CE 203

Fluid Mechanics

(Week 1):09/01/2017

Lecture 1

Introduction:

Welcome you all to the course on Fluid Mechanics.

- You have all studied:
  - Classical Mechanics
  - Engineering Mechanics
  - Solid Mechanics

- In the above courses, you have seen that, Mechanics consists of:
  - Statics, and
  - Dynamics.

- So, this course on Fluid Mechanics will also deal with studies on:
  - Fluids in rest (Fluid-Statics), and
  - Fluids in motion (Fluid-Dynamics).

- In solid mechanics (and other courses), you have seen the concepts on:
  - Force, acceleration,
  - Conservation of mass, linear momentum, angular momentum, energy, etc,
  - Deformation, Strain, Stress, etc.

- In Fluid Mechanics also, we will be revisiting the same terminology.

- So the question now is ***what is a fluid? How is Fluid mechanics different from solid mechanics?***

  "Fluid is an object occupying volume in space and that does not have independent shape."
  Fluids cannot resist shear unlike the solids.

- Fluids consist of:
  - Gases, and
  - Liquids.

(From the civil engineering point of view, we will be mostly dealing with liquids in this course).

- Fluids exist on earth and universe in most objects.

- It is not only Civil Engineering that deals with the mechanics of fluids.
  Several mathematicians, physics and chemistry scientists, other engineers, etc. too require knowledge of mechanics of fluids.

- In fact, the contributions from all of them were significant in the development of knowledge in fluid mechanics.

- You can readily visualize the applications of fluid mechanics in:
  - Domestic water pipe flows, oil pipe flows, etc.
  - Irrigation canals,
  - Power turbines, Pumps, Engines, etc.

- In Solid Mechanics, you were dealing with rigid bodies. You were dealing with deformation of the bodies, etc.
- However, in fluid mechanics, you will see that fluid is not rigid and also it is the rate of deformation that is significant in fluid mechanics.

- Though most of the theory studied in solid mechanics is applicable to fluids, mere theory may not be sufficient to mitigate concerns on fluid and its flows.
  "We need to develop workable theory that can be substantiated and/or developed based on experimental observations."

- The theory and experiments should go hand in hand.

- You may see, in such situations, many empirical relations that help in relating terms, based on experiments, without going into the intricacies of the physics involved.

- As a civil engineer, when you graduate from here, you may be asked to:
    - Design water pipe network,
    - Design irrigation canals,
    - Design hydropower capacity of a dam,
    - Design borewells, etc.

For these activities you should have a sufficient knowledge on fluid mechanics.

- Now, before going into the details of the subject, it is better to know the history of development of this subject and how the stalwarts and the eminent scientists have contributed to this subject.

Brief History

Without elaborating, let us see a brief historical development of the subject.

- Water is an essential commodity for mankind and you have seen that many ancient civilizations thrived on river banks.
- Whether be it Indus Valley Civilization on Egyptian Civilization or Persian Civilization, etc., the society there put emphasis on utilizing water as well as the capabilities of moving water.
- Archimedes (285-212 BC) had formulated laws of buoyancy.
- Leonardo Da Vinci (1452-1519 AD) put forward the concept of conservation of mass.
- Isaac Newton (1642-1727 AD) postulated laws on momentum. Also, introduced concepts on *viscosity*.
- Many other scientists like Bernoulli, Euler, Lagrange, Laplace, etc. contributed to the knowledge on fluid mechanics in 18^{th} century and 19^{th} century.
- There were also scientists like Chezy, Manning, Weber, Hagen, Poiseuille, Darcy, etc. who promoted experimental studies and came up with different observations.
- The experimental and theoretical scientists began to unify in the 19^{th} century and introduced:
    - Concepts on modeling, and
    - Dimensional analysis, etc.

    Scientists like Reynolds, Navier, Stokes, etc. were prominent among them.
- 20^{th} century saw enormous rise in knowledge and research on fluid mechanics.

Computational Fluid Mechanics is quite popular now and is used to analyze various fluid flow problems. You may see its applications in : Hydraulic engineering, channel flows, river engineering, chemical reactors, oil fields, etc.

The Course Syllabus

In this course, we will be using the following book as the course text book:

Fluid Mechanics by F.M. White (6^{th} – 7^{th} Edition)

The following book is used as reference text:

Fluid Mechanics by P.K. Kundu, I.M. Cohen, D.R. Dowling

The course will cover:

- Fluid properties,
- Introduction to tensorial concepts and index notations,
- Hydrostatic forces on plane and curved surfaces,
- Buoyancy and equilibrium,
- Stability and Meta-Centric height,
- Conservation principles through tensorial notations,
- Navier-Stokes equations,
- Flow through pipes,
- Turbulent flow,
- Boundary-layer concepts,
- Dimensional Analysis, etc.

The course is spanned for a total of 17 weeks including 1 mid-semester week and 1 end-semester week.

The student evaluation will be based on:

1. Tutorials (every week, total 11 tutorials),
2. Short quizzes (of 3 to 5 minute duration),
3. Mid semester exam,
4. End semester exam.

Attendance is compulsory and there will be no relaxation on rules (Minimum 75%)

All the Best