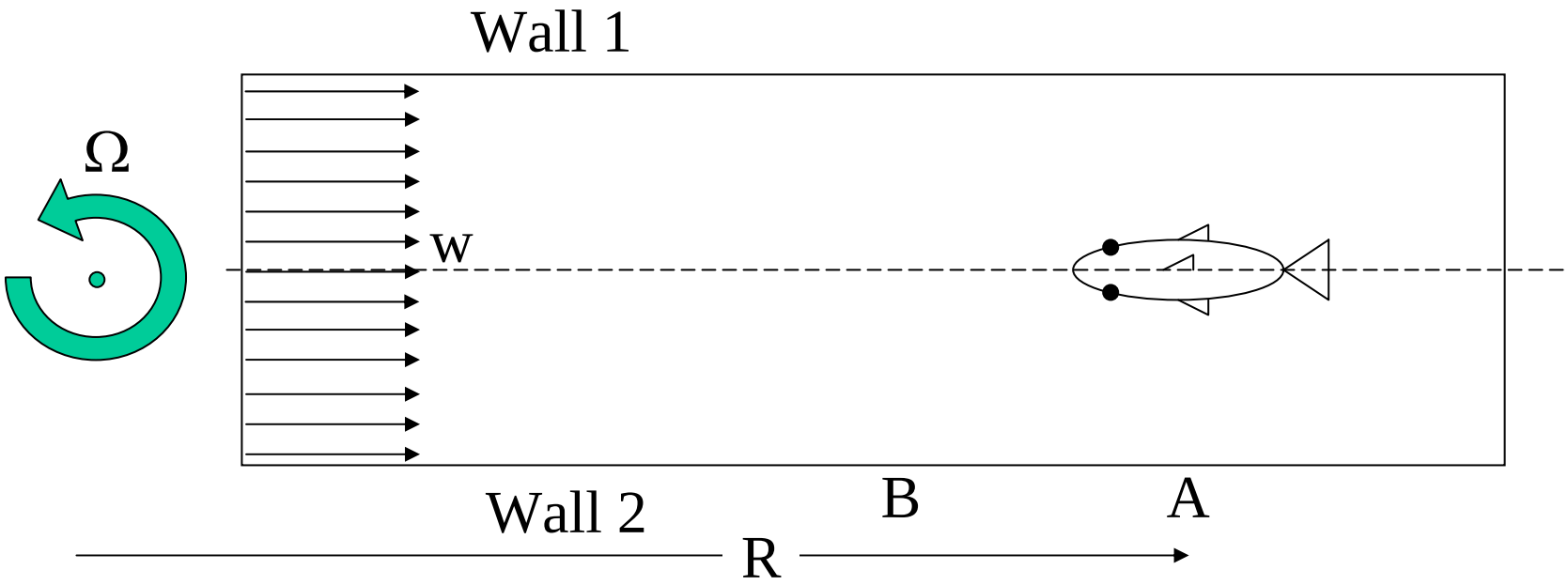
- An amazing result for strongly rotating flow
- Any steady motion is two-dimensional!



- 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?

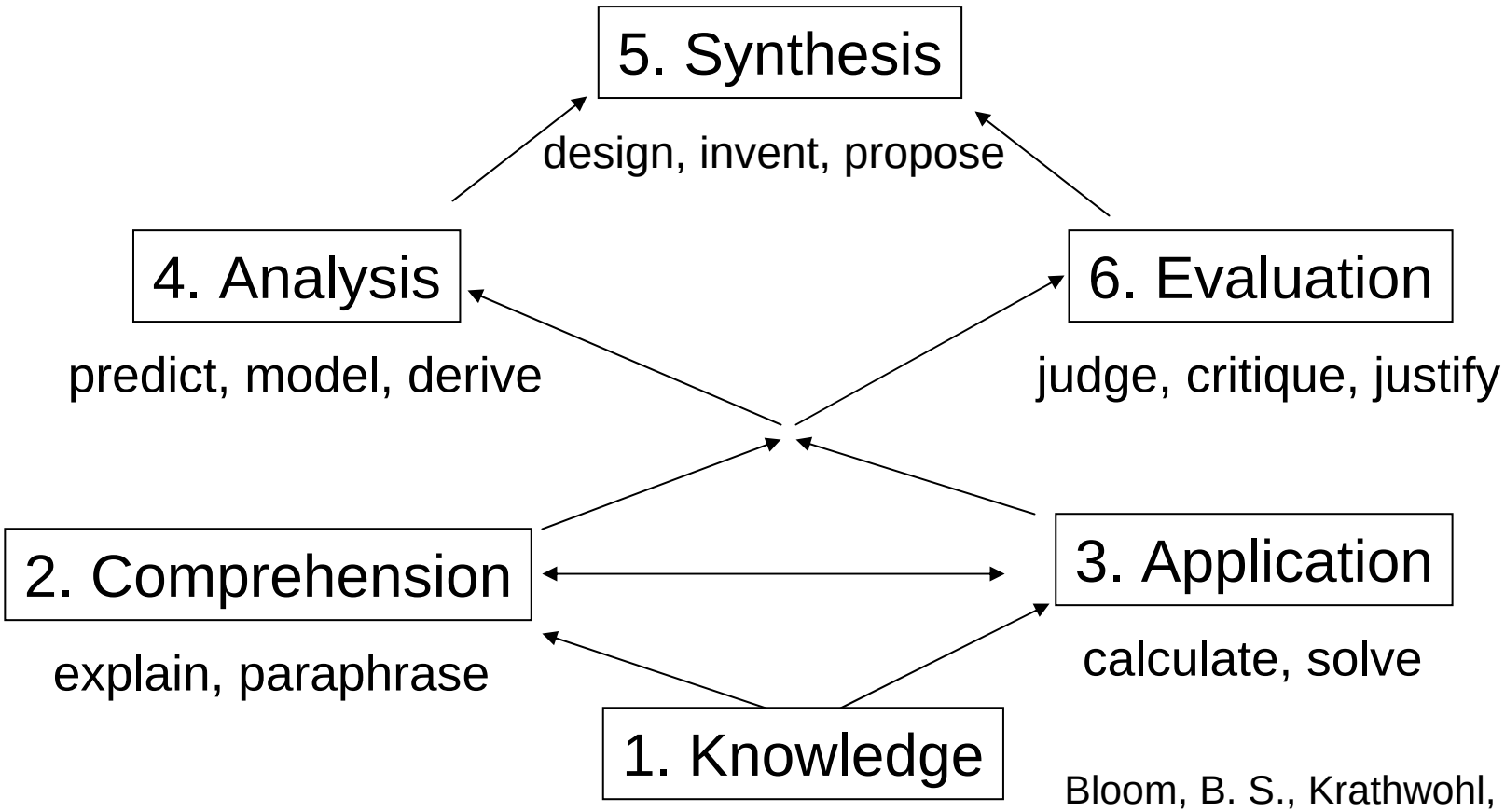


- Concept Question: The picture is a top view of a fish swimming in a rotating water channel. The water is moving radially outward with a uniform relative velocity, w. The fish has the same density as the surrounding fluid.

  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



Bloom, B. S., Krathwohl, D. R. (1984) *Taxonomy of Educational Objectives*, New York: Addison Wesley.

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**