机械与动力工程学院博士生资格考试笔试大纲

Syllabus of Ph.D. Qualification Examination (SJTU-ME)

*笔试主题 Exam Topic	高等工程流体力学 Advanced Engineering Fluid Mechanics
*考核形式 Exam Format	闭卷考试，1 小时 Closed-book exam, 1 hour
*考核目标 Exam Target	1. 使用质量、动量和能量守恒定律建立流动问题物理模型的方法和能力。 2. 使用张量分析、复变函数、统计方法等数学工具，解析求解流动问题模型的方法和能力。 1. The capability to build physical models of fluid flow problems using mass, momentum and energy conservation laws. 2. The capability to find analytical solution to fluid flow models by math tools, including tensor analysis, complex function, statistics
*考核内容 Exam Contents	1. 流体基本概念：流体的定义，连续介质模型，粘性，压缩性。 2. 向量和张量分析：向量的几何运算，坐标体系，张量的代数运算、微积分运算，曲线坐标系，Lame 系数。 3. 流体运动学：欧拉观点与拉格朗日观点，物质导数，速度分解分解定理，雷诺输运定理，流线、迹线、脉线，涡量和涡。 4. 流体力学基本方程：连续方程，动量方程，能量方程，牛顿流体的本构方程。 5. 平面势流：速度势函数和流函数，基本势流和复合势流，复速度计算，布拉修斯公式，库塔-茹柯夫斯基理论，保角变换，茹柯夫斯基变换和茹柯夫斯基翼型。 6. 理想流体的旋涡运动：汤姆森理论，涡量场，涡线，涡管，卡门涡街。 7. 粘性不可压流动的精确解：Couette 流动，Poiseuille 流动，轴对称流动，Stokes 第一类问题和第二类问题，滞止流动。 8. 层流边界层：边界层厚度，边界层方程及其相似解，层流边界层稳定性，层流到紊流的转换。 9. 紊流：紊流的特征，紊流的统计分析方法，紊流的基本方程，各向同性紊流，紊流模型，壁面紊流，自由紊流。 10. 理想可压缩流动：小扰动传播方程和音速，有限振幅波传播的特征，激波的形成，正激波和斜激波。 1. Basic concepts of fluid flow: definition of fluid, continuum hypothesis, viscosity, compressibility. 2. Vector and tensor analysis: vector geometric operation, tensor algebraic operation, tensor calculus, curvilinear coordinate system, Lame coefficients 3. Fluid kinematics：Euler and Lagrangian description, material derivative, decomposition of velocity gradient, Reynolds transport theorem, flow lines (streamlines, pathlines and streakline), vorticity

	and vortices. 4. Differential and integral balance of fluid motion: continuity equation, momentum equation, energy equation, constitutive equation of Newtonian fluid. 5. Potential flow: velocity potential and stream function, basic potential flows and their superposition, complex velocity, Blasius theorem, Kutta-Zhukovskii theorem, conformal transformation, Zhukovskii transformation and Zhukovskii airfoil. 6. Vertical flow of ideal fluid: Thomson theorem, vorticity field, vorticity line, vorticity tube, Karman vortex street. 7. Exact solution of viscous incompressible flow: Couette flow, Poiseuille flow, axis-symmetric flow, Stokes' first problem, Stokes' second problem, stagnation flow. 8. Laminar boundary layer: boundary layer thickness, boundary layer equations and their similarity solution, stability of laminar boundary, laminar-turbulent transition. 9. Turbulence: characteristics of turbulence, statistical analysis of turbulence, isotropic turbulence, turbulence modeling, bounded turbulence and free turbulence. 10. Flow of ideal compressible fluid: propagation of infinitesimal disturbance and sonic speed, propagation of finite disturbance, formation of shock wave, normal shock wave, oblique shock wave.
*参考书目 References	1. 张鸣远，景思睿，李国君. 高等工程流体力学，西安交通大学出版社，2006 2. 费祥麟. 高等流体力学，西安交通大学出版社 3. 王献孚、熊鳌魁. 高等流体力学，华中科技大学出版社 1. Fluid Mechanics for Engineers: A Graduate Textbook, M. T. Schobeiri, Springer, ISBN: 9783642115936, 2010 2. Fluid Mechanics: An Introduction to the Theory of Fluid Flows, F.Durst, Springer, 2008
备注 Notes	