



Ferdowsi University of Mashhad  
Department of Mechanical Engineering

## Unsteady Gas Dynamics Syllabus

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<http://e.roohi.profcms.um.ac.ir/index.php/interests-and-research/8089>

### Textbooks:

- Anderson, J.D., “**Modern Compressible Flow with Historical Perspective**, Mc Graw Hill, 2<sup>nd</sup> edition, 2003.
- روحی، احسان، دینامیک گازها، در دست انتشار (فایل الکترونیکی)
- Ben-Dor, G., **Shock Wave Reflection Phenomena**, Springer, 2<sup>nd</sup> edition, 2007.
- Liepmann, H., A. Roshko, *Elements of Gas Dynamics*, John Wiley Publishers, 1957.
- Thompson, P. A., *Compressible Fluid Dynamics*, Maple Press Company, 1984.

### Contents:

- Chapter 1: **A Review of Governing Equations**, (MCF, Roohi)
  - Continuity, Momentum, Energy equations
  - Conservative form vs. non-conservative form
  - Derivation of speed of sound
- Chapter 2: **Normal and Oblique Shock Waves** (MCF, Roohi)
  - Concepts and definitions
  - Review of shock relations
  - Rayleigh relations for shock waves
  - Rankine-Hugoniot relation
  - Derivations of Rankine-Hugoniot relation in different forms
- Chapter 3: **Shock Reflections and Interaction** (Ben-Dor)
  - Regular vs. irregular reflections,
  - Criterion for irregular reflections,

Types of irregular reflections,  
Hysteresis Phenomenon,  
Shock polars, velocity hodograph  
 $\rho$ - $\theta$  plane, T-  $\theta$  plane

• Chapter 4: **Unsteady 1-D flow** (Roohi, Thompson, Liepmann, Anderson)

Piston problem: moving normal shock  
Sample problems  
Linearized flow: Wave equations  
Linearized Riemann problem  
Non-linear Riemann problem  
Shock formation time  
Piston withdrawal  
Shock-tube problem

Chapter 5: **Wave-wave interactions** (Roohi, Thompson, Liepmann, Anderson)

Reflection of expansion waves from wall  
Shock-shock interaction  
Shock-wall interaction  
Shock-expansion interaction  
Head-on collisions  
Shock overtaking the other  
x-t, a-u, p-t diagrams of the wave reflections and interactions  
Similarity between 1D unsteady and 2-D steady process

Chapter 6: **Methods of Characteristics** (Anderson)

2-D Method of Characteristics  
Axisymmetric method of Characteristics  
Supersonic nozzle design

**Score Policy:**

Written HW's: 10%  
Mid Term: 25%  
Computer HW's: 35%  
Final: 30%