

INTRODUCTION TO DIFFERENTIAL ANALYSIS

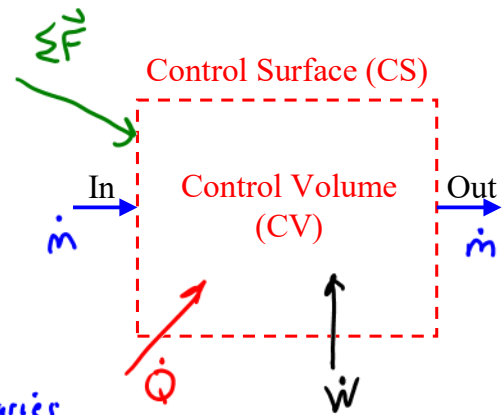
In this lesson, we will:

- Discuss/review the three main techniques to solve fluid flow problems
- Discuss **Flow Domains** and **Boundary Conditions**
- Explain the **Step-by-Step Procedure** for differential analysis of fluid flows

Techniques for Solving Fluid Flow Problems

1. Control volume analysis (Ch. 5, 6, 8 of Çengel and Cimbala, Ed. 4)

- Solve integral (CV) equations
- Calculate gross (overall) properties
e.g. total force, total power out
- Don't care about details inside the CV
- Treat CV as a "black box" → care about the boundaries

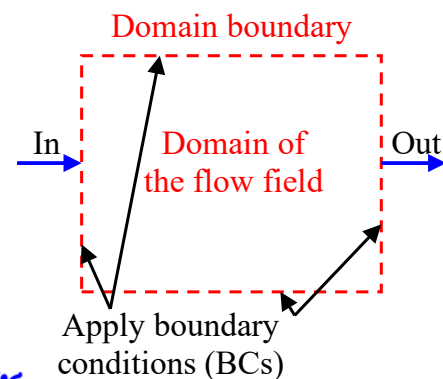


2. Dimensional analysis and experiment (Ch. 7 of Çengel and Cimbala, Ed. 4)

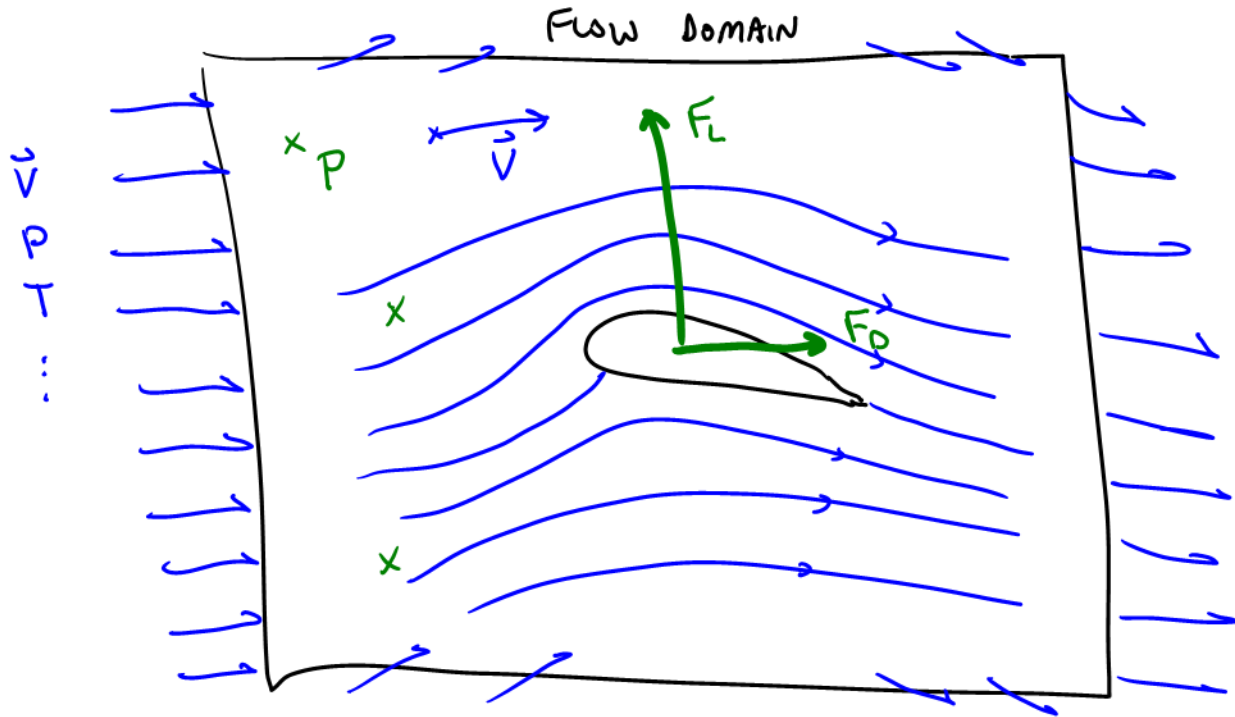
- Don't try to solve the equations at all
- Use dimensions → form nondimensional parameters
→ help us design experiments, get some Π relationships
- Then do experiment(s)

3. Differential analysis (Ch. 9, 10, 15 of Çengel and Cimbala, Ed. 4)

- Set up a domain
- Solve differential equations
- Specify Boundary Conditions
- Solve the eqs & BCs
 - Analytically
 - Using a computer (computational fluid dynamics) (CFD)
- Generate details inside the domain



Flow Domains and Boundary Conditions



Two ways to solve the differential equations

1) Analytically - limited to simple problems

2) Computationally - w/ CFD

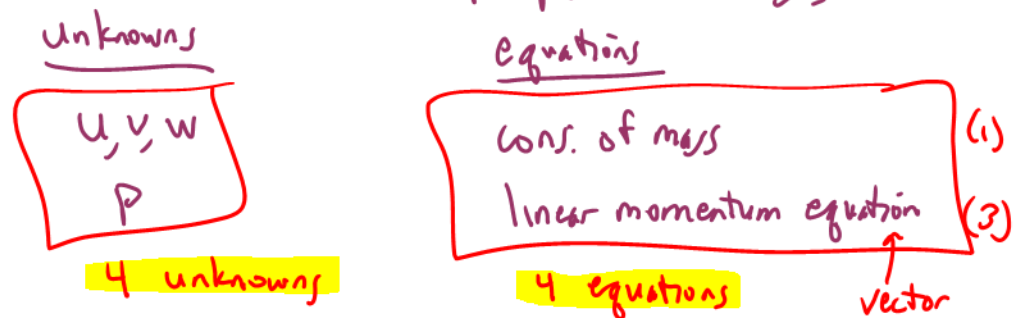
theoretically no limit for
complexity

Procedure for Differential Analysis

(nearly the same for analytical or CFD solutions)

- Step 1 Identify the flow geometry & flow domain
- Step 2 List assumptions & approximations (A & A)
& Boundary conditions (BCs)
- Step 3 List all appropriate differential equations
& unknowns

E.g., For 3-D incompressible flow w/o significant temperature changes



[add T & energy equation, plus ρ & eq. of state] vector eq.

- Step 4 Solve equations
 - Step 5 Apply BCs
- } often done simultaneously

With CFD, Steps 4 & 5 are switched

- Step 6 Verify the results (satisfy eqs & BCs)
- Step 7 Calculate other quantities of interest
(lift, drag, pressure drop, ...)