

上海交通大学研究生专业课程信息收集表

Information Form for SJTU Graduate Profession Courses

课程基本信息 Basic Information				
*课程名称 Course Name	(中文 Chinese) 工程材料断裂机理			
	(英文 English) Fracture in Engineering Materials			
*学分 Credits	2	*学时 Teaching Hours	32	
*开课学期 Semester	春季学期 Spring	*是否跨学期 Cross-semester?	否 No	跨 Spanning over 一个学期 Semesters (含夏季学期)。
*课程类型 Course Type	专业基础课 Program Core Course	*课程分类 Course Type	通用课程 Both full & part time students	
*课程性质 Course Category	专业课 Specialized Course	课程层次 Targeting Students	硕博共用 All graduates	
*授课语言 Instruction Language	英文 English	主要授课方式 Teaching Method	课堂教学 In class teaching	
*成绩类型 Grade	等第制 Letter grading	主要考核方式 Exam Method	论文 Essay	
*开课院系 School	材料学院			
所属学科 Subject	材料科学与工程			
负责教师 Person in charge	姓名 Name	工号 ID	单位 School	联系方式 E-mail
	赵晓峰		材料学院	xiaofengzhao@sjtu.edu.cn
课程扩展信息 Extended Information				
*课程简介 (中文) Course Description	<p>本课程主要面向材料研究相关方向的硕士、博士研究生，讲授常见工程材料（如金属、陶瓷、复合材料等）强度与断裂的基本问题，以及如何利用这些原理设计性能优异的材料和结构，提高学生解决和分析问题能力，训练科学的思维方式。</p> <p>本课程首先讲授材料强度和断裂的基本物理概念，如理论断裂强度、剪切强度、Griffith断裂基本理论、韧性断裂、脆性断裂等。然后讲述材料强度和断裂韧性的测试技术，重点介绍科学研究中常用的压痕法和单边开口梁法。在此基础上，讲授材料强韧化的基本原理和方法（如相变增韧、复合材料设计等），以及断裂形貌分析，课程同时引入最新的科研成果，时刻保持更新。</p> <p>本课程将以几种常用的、典型的工程材料，如高温合金、航空发动机地面燃气轮机热障涂层、陶瓷基纤维复合材料、核反应堆燃料元件包壳材料、轻金属合金等为例，讲述这些材料的设计原理及应用要求，并针对工程中广泛存在的蠕变、疲劳、应力腐蚀、氢脆等关键失效方式进行分析。</p> <p>课程主要采用课堂授课/在线授课方式，重点在于基本概念的讲述，以实际应用案例出发，引发学生思考。同时某些知识点采用反转课堂，让学生分组选择知识点并制作 PPT 课堂讲授，加强学生独立思考与互动。考试采用课堂报告或论文形式。</p>			
*课程简介 (English) Course Description	This course should give students both a basic understanding on the strength and fracture toughness of engineering materials (such as metals, ceramics, composites, etc.), and the use of fracture mechanics in materials selection and product design. This course is intended for Graduate students, assuming that students have both a basic knowledge of the engineering			

materials and Material Mechanics.

The course will begin by developing the theoretical framework for the fracture and strength of solids (e.g. theoretical cleavage strength, shear strength, Griffith theory) and then developing an understanding of brittle and ductile fracture. Then the techniques for the measurement of strength and fracture toughness will be presented, with a focus on the indentation technique, which is one important method for scientific research. In addition, this course will also present the basic concepts on the material strengthening and toughening (e.g. phase transformation toughening, composite approach, Eshelby theory, etc), as well as fractography. The course will also give students the recent research findings on the materials fracture or strength.

This course will use several engineering materials, such as high temperature superalloy, thermal barrier coatings for aeroengine, fiber reinforced composites, nuclear fuel particles and light alloys, as examples, to introduce the knowledge of engineering fracture, for example, the creep, fatigue, stress corrosion and Hydrogen brittleness induced failure.

The course will be interactive and there will be periods for students to raise questions and discuss aspects of their own experimental work with the instructor.

	周次	教学内容	授课学时	教学方式
*教学大纲 (中文) Syllabus	1-3	1. 材料强度与断裂基础 1.1 理论抗拉强度 1.2 理论剪切强度 1.3 应力集中理论 (Inglis Theory) 1.4 Griffith 理论 1.5 韧性断裂 1.6 脆性断裂 1.7 断裂韧性概念 1.8 韧性-脆性转变	6	直播/课堂 讲授
	4-5	2. 材料强度与断裂韧性测试技术 2.1 强度测试 2.2 断裂韧性测试 2.3 纳米/微米压痕理论 2.4 影响材料强度和韧性的因素 2.5 强度断裂统计方法 (Weibull 统计) 2.6 案例分析	4	直播/课堂 讲授
	6-7	4. 材料断裂与增韧 4.1 裂纹形核机制 4.2 断裂形貌 4.3 脆性材料增韧机制 4.4 相变增韧 4.5 纤维增韧与复合材料 4.6 Eshelby 理论 4.7 工程材料设计 4.8 强度中的尺寸效应	4	直播/课堂 讲授
	8	答疑/期中测验	2	课堂答疑/ 期中测验
	9-10	5. 蠕变与疲劳断裂 5.1 塑性变形 5.2 位错密度	4	直播/课堂 讲授

		5.3 材料强化机制 5.4 蠕变断裂 5.5 疲劳断裂 5.6 应力腐蚀 5.7 氢脆现象		
	11-14	6. 工程材料断裂案例分析 6.1 高温合金 6.2 航空发动机热障涂层 6.3 陶瓷基纤维复合材料 6.4 核燃料包壳材料 6.5 高温气冷堆燃料颗粒 6.6 金属泡沫	8	直播/课堂讲授
	15-16	7. 期末考试	4	课堂汇报 PPT
*教学大纲 (English) Syllabus	Week	Content	Hours	Format
	1-3	1. Fundamentals on Material Strength and Fracture 1.1 Theoretical cleavage strength 1.2 Theoretical shear strength 1.3 Stress concentration (Inglis Theory) 1.4 Griffith Theory 1.5 Ductile fracture 1.6 Brittle fracture 1.7 Fracture toughness 1.8 Ductile to Brittle transformation	6	Online/class teaching
	4-5	2. Techniques to measure the strength and fracture toughness 2.1 Strength testing 2.2 Fracture toughness testing 2.3 Indentation fracture theory 2.4 Factors affecting the strength and fracture toughness 2.5 Failure statistics and Weibull Distribution 2.6 Examples	4	Online/class teaching
	6-7	3. Fracture and Toughening 3.1 Nucleation and formation of cracks 3.2 Fractography 3.3 Toughening mechanism 3.4 Phase transformation toughening 3.5 Composite Materials 3.6 Eshelby theory 3.7 Engineering design 3.8 Size effect in strength testing	4	Online/class teaching
	8	Course Tutoring/Quiz	2	课堂答疑/ 期中测验
	9-10	4. Creep and Fatigue 4.1 Plastic deformation 4.2 Dislocation density 4.3 Strengthen mechanism 4.4 Creep 4.5 Fatigue 4.6 Stress corrosion	4	Online/class teaching

		4.7 Hydrogen brittleness		
	11-14	5. Case study 5.1 Superalloy in gas turbine 5.2 Thermal barrier coatings for aeroengine 5.3 Fibre reinforced ceramics 5.4 Nuclear cladding materials 5.5 TRISO particles for high temperature gas cooled reactors. 5.6 Metal foams	8	Online/class teaching
	15-16	7. Final Examination	4	Online/class PPT
*课程要求 (中文) Requirements	考核方式：期中测验占成绩 30%，期末考试占 70%。期末考试有两种方式： 1. 课堂 Presentation: 选取课程有关的内容做一个会议的报告（15 分钟）； 2. 论文：选取课程相关内容，撰写一份综述性或者研究论文，格式按杂志论文。			
*课程要求 (English) Requirements	Midterm test (30%)+final test (70%). The final test can be: 1. Presentation: the student can choose one topic related to this course and give talks (15 mins) in class. 2. Essay: write a paper/literature review on one topic related to this course and submitted before the end of semester.			
*课程资源 (中文) Resources	参考书目： 1. David. J. Green, An introduction to the mechanical properties of ceramics, Cambridge University Press, 1998, Chapter 8 2. B. R. Lawn, Fracture of Brittle Solids, Second Edition, Cambridge University Press, Cambridge, UK, 1993. 3. M.A. Meyers and K.K. Chawla, Mechanical Behavior of Materials, Prentice-Hall , 1999. 4. Mark L. Weaver, Mechanical Behavior of Materials, Course Notes, University of Alabama			
*课程资源 (English) Resources	Reference books: 1. David. J. Green, An introduction to the mechanical properties of ceramics, Cambridge University Press, 1998, Chapter 8 2. B. R. Lawn, Fracture of Brittle Solids, Second Edition, Cambridge University Press, Cambridge, UK, 1993. 3. M.A. Meyers and K.K. Chawla, Mechanical Behavior of Materials, Prentice-Hall , 1999. 4. Mark L. Weaver, Mechanical Behavior of Materials, Course Notes, University of Alabama			
备注 Note	学生课堂 PPT 汇报的时间可根据人数调整（14-16 周）。			