南方科技大学 SOUTHERN UNIVERSITY OF SCIENCE AND TECHNOLOGY

课程详述

COURSE SPECIFICATION

以下课程信息可能根据实际授课需要或在课程检讨之后产生变动。如对课程有任何疑问，请联系授课教师。

The course information as follows may be subject to change, either during the session because of unforeseen circumstances, or following review of the course at the end of the session. Queries about the course should be directed to the course instructor.

1.	课程名称 Course Title	飞行器原理 **Principles of Flight Vehicles**
2.	授课院系 Originating Department	力学与航空航天工程系 Department of Mechanics and Aerospace Engineering
3.	课程编号 Course Code	MAE320
4.	课程学分 Credit Value	3
5.	课程类别 Course Type	专业选修课 Major Elective Courses
6.	授课学期 Semester	春季 Spring
7.	授课语言 Teaching Language	中英双语 English & Chinese
8.	授课教师、所属学系、联系方式（如属团队授课，请列明其他授课教师） Instructor(s), Affiliation& Contact （For team teaching, please list all instructors）	曹人靖 产学研教授 力学与航空航天工程系 caorj@sustech.edu.cn CAO Renjing, Professor (Industry-University-Research) Department of Mechanics and Aerospace Engineering caorj@sustech.edu.cn
9.	实验员/助教、所属学系、联系方式 Tutor/TA(s), Contact	待公布 To be announced /
10.	选课人数限额(可不填) Maximum Enrolment （Optional）	

11. 授课方式 Delivery Method	讲授 Lectures	习题/辅导/讨论 Tutorials	实验/实习 Lab/Practical	其它(请具体注明) Other（Please specify）	总学时 Total
学时数 Credit Hours	48				48

12.	先修课程、其它学习要求 **Pre-requisites or Other Academic Requirements**	流体力学（MAE303） 或 工程流体力学（MAE207） Fluid Mechanics(MAE303) OR Engineering Fluid Mechanics (MAE207)
13.	后续课程、其它学习规划 **Courses for which this course is a pre-requisite**	无 NA
14.	其它要求修读本课程的学系 **Cross-listing Dept.**	无 NA

教学大纲及教学日历 SYLLABUS

15. 教学目标 Course Objectives

飞行器原理是航空航天类本科生的专业选修课。通过本课程的学习，让学生系统掌握与飞行器相关的知识，包括：飞行环境与飞行力学、飞行器结构与性能、飞行器空气动力学基础与气动布局、飞行器推进系统原理、气动弹性与气动声学基础等科学概念与理论。在教学过程中，配合相关 CAE 仿真工具与方法，加深对飞行器流动与动力学知识的理解，深化对飞行器原理基本知识的掌握，提升学生对航空航天概论、高等数学、流体力学、空气动力学等学科知识的综合理解能力，为后续航空航天类专业课程的知识学习打下基础。

This course is one of the subject-elective modules suitable for undergraduates in aerospace engineering. The course will provide students with the fundamentals, concepts and theories associated with flight vehicles by introducing flight condition and mechanics, flight vehicle structures and performance, flight vehicle aerodynamics, propulsion system, aero-elasticity and aero-acoustics, along with some basic CAE tools introduction for students to better understand the aerofoil flow dynamics. This course will provide students better understanding on fundamentals of flight vehicles and comprehensive understanding on previous courses like general aerospace engineering, calculus, fluid mechanics and aerodynamics as solid basis for further subject-based study in the aerospace engineering area.

16. 预达学习成果 Learning Outcomes

飞行器原理的基本知识在航空航天领域中有着广泛的应用，对学生将来从事飞行器设计或开展相关研究具有极大帮助。通过本课程的学习，希望让学生了解飞行器基本结构与性能、飞行环境与飞行力学、飞行器机翼气动力产生的机理、附面层在飞行器气动力中的影响、流动分离的特征及影响。同时，了解 CAE 数值模拟在飞行器数值仿真、优化中的作用，训练学生的思维、分析与解决问题能力的提高都有重要的意义。

The flight vehicles find broad wide applications in various aeronautical engineering. The study of Principles of Flight Vehicles is helpful for the students to conduct aircraft design or further relevant research in the future. Through the completion of study of this course, the students will have the ability to understand the basic structures and performance of flight vehicles, flight conditions and dynamics, some mechanisms of lift generation on aircraft, the impact of the boundary layer and separation flow on aerodynamic behaviors. The course is significant for students to develop a conceptual understanding of the core concepts, and obtain abilities to apply the theoretical framework to solve practical engineering problems.

17. 课程内容及教学日历 （如授课语言以英文为主，则课程内容介绍可以用英文；如团队教学或模块教学，教学日历须注明主讲人）
Course Contents (in Parts/Chapters/Sections/Weeks. Please notify name of instructor for course section(s), if this is a team teaching or module course.)

1. Introduction to the flight conditions which include the atmospheric environments (Troposphere, Stratosphere, Mesoshpere, Exoshpere), the space environment (vacuum, electromagnetic radiation, high-energy particles, plasma) and the atmosphere physical properties (viscosity, compressibility, friction) and associated international standards. (3 credit hours)

Section 1. 介绍飞行环境，包括大气环境（对流层、平流层、中间层、热层和散逸层等）、空间环境（真空、电磁辐射、高能粒子、等离子所形成的飞行环境）、大气物理特性（粘性、压缩性、摩擦力等）以及相应的国际标准。（3 学时）

2. Brief introduction to the development history, concepts and typical features of military and civil aircrafts with rotary wing and fixed wing, the concepts and technical features of UAVs and the state-of-the-arts of modern flight vehicles are also presented. (3 credit hours)

Section 2.介绍军用与民用飞行器的发展简史、设计理念及典型结构特征，包括旋翼机与固定翼飞行器，以及无人驾驶飞行器 UAV 和当代最先进飞行器类型及其技术特征。（3 学时）

3. The basic structures, components and their functions of flight vehicle are introduced, typically the fuselage, wing, tail-wing, landing-gear and fly-by-wire system are presented. (3 credit hours)

Section 3.介绍飞行器的基本结构、组成和各部件的功用，包括机身、机翼、尾翼、起落装置、电传操纵系统（FBW）等。（3 学时）

4. Variables regarding the dynamic motions of flight vehicles are introduced, which include the speed, altitude, range, take-off, landing and maneuvering operation (loop, roll, pitching and yawing). (3 credit hours)

Section 4.介绍飞行器质心运动规律的诸参数，包括飞机的速度、高度、航程、航时、起飞、着陆和机动飞行（如筋斗、翻滚、俯仰、偏航等）等性能。（3 学时）

5. The theory of wing, Bernoulli principle as well as the aerodynamic characteristics and lift generation of airfoil are introduced, accordingly some lift-augmentation techniques are presented with the examples of wing rib and flap devices. (3 credit hours)

Section 5.介绍翼型理论、伯努利方程及其翼型产生升力的原理、翼型扰流及增升原理与增升装置。（3 学时）

6. An introduction to Prandtl boundary layer theory, Reynolds number, flow transition, turbulent flow characteristics is presented and some effective flow control techniques and devices as being applied to flight vehicles are also presented. (3 credit hours)

Section 6.介绍普朗特附面层理论、雷诺数、流动转捩、湍流特性，以及应用于飞行器流动控制技术与装置。（3 学时）

7. An introduction to Prandtl boundary layer theory, Reynolds number, flow transition, turbulent flow characteristics is presented and some effective flow control techniques and devices as being applied to flight vehicles are also presented. (3 credit hours)

Section 7.介绍普朗特附面层理论、雷诺数、流动转捩、湍流特性，以及应用于飞行器流动控制技术与装置。（3 学时）

8. 3D flow and flow separation criteria are presented, the typical 3D flow characteristics and wing tip vortex physics of flight vehicles are described when flight vehicles are subject to high angle of attack, strong flow separation under maneuvering operations. (3 credit hours)

Section 8.介绍三维分离流及其判断准则、飞行器三维流动结构特征，包括大迎角飞行姿态、机动飞行状态产生的三维分离流动、翼尖涡及其结构特征。（3 学时）

9. Coupling effects between aerodynamics and structural dynamics as fundamental phenomena to aero-elasticity are presented, accordingly how the aero-elasticity influences the performance of aircraft's maneuverability and stability are also presented. (3 credit hours)

Section 9.飞行器在空气动力作用下产生的弹性变形如何与气动力耦合，形成一种结构变形与空气动力交互作用的所谓气动弹性现象，气动弹性对飞行器的操纵性和稳定性会产生显著影响。（3 学时）

10. Basic aero-acoustics is introduced, to take propeller and jet noise as example, the major noise sources and associated characteristics are presented. (3 credit hours)

Section 10.介绍气动声学基本原理，以飞行器螺旋桨噪声、发动机喷流噪声为例，介绍飞行器的主要噪声源及其特征。（3 学时）

11. The history of aero-engine is briefly introduced, and the basic principles of aero-engine system, its components, related function and some concepts of aircraft-propulsion integration are also presented. (3 credit hours)

Section 11.介绍航空发动机的发展简史，重点介绍喷气式发动机的基本原理、基本结构和特性，以及飞行器-推进系统一体化设计理念。（3 学时）

12. To take the compressor and turbine as examples, the basic knowledge of internal thermal-aerodynamic process of aero-engine is described in terms of aero-thermal dynamic equations. (3 credit hours)

Section 12.介绍航空发动机内流气动热力学的基本原理、热力与气动方程，以压气机、涡轮为例，介绍发动机内部气动-热力过程及其特征。（3 学时）

13. Basic aerodynamics in turbomachines is illustrated with focus on the concepts of cascade, blade profile, compressor 3D flow, rotor/stator interaction, compressor characteristics. (3 credit hours)

Section 13.介绍现代飞行器推进系统的叶轮机内流空气动力学基础，包括叶栅、基元级、压气机三维流动、转静干涉、压气机特性曲线等。（3 学时）

14. Basic aerodynamics in turbomachines is illustrated with focus on the concepts of cascade, blade profile,

compressor 3D flow, rotor/stator interaction, turbine characteristics. (3 credit hours)

Section 14.介绍现代飞行器推进系统的叶轮机内流空气动力学基础，包括叶栅、基元级、涡轮三维流动、转静干涉、涡轮特性曲线等。（3 学时）

15. The novel concepts, structures and aerodynamic features of flight vehicle in the future are demonstrated by taking the micro-flight vehicles and UAVs as examples. (3 credit hours)

Section 15.介绍新概念飞行器的理念、结构及气动特征，包括：微型飞行器、无人机等。（3 学时）

16. Some useful CAE tools such as XFOIL and CFD software as kinds of numerical wind tunnel are introduced for flight vehicle concept analysis and optimization are presented for further potential applications. (3 credit hours)

Section 16.以 XFOIL 软件或者其他 CFD 软件为例，介绍数值仿真技术在飞行器设计中的应用，通过课堂演示，介绍虚拟设计技术或者数字风洞技术在未来飞行器设计中的应用。（3 学时）

18. 教材及其它参考资料 Textbook and Supplementary Readings

教材（Textbook）：

Mark Drela, Flight Vehicle Aerodynamics, Cambridge, Massachusetts, MIT Press, 2014.

参考资料（References）：

贾玉红主编，航空航天概论，北京：北京航空航天大学出版社，2014.

J.D. Anderson, Jr., Introduction to Flight, New York, NY : McGraw-Hill Education, 2016.

P. Nirajan, Fluid Mechanics and Thermodynamics of Turbomachinery, Valley Cottage, N.Y. : Scitus Academics LLC, c2016.

H., Schlichting, K. Gersten, “Boundary Layer Theory,” Springer, 9th edition, 2017.

计算工具（Calculation Tools）

Programs XFOIL (2D airfoil design and analysis) and AVL (Vortex Lattice Method) can be downloaded from: http://web.mit.edu/drela/Public/web/xfoil/; http://web.mit.edu/drela/Public/web/avl/.

Program XFLR5 (2D and 3D analysis of airfoils and wings at low Reynolds numbers) can be downloaded from: http://www.xflr5.com/xflr5.htm

The vortex lattice code Tornado can be downloaded from: http://www.redhammer.se/tornado/

课程评估 ASSESSMENT

19.

评估形式 Type of Assessment	评估时间 Time	占考试总成绩百分比 % of final score	违纪处罚 Penalty	备注 Notes
出勤 Attendance				
课堂表现 Class		10		

Performance				
小测验 Quiz				
课程项目 Projects		30	抄袭本项记 0 分 Cheating: 0	
平时作业 Assignments		10	抄袭平时作业记 0 分 Cheating: 0	
期中考试 Mid-Term Test				
期末考试 Final Exam		50	考试作弊本门课程记 0 分 Cheating: 0	
期末报告 Final Presentation				
其它（可根据需要改写以上评估方式） Others (The above may be modified as necessary)				

20. **记分方式 grading system**

☑ **A. 十三级等级制 Letter Grading**
☐ **B. 二级记分制（通过/不通过） Pass/Fail Grading**

课程审批 REVIEW AND APPROVAL

21. **本课程设置已经过以下责任人/委员会审议通过**
This Course has been approved by the following person or committee of authority

力学与航空航天工程系教学指导委员会
The commission of teaching instruction in department of mechanics and aerospace engineering