# SYLLABUS
# SPRING 2023/24

## AE 306 AERODYNAMICS II (COMPRESSIBLE AERO.)

**Instructor:** Asst. Prof. Dr. Emre Kara (Room Z04)

**Lecture Assistant:** Res. Asst. Burak Çiftçioğlu

**Lectures:** 08:30 – 11:05 Tuesday - A11

**Course Webpage:** http://www1.gantep.edu.tr/~emrekara/index.php/ae306/

**Course Objectives**
To define compressibility and its effects on fundamental flow equations.
To teach students shock and expansion waves and related calculation methods.
To teach students linearization of fundamental equations and the conditions under which they apply.
To furnish the students with the ability to calculate the flow field and aerodynamic forces in compressible flow.

**Lecture notes**
AE306 lecture notes will be a compound of

- "Compressible Flow" lecture notes of Javier Urzay (from Center for Turbulence Research, Stanford University). You can find them in Scribd.
- "Fundamentals of Aerodynamics" textbook and
- "Modern Compressible Flow: With Historical Perspective" textbook.

**Textbooks**

- **"**Fundamentals of Aerodynamics*"*, J.D. Anderson, McGraw-Hill, 2001 or newer.
- "Modern Compressible Flow: With Historical Perspective", Third Edition, J.D. Anderson, McGraw-Hill, 2003.

**Supplementary Textbooks**

- "Gas Dynamics", M.H. Aksel and O.C. Eralp, Prentice-Hall, 1993.
- "Aerodynamics for Engineering Students", Fifth Edition, E.L. Houghton and P.W. Carpenter, Butterworth-Heinemann, 2003.
- "Aerodynamics for Engineers", 5th Edition, J.J. Bertin, M.L. Smith, Prentice-Hall, 2008.
- "Compressible Flow", M.A. Saad, Prentice Hall, 1993.
- "The Dynamics and Thermodynamics of Compressible Fluid Flow", A.H. Shapiro, Wiley, 1953.

**Prerequisite:** AE 305

**TENTATIVE SCHEDULE (Lecture notes will be followed as the primary source for the exams. Changes/Shifts in Exam dates can be made because of holidays.)**

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| Week 1 (Feb 13th) | Introduction |
| Week 2 (Feb 20th) | ***Chapter 1: Compressible Flow: Fundamental Aspects***<br>1.1 Conservation Equations (Review on Thermodynamics and Fluid Mechanics)<br>1.2 Speed of Sound and Mach Angle |
| Week 3 (Feb 27th) | 1.3 Isentropic Flows<br>1.4 Bernoulli Equation for Compressible Flows<br>1.5 Compressibility<br>1.6 Stagnation and Static Quantities<br>1.7 Ideal Motion of Gases in Variable-Area Ducts |
| Week 4 (Mar 5th) | 1.8 Effects of Variable Area in Subsonic and Supersonic Flows<br>***Chapter 2: Shocks (Normal and Oblique) and Expansion Waves***<br>2.1 Surfaces of Discontinuity<br>2.2 Shock Waves |
| Week 5 (Mar 12th) | 2.3 Weak Shocks<br>2.4 Prandtl-Meyer Expansion Fans<br>2.5 Supersonic Wave Drag and Compression Lift<br>2.6 Reacting Normal Discontinuities<br>2.7 Interactions of Shock Waves with Walls<br>2.8 Internal Structure of Shock Waves and Non-Equilibrium Processes<br>HW1 will be given at the end of the lecture. It will be collected by the lecture assistant at the beginning of the next week's lecture. |
| Week 6 (Mar 19th) | Problem Solving Session for MT1 |
| Week 7 (Mar 26th) | **MIDTERM 1 – Mar 26th, 2024: Tuesday, 08:30 – A11** |
| Week 8 (Apr 2nd) | ***Chapter 3: Compressible Flows in Ducts and Nozzles***<br>3.1 Dynamics of Convergent-Divergent Nozzles<br>3.2 Rocket Engine Nozzles<br>3.3 a. Flows in Ducts with Heat Addition |
| Week 9 | **RAMADAN HOLIDAY** |
| Week 10 (April 16th) | 3.3 b. Flows in Ducts with Friction<br>***Chapter 4: Wave Motion in Compressible Flows***<br>4.1 Moving Normal Shock Waves |
| Week 11 | **APRIL 23RD, NATIONAL SOVEREIGNTY AND CHILDREN'S DAY** |
| Week 12 (April 30th) | 4.2 Reflected Shock Wave<br>4.3 Physical Picture of Wave Propagation<br>4.4 Elements of Acoustic Theory<br>4.5 Finite (Nonlinear) Waves |

Week 13 (May 7th) 4.6 Incident and Reflected Expansion Waves
4.7 Shock Tube Relations
***Chapter 5: Two Dimensional (Linearized) Compressible Flows***
5.1 Irrotational Flow
5.2 The Velocity-Potential Equation
5.3 Small Perturbation Theory
HW2 will be given at the end of the lecture. It will be collected by the lecture assistant at the beginning of the next week's problem solving session.

Week 14 (May 14th) Problem Solving Session for MT2

Week 15 (May 21st) **MIDTERM 2 – May 21st, 2024: Tuesday, 08:30 – A11**

Week 16 (May 28th) 5.4 Linearized Velocity Potential Equation
5.5 Linearized Pressure Coefficient
5.6 Linearized Subsonic Flow
5.7 Improved Compressibility Corrections
5.8 Linearized Supersonic Flow
5.9 Critical Mach number
HW3 will be given at the end of the lecture. It will be collected by the lecture assistant at the beginning of the final.

**Exams**
There will be two midterms and one final examination.

**You must bring one A4 page (both sides of the page can be filled) of formula sheet (HANDWRITTEN BY YOUR OWN) for each exam. You can bring two A4 pages of formula sheet to the final. Necessary tables will be supplied by lecture assistant; each student should bring his/her own copy of this AERODYNAMICS TABLE to each exam.**

**Course Grade**
The grading will be based on a weighting of **15** % on the homeworks, **20** % on the midterm-1, **25** % on the midterm-2, and **40** % on the final exam.
Performance is assessed based on

1. The skill to solve given problems
2. Clarity of the motivation of the steps involved in solving a problem
3. Clarity of the presentation of the results.

Each of these three points carries equal weight.

**Policies:**

- Regular and punctual attendance (at least 70%) and participation are expected.
- Computers and cell phones must be turned off during lectures, no texting, chatting etc.
- Absence from tests must be explained with medical certificates or other valid reasons beyond your control and planning.
- Ask anyone for help on homework, but what you submit must be your own work.