ME 57200 Aerodynamic Design

Lecture #24: Final Exam Review

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Announcements

- Project Final Report Due: Wednesday, 05/22

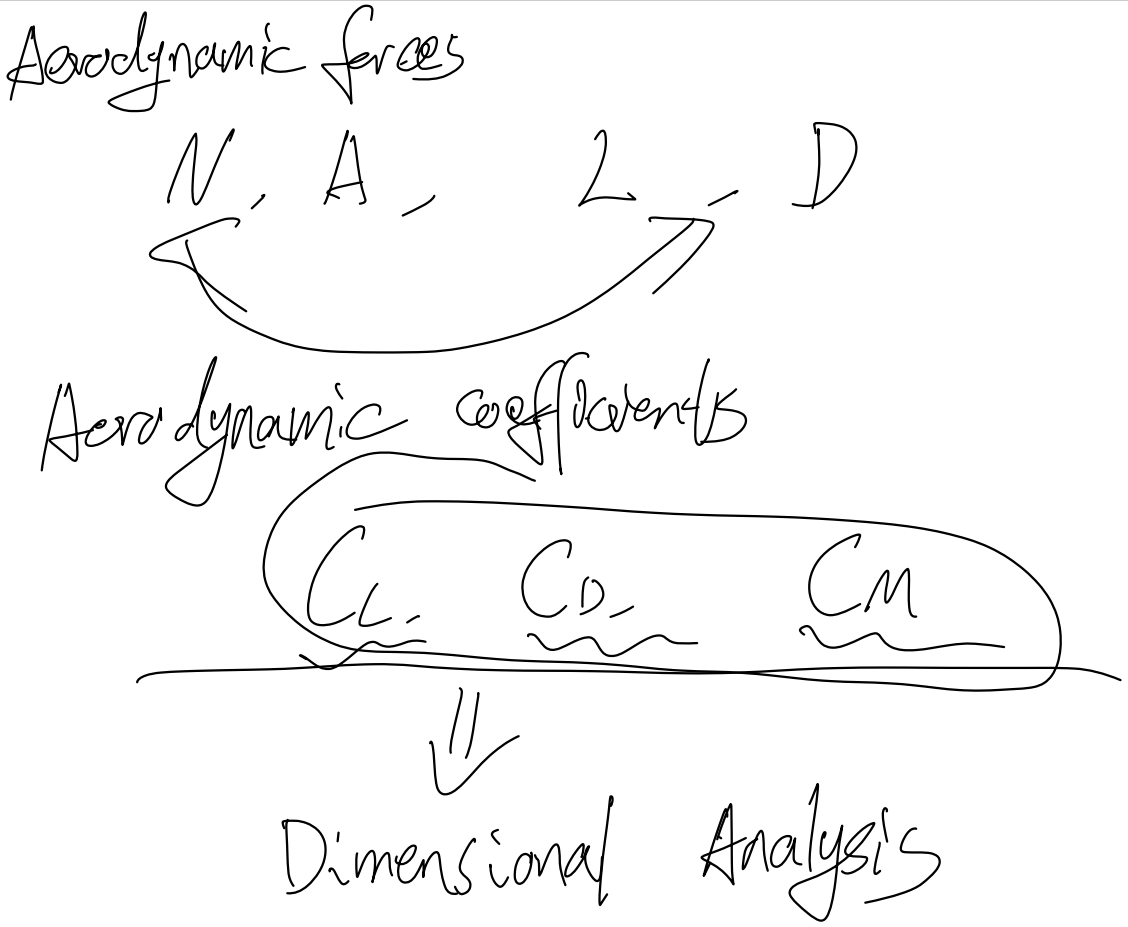
- Final Exam: Take-home exam on Tuesday, 05/21.
  - Will be available from 12:00 – 6:00 pm
  - Submit before 6:00 pm
  - Late submission will receive a score of 0%.

- Final Exam Format:
  - 10 True/False Questions: 20 pt
  - 8 Math-based Problems: 80 pt
  - Total: 100 pt

Final Exam Review

Topics to be covered

- Aerodynamic forces and coefficients
- Dimensional analysis
- Basic equations in aerodynamics
- Vorticity, circulation, stream function, velocity potential, Laplace equation…
- Elemental Flows
- Lifting flow, Kutta-Joukowski Theorem
- Thin airfoil theory
- Flow over finite wings
- Compressible flows
  - Basic equations
  - Total conditions
- Shock waves
  - Property change across shock waves
  - Speed of sound


Aerodynamic forces
N
A
L
D
Aerodynamic coefficients
CL
CD
CM
Dimensional Analysis

Vorticity, circulation, stream-function, velocity potential.

Laplace Equation.

Basic Equations in Aerodynamics.

- Continuity Equation.
- Momentum Equation
- Energy Equation

$\Rightarrow$ N-S Equations

Substantial Derivative

Elemental flow:

① uniform flow, source/sink flow, doublet flow, vortex flow

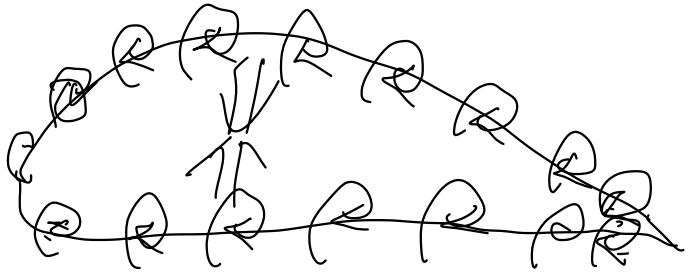
stream function, velocity potential.

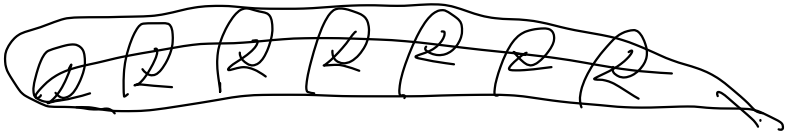
② Combined flows

Laplace equation

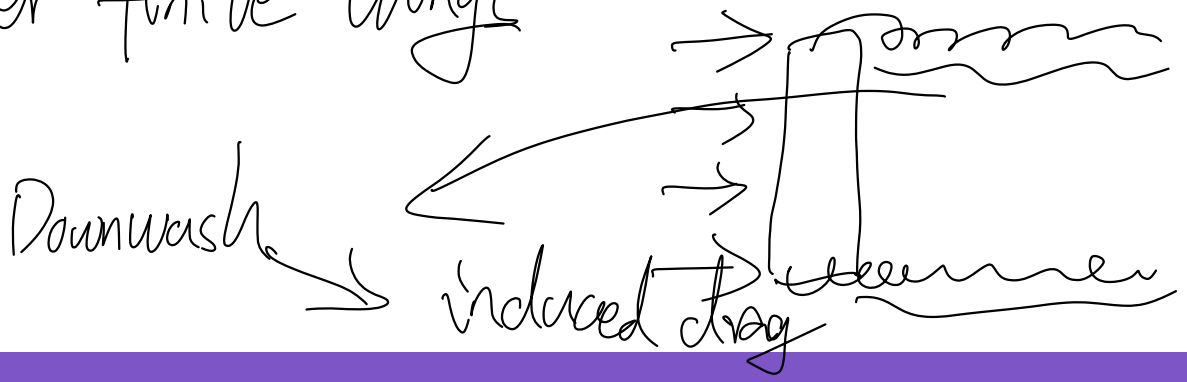
Lifting flow: Kutta–Joukowski Theorem

- Thin airfoil theory.

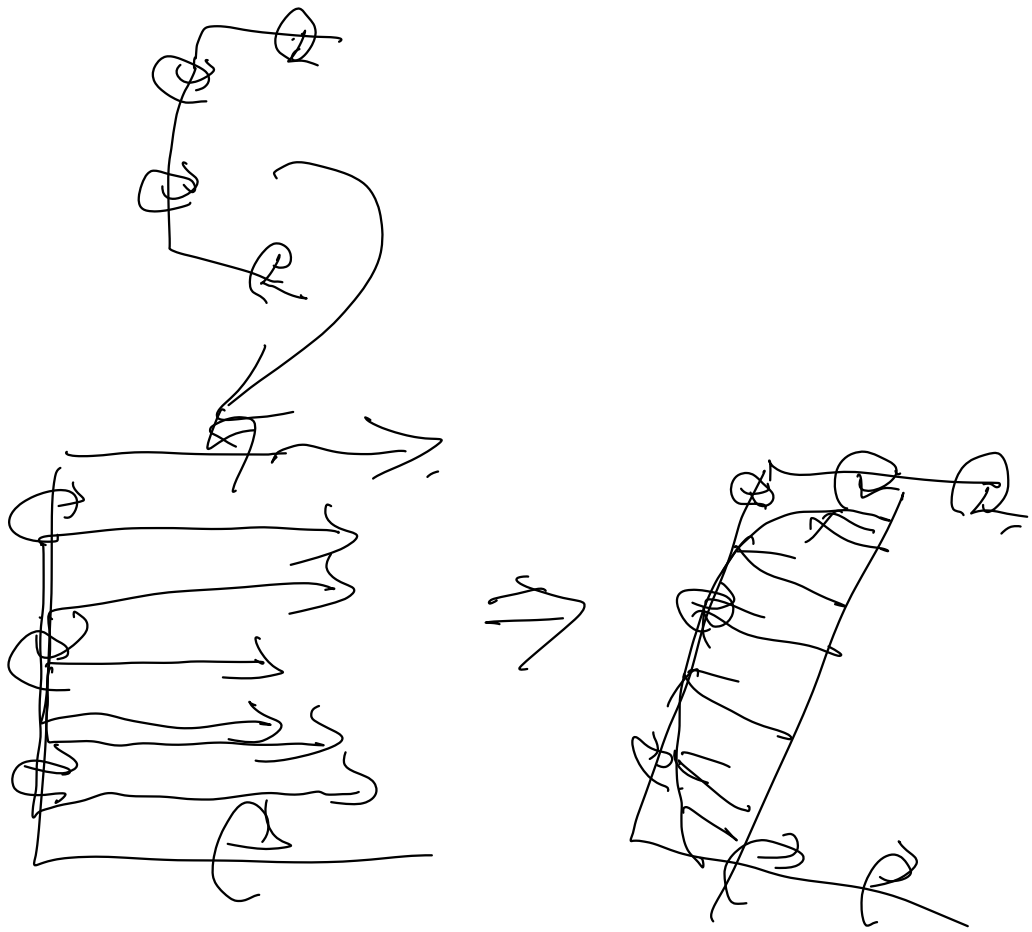




- Flow over finite wings



Lifting – line theory



Elliptical lift distribution.

Elliptical wing ⟸ optimum design.

Compressible flows:

P, ρ, T, e, h, s

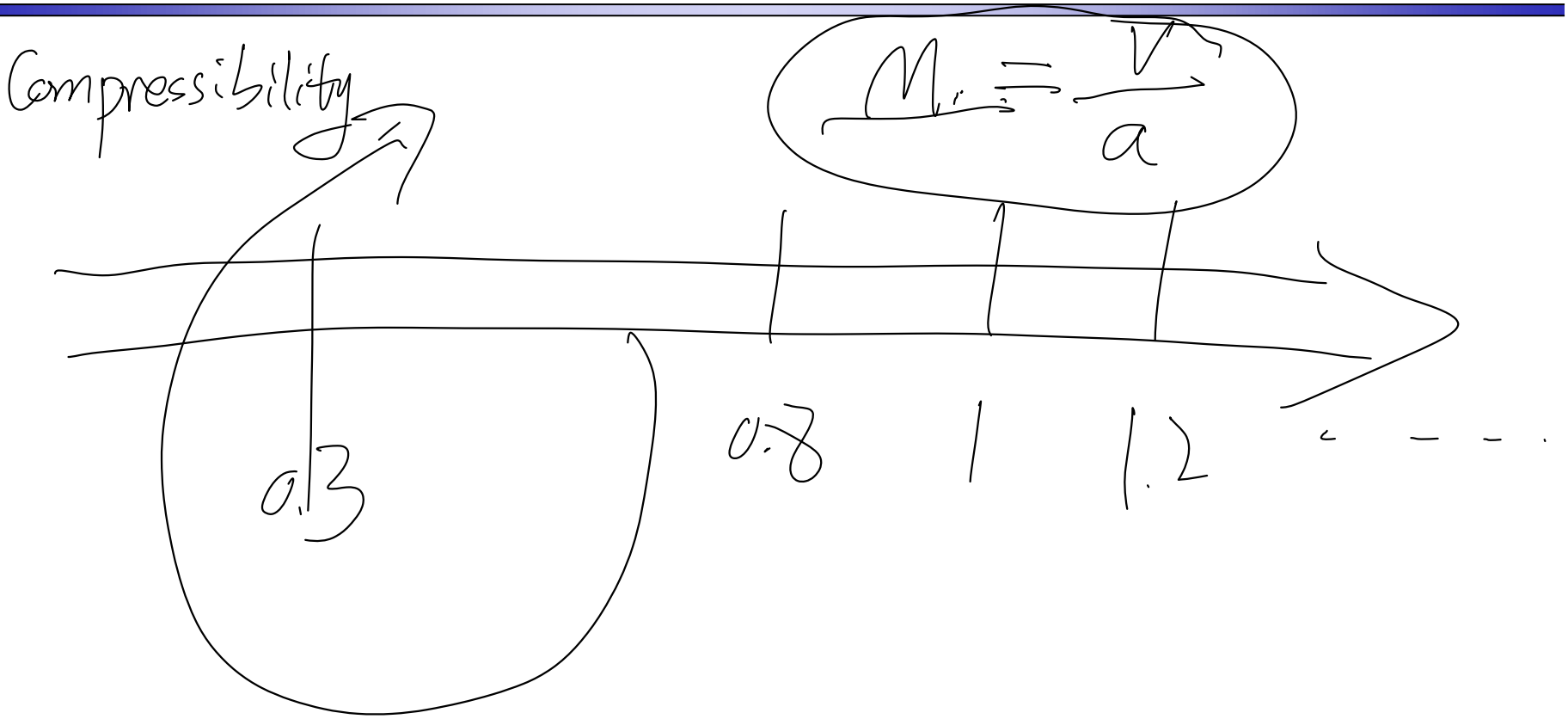
Continuity Eq.

Momentum Eq.

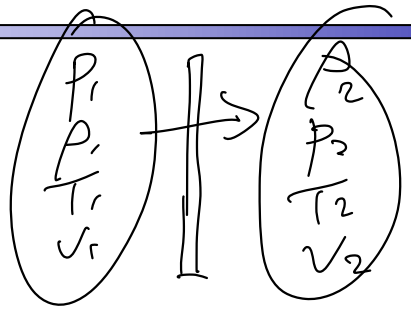
Energy Eq.

$h = C_p T$.

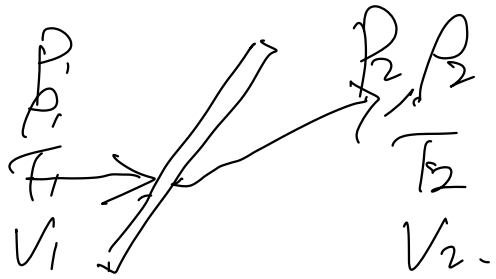
Equation of state.


Compressibility
$M = \frac{V}{a}$
0.3
0.8
1
1.2

Shock waves.. { Normal shock.



Oblique shock.



Total condition.

$$P + \frac{1}{2}\rho V^2 = P_{tot}$$

$$h + \frac{1}{2}\rho V^2 = h_{tot}$$