# 上海交通大学课程(ABET)教学大纲

# SJTU Course Syllabus

| A. 课程基本信息/Course Information | | | | | |
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| 课程代码<br>Course Code | AV309 | 学时<br>Credit Hours | 48 | 学分<br>Credits | 3 |
| 课程名称<br>Course Title | 空气动力学 II<br>Aerodynamics II | | | | |
| 课程性质<br>Course Type | 航空航天工程专业必修课、其它工科专业可以选修<br>Compulsory course for Aerospace Engineering majors, open to all other engineering majors | | | | |
| 授课对象<br>Intended Audience | 航空航天工程专业大三学生、其它工科专业有兴趣选修的学生<br>Aerospace Engineering juniors and other interested engineering students. | | | | |
| 授课语言<br>Language of Instruction | 英文<br>English | | | | |
| 开课院系<br>Offered by | 航空航天学院<br>School of Aeronautics and Astronautics | | | | |
| 先修课程<br>Prerequisite(s) | 《空气动力学 I》或者《流体力学》<br>Aerodynamics I or Fluid Mechanics | | | | |
| 授课教师<br>Instructor(s) | 余文胜<br>Dr. Yu Wensheng | | 课程网址<br>Course Webpage | | 待定<br>TBD |
| 课程简介<br>Course Description | 本课程为航空航天工程专业本科生必修课程，也可以供感兴趣的其它工科专业学生选修。主要内容有：流体的可压缩性、流体中的小扰动与音速、可压缩流体的基本控制方程；准一维等熵流动、正激波、带面积变化的准一维无粘流动；斜激波与膨胀波；线化亚音与超音流动、特征线方法；超音速翼型的激波－膨胀波理论与线化理论；亚音相似率、面积法则、超临界翼型、机翼升力线斜率的可压缩修正；可压缩粘性流动、边界层、湍流基础。通过本课程的学习，学生应该掌握以下基本知识与能力：（1）为在空气中高速运动的二维物体建立合适的空气动力学模型，并应用这些模型来预测其气动力和飞行性能；（2）评估这些空气动力学模型的适用度，并估算其误差。<br>This course is a compulsory course for aerospace undergraduate students. The main contents are: compressibility of fluid, small perturbation and sonic speed, and fundamental equations governing compressible fluid flow; quasi-one-dimensional isentropic flow and normal shock; quasi-one-dimensional inviscid flows with area-change; oblique shock and expansion wave; linearized subsonic and supersonic flows; method of characteristics; supersonic airfoil with shock-expansion theory and linearized theory; Similarity laws for subsonic flows, Area Rule, supercritical airfoils, and compressible corrections to the wing lift slope; introduction to compressible viscous flow, boundary layer, and turbulence.<br>Upon finishing the course, the students are expected to obtain the following basic knowledge and are capable of: (1) Formulate and apply appropriate aerodynamic models to predict the forces on and performance of two-dimensional high-speed configurations; (2) Assess the applicability of aerodynamic models to predict the forces on and performance of two-dimensional high-speed configurations and estimate the errors resulting from their application. | | | | |

B. 课程教学大纲/Detailed Syllabus

1. 学习目标/Learning Outcomes

After completing the course, students should be able to:

Explain what characteristics air has in the context of high-speed flow (B1/2/6.2);

Apply flow similarity, non-dimensional coefficients such as the lift and drag coefficients, and non-dimensional parameters such as Mach number and Reynolds number in aerodynamic modeling of realistic configurations (B1/2/6.2);

Explain the mechanism of conversion between internal energy and kinetic energy of gas in internal flow configurations, and the phenomenon of choking and standing normal shock (B1/2/6.2, D9);

Explain the basic elements of supersonic airfoil models, including the shock-expansion theory and the linearized supersonic theory, and apply them to estimate the forces on airfoils (B1/2/6.2);

Explain the sources of lift and drag forces (including friction, induced, wave, and pressure drag) acting on 2D/3D configurations placed in compressible stream (B1/2/6.2, D9);

Carry out a chosen design project related to the knowledge covered in the course, write a technical report and make an oral presentation (A3.1/4, C2/9, D9).

2. 教学内容、进度安排及要求/Schedule & Requirements

| 教学内容<br>Topic | 学时<br>Credit Hour | 教学方式<br>Format | 作业及要求<br>Assignment | 基本要求<br>Requirement | 考查方式<br>Evaluation |
|---|---|---|---|---|---|
| Elements of Compressible Flows: (1) Review of Thermodynamics: Perfect Gas, Internal Energy and Enthalpy, Entropy, Second Law of Thermodynamics, Isentropic Relations; (2) Definition of Compressibility; (3) Review of Governing Equations for Compressible Flows; (4) Total (Stagnation) Condition; (5) Sound Speed; Regions of Dependence and Influence. | 3 | Lecture | 5-10 problems each week | class attendance | Q&A |
| Quasi One-Dimensional Isentropic Compressible Flows: (1) Governing Equations; (2) Flow with Simple Area Change; (3) Mass Flow Formula and Choking. | 3 | Lecture | 5-10 problems each week | preview class attendance | Q&A |
| Normal Shock Wave: (1) Governing Equations for Normal Shock; (2) Shock Relations; (3) Measurement of Velocity in a Compressible Flow. | 3 | Lecture Recitation | 5-10 problems each week | preview class attendance | Q&A |
| Quasi One-Dimensional Compressible Flows: (1) Flow with Simple Area Change and Normal Shock; (2) The seven flow patterns inside a Laval Nozzle; (3)Supersonic Wind Tunnel. | 6 | Lecture | 5-10 problems each week | preview class attendance | Q&A |

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| Oblique Shock and Expansion Waves: (1) Oblique Shock Relations; (2) Flow over Wedges and Cones; (3) Shock Interaction and Reflection; (4) Detached Shock; (5) Prandtl-Meyer Expansion Wave; (6) Shock-Expansion Theory: Application to Supersonic Airfoils; (7) Nozzle Exit Flow | 6 | Lecture Recitation | 5-10 problems each week | preview class attendance | Q&A |
| Mid-Term Exam | 2 | Exam | none | class attendance | exam |
| Linearized Supersonic Flows: (1) Full-Velocity Potential Equation; (2) Linearized -Velocity Potential Equation; (3) Linearized Supersonic Pressure Coefficient; (4) Supersonic Airfoil | 4 | Lecture | 5-10 problems each week | preview class attendance | Q&A |
| Method of Characteristics: (1) Quasilinear PDE; (2) Characteristic Theory; (3) Method of Characteristics Applied to 2-D Supersonic Flows; (4) Supersonic Nozzle Design | 6 | Lecture Recitation | 5-10 problems each week | preview class attendance | Q&A |
| Linearized Subsonic Flows & Transonic Flows: (1) Prandtl-Glauert Rule; (2) Sound Barrier; (3) Area Rule; (4) Supercritical Airfoil. | 6 | Lecture | 5-10 problems each week | preview class attendance | Q&A |
| Viscous Compressible Flow: (1) Compressible Couette Flow; (2) Compressible Poiseuille Flow; (3) Compressible Boundary Layer over a Flat Plate; (4) Reference Temperature Method; (5) Stagnation Point Aerodynamic Heating; (6) Introduction to Turbulence and Turbulence Modelling. | 6 | Lecture Recitation | 5-10 problems each week | preview class attendance | Q&A |
| Term Project Presentation; Final Review. | 3 | Student Presentation | none | Project report and ppt. | Q&A |

3. 考核方式及规定/Grade Composition and Grading Policy

8% Class Attendance and Student Course Notebook (including format and content)
12% Homework Assignments
20% Written Quiz and Mid-Term Exam (Closed-Book, with Aerodynamics Tables provided)
35% Written Final Exam (Closed-Book, with Aerodynamics Tables provided)
25% Term Project Report and Presentation

4. 教材或参考资料 Textbook & References

Textbook:

John D. Anderson Jr. (2011), *Fundamentals of Aerodynamics*, 5th Edition, McGraw-Hill Book Company.

References:

Maurice J. Zucrow and Joe D. Hoffman, *Gas Dynamics*, Volumes I and II, John Wiley and Sons, Inc.
A.H. Shapiro (1954), *The Dynamics and Thermodynamics of Compressible Fluid Flow*, The Ronald Press Company.
Kuethe and Chow, *Foundation of Aerodynamics*, 5th Edition, John Wiley and Sons.
Bertin and Smith, *Aerodynamics for Engineers,* 3rd Edition, Prentice Hall.

5. 其它/Additional Information:

6. 备注/Note(s):