《空气动力学 II》课程教学大纲

Course Syllabus: Aerodynamics II

<table>
<tr><td colspan="6">课程基本信息（Course Information）</td></tr>
<tr><td>课程代码
（Course Code）</td><td>AV309</td><td>学时
（Credit Hours）</td><td>48</td><td>学分
（Credits）</td><td>3</td></tr>
<tr><td rowspan="2">课程名称
（Course Name）</td><td colspan="5">空气动力学 II</td></tr>
<tr><td colspan="5">Aerodynamics II</td></tr>
<tr><td>课程属性
(Course Type)</td><td colspan="5">Compulsory course for Aerospace Engineering majors, open to all other engineering majors</td></tr>
<tr><td>开课院系
（School）</td><td colspan="2">School of Aeronautics and Astronautics</td><td>开课学期
（Term）</td><td colspan="2">Fall</td></tr>
<tr><td>先修课程
（Prerequisite course）</td><td colspan="5">Aerodynamics I or Fluid Mechanics</td></tr>
<tr><td>授课教师
（Instructors）</td><td colspan="5">Dr. Yu Wensheng</td></tr>
<tr><td>课程简介（Description）
300-500 字</td><td colspan="5">This course is a compulsory course for aerospace undergraduate students. The main contents of the course 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, friction, and/or heat transfer; oblique shock and expansion wave; linearized subsonic and supersonic flows; method of characteristics; compressible viscous flow, boundary layer, and turbulence; introduction to computational fluid dynamics; introduction to hypersonic flow.

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/three-dimensional high-speed configurations; (2) Assess the applicability of aerodynamic models to predict the forces on and performance of two/three-dimensional high-speed configurations and estimate the errors resulting from their application.</td></tr>
<tr><td colspan="6">课程教学大纲（Course Syllabus）</td></tr>
<tr><td>*学习目标(Learning Outcomes)</td><td colspan="5">After completing the course, students should be able to:

Explain what characteristics air has in the context of high-speed flow;
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;
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;
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
Explain the sources of lift and drag forces (including friction, induced, wave, and pressure drag) acting on 2D/3D configurations placed in compressible stream;
Explain the use of wind tunnel testing in aerodynamic modeling focusing on the importance of flow similarity in scale testing required to simulate flight conditions</td></tr>
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	教学内容 topics	学时 Credit hours	教学方式 Teaching methodology	作业及要求 tasks	基本要求 Intended learning outcomes	考查方式 Assessment methods
*教学内容 进度安排 及要求 (Class Schedule & Requirements)	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	Classroom sessions	Homework assignments	Preview; Reading textbook;	Q&A
	Quasi One-Dimensional Isentropic Compressible Flows: (1) Governing Equations; (2) Flow with Simple Area Change; (3) Mass Flow Formula and Choking.	3	Classroom sessions	Homework assignments	Preview; Reading textbook;	Q&A
	Normal Shock Wave: (1) Governing Equations for Normal Shock; (2) Shock Relations; (3) Measurement of Velocity in a Compressible Flow.	3	Classroom sessions	Homework assignments	Preview; Reading textbook;	Q&A
	Quasi One-Dimensional Compressible Flows: (1) Flow	6	Classroom sessions	Homework assignments	Preview; Reading textbook;	Q&A

	with Simple Area Change and Normal Shock; (2) Flow inside a Laval Nozzle; (3) Flow with Simple Friction; (4) Flow with Simple Heating/Cooling; (5)Supersonic Wind Tunnel.					
	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	Classroom sessions	Homework assignments	Preview; Reading textbook;	Q&A
	Mid-Term Exam	3	Classroom sessions	Homework assignments	Preview; Reading textbook;	Q&A
	Linearized Supersonic Flows: (1) Full-Velocity Potential Equation; (2) Linearized -Velocity Potential Equation; (3) Linearized Supersonic Pressure Coefficient; (4) Supersonic Airfoil	3	Classroom sessions	Homework assignments	Preview; Reading textbook;	Q&A
	Method of Characteristics: (1) Quasilinear PDE; (2) Characteristic Theory; (3) Method of Characteristics Applied to 2-D	6	Classroom sessions	Homework assignments	Preview; Reading textbook;	Q&A

	Supersonic Flows; (4) Supersonic Nozzle Design					
	Linearized Subsonic Flows & Transonic Flows: (1) Prandtl-Glauert Rule; (2) Sound Barrier; (3) Area Rule; (4) Supercritical Airfoil.	6	Classroom sessions	Homework assignments	Preview; Reading textbook;	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.	9	Classroom sessions	Homework assignments	Preview; Reading textbook;	Q&A
考核方式 (Assessment methods and Grading)	20% Homework 20% Written Mid-Term Exam 30% Written Final Exam 30% Term Project Report and Presentation					
教材或参考资料 (Textbooks & Other Reading Materials)	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.					
备注 （Notes）						