

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	生物力学 Biomechanics
2.	授课院系 Originating Department	生物医学工程系 Department of Biomedical Engineering
3.	课程编号 Course Code	BMEB318
4.	课程学分 Credit Value	3
5.	课程类别 Course Type	专业核心课 Major Core Courses
6.	授课学期 Semester	3 秋季 Fall
7.	授课语言 Teaching Language	英文 English
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)	刘超, 生物医学工程系, 助理教授; Chao Liu, Biomedical Engineering, Assistant Professor, liuc33@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	无 None				
13. 后续课程、其它学习规划 Courses for which this course is a pre-requisite	无 None				
14. 其它要求修读本课程的学系 Cross-listing Dept.	无 None				

教学大纲及教学日历 SYLLABUS

15. 教学目标 Course Objectives

Biomechanics is the study of the structure and function of biological systems such as humans, animals, plants, organs, and cells by means of the methods of mechanics. In this course, fundamental knowledge of the biomechanical aspects and structural behavior of the human musculoskeletal system together with basic biomechanics concept will be introduced, and it is believed that it is an essential prerequisite for any experimental, theoretical, or analytical approach to analyze its physiological function in the body.

The objectives of this course are:

- (1) To introduce students to classical and modern biomedical engineering in the field of biomechanics;
- (2) To utilize mathematics, physics, and basic sciences to devise and implement solutions to biomechanical problems;
- (3) To develop the ability to apply concepts to various problems.

本课程教学目标: 1. 从生物力学的领域出发, 给学生介绍传统和现代生物医学工程概念; 2. 使用数学、物理和基础学科来设计解决生物力学问题的方案; 3. 培养学生解决实际问题的能力;

16. 预达学习成果 Learning Outcomes

1. To attain basic knowledge of engineering methodology as applied to biomechanics
2. To attain a systemic appreciation of the various areas in biomechanics and to develop the ability to apply concepts to various problems.

1. 掌握生物力学问题的工程方法的基础知识;
2. 了解和掌握生物力学内的各个领域的概念, 培养解决生物医学工程学科问题的能力。

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.)

Lecture 1: 材料力学-微积分复习 Mechanics of materials - calculus review (2 学时)

Topic: Fundamental concept of mechanics, Force vector, Stress and strain, Deformable body mechanics

应力, 应变和本构关系; 线性一阶非齐次微分方程

Stress, strain and constitutive relations; linear first order non-homogeneous differential equations

Lecture 2: 细胞生物力学-粘弹性 Cellular biomechanics - viscoelasticity (2 学时)

Topic: Dynamics

细胞是高等生物的基本构建块。粘弹性模型将用于模拟细胞的机械特性。

The cell is the building block of higher organisms. Viscoelastic models will be used to model mechanical behavior of cells.

Lecture 3: 细胞的机械转导与机械刺激 Mechanotransduction and mechanical stimulation of cells (2 学时)

Topic: Mechanical properties of biological tissues, Micro/Nano biomechanics

机械转导是对细胞如何感知和响应机械刺激的研究。介绍 Mechanoreception, 信号传输和目标激活的概念。讨论用于机械刺激细胞的工程技术。

Mechanotransduction is the study of how cells sense and respond to mechanical events. The concepts of Mechanoreception, signal transmission, and target activation will be introduced. Engineering techniques for mechanical stimulation of cells will be discussed.

Lecture 4: 肌肉和运动 Muscles and movement (2 学时)

Topic: Dynamics, Statics, Kinetics, Mechanical properties of biological tissues

注重在骨骼肌的解剖学和生理学, 具有活动元素的扩展粘弹性模型将用于模拟肌肉生物力学。

Focused on the skeletal muscle anatomy and physiology, an extended viscoelastic model with an active element will be used to model muscle biomechanics.

Lecture 5: 骨 The bone (2 学时)

Topic: Applications of statics to biomechanics, Mechanical properties of biological tissues

在结构和组成方面介绍作为结构器官的骨骼。比较皮质骨和骨小梁的生物力学特性。使用固体力学模型分析骨生物力学。

Introduce the bone as a structural organ in terms of structure and composition. Biomechanical properties of cortical and trabecular bone will be compared. Bone biomechanics will be analyzed with solid mechanics models.

Lecture 6: 骨折力学 Bone fracture mechanics (2 学时)

Topic: Dynamics, Kinetics

介绍骨折和骨质衰竭机制, 并将采用能量平衡方法进行分析。将呈现应力集中及其与骨微观结构的相关性。讨论时间依赖性或与疲劳性骨折。

Bone fracture and failure mechanics will be introduced and will be analysed with an energy balance approach. Stress concentration and its relevance to the bone microstructure will be presented. Time-dependency or fast vs. fatigue fractures will be discussed.

Lecture 7: 骨的功能性适应 Bone functional adaptation (2 学时)

Topic: Dynamics, Multiaxial deformations and stress analyses, Biomaterials

从沃尔夫定律出发, 介绍骨骼的动态可塑性; 使用惯性矩的概念讨论骨骼对弯曲的抵抗力。讨论骨骼机械适应的临床意义。

Starting from Wolff's law, introduce the dynamic nature of the bone; discuss bone's resistance to bending using the concept of moment of inertia. Discuss the clinical implications of the mechanical adaptation of bone.

Lecture 8: 肌骨相互作用 Muscle-bone interaction (2 学时)

Topic: Moment and torque in human body, Applications of statics to biomechanics

以前肢和后肢为例, 介绍动物内部的机械力是如何传递到外部环境。分析包括力和力矩平衡。

Using the forelimb and hindlimb as examples, introduce how internal force within an animal is transmitted to the outside environment. The analysis includes force and moment balance.

Lecture 9: 软结缔组织概述 Soft connective tissues overview (2 学时)

Topic: Dynamics, Multiaxial deformations and stress analyses

根据数据提出韧带, 肌腱和软骨的解剖结构及其生物力学特性。从生物力学角度讨论当前临床干预措施在治疗软组织损伤和疾病。

Present the anatomy of ligaments, tendons, and cartilage and their biomechanical properties from empirical data. Discuss biomechanical relevance of current clinical interventions in treating soft tissue injuries and diseases.

Lecture 10: 软结缔组织-机械性能 Soft connective tissues - mechanical properties (2 学时)

Topic: Dynamics, Multiaxial deformations and stress analyses, Mechanical properties of biological tissues

将韧带, 肌腱和软骨中的解剖结构与其生物力学行为联系起来。突出材料特性如何影响整体机械性能的概念。

Relating anatomical structures in ligaments, tendons, and cartilage with their biomechanical behaviors. Highlight the concept of how material properties contribute to bulk mechanical properties.

Lecture 11: 软结缔组织-粘弹性 Soft connective tissues - viscoelasticity (2 学时)

Topic: Dynamics, Mechanical properties of biological tissues, Biomaterials

粘弹性模型在韧带, 肌腱和软骨的应用。

Viscoelastic models will be re-visited with their application in ligaments, tendons, and cartilage.

Lecture 12: 期中考试 Mid-term test (2 学时)

将测试第 1 至第 11 讲的课程内容。

Course content from lecture 1 to 11 will be tested.

Lecture 13: 运动 Locomotion (2 学时) - 课程项目立项 project proposal due

Topic: Linear and angular kinematics, Impulse and momentum

以描述和定量的角度介绍人类陆地运动（行走和跑步）。

Human terrestrial locomotion (walking and running) will be introduced from both descriptive and quantitative points of view.

Lecture 14: 眼生物力学 Ocular biomechanics (2 学时) - 期中考试总结 Mid-term review

Topic: Static, Applications of statics to biomechanics

介绍眼睛的解剖和生理学。将使用薄壁和厚壁球壳中的流体静力学来讨论眼睛的生物力学。

The anatomy and physiology of the eye will be presented. Biomechanics of the eye will be discussed using fluid statics in thin- and thick-walled spherical shell.

Lecture 15: 呼吸系统-呼吸生物力学 The respiratory system - biomechanics of breathing (2 学时)

Topic: Static, Applications of statics to biomechanics

将呼吸系统分为两个子系统：导气管和相关结构。分析呼吸的生物力学。分析肺弹性和表面张力效应。

Present the respiratory system into two subsystems: the conducting airways and the associated structures. The biomechanics of breathing will be analysed. Analyse lung elasticity and surface tension effects.

Lecture 16: 呼吸系统-传质 The respiratory system - mass transfer (2 学时)

Topic: Static, Applications of statics to biomechanics, Mass transfer

肺部传质将从两个角度展示：(i) 微观传导，关注单个腺泡中的气体运输；(ii) 宏观的，专注于整个肺部。

Mass transfer in the lung will be presented from two points of view: (i) a microscopic one, in which we focus on gas transport in a single acinus; and (ii) a macroscopic one, in which we focus on the entire lung.

Lecture 17: 呼吸系统-颗粒运输 The respiratory system - particle transport (2 学时)

Topic: Static, Applications of statics to biomechanics, Particle transport

介绍肺中颗粒转运在药物递送中的重要性。转运过程将使用球体在流体中的阻力来建模。

The importance of particle transport in the lung as a drug delivery vector will be presented. The transport process will be modelled with spheres experiencing fluid drag force.

Lecture 18: 间质流体流动，Darcy 定律 Interstitial fluid flow, Darcy's law (2 学时)

Topic: Dynamic, Impulse and momentum

多孔介质理论将用于分析细胞外基质中的流体流动。介绍达西定律及渗透率的概念。

Porous media theory will be used to analyse fluid flow in the extracellular matrix. Darcy's law, including the concept of permeability will be presented.

Lecture 19: 血流动力学-血液流变学 Hemodynamics - blood rheology (2 学时)

Topic: Dynamic, Impulse and momentum, Applications of statics to biomechanics

介绍血液成分与其流变学之间的联系。导出血液的本构方程。

Introduce the connection between blood composition and its rheology. Derive the constitutive equations for blood.

Lecture 20: 血流动力学-大动脉 Hemodynamics - large artery (2 学时)

Topic: Dynamic, Impulse and momentum, Applications of statics to biomechanics

在大动脉中的血液模拟为均匀流体，推解体积流速和剪切应力的方程。

Modelling the blood as a homogeneous fluid in large arteries, derive the equations for volumetric flow rate and shear stress.

Lecture 21: 血流动力学-小血管 Hemodynamics - small vessels (2 学时)

Topic: Dynamic, Impulse and momentum, Applications of statics to biomechanics

讨论小血管中血液的非牛顿流体特征。描述红细胞大小的血管中的血流体力学。

Discuss the non-Newtonian feature of blood in small vessels. Mathematically describe blood flow in vessels with size of red blood cells.

Lecture 22: 循环系统-心脏 The circulatory system - the heart (2 学时)

Topic: Dynamic, Impulse and momentum, Applications of statics to biomechanics

循环系统的解剖学概述及其与生物力学的相关性。从生物力学角度深入研究心脏收缩周期。

Overview of the anatomy of the circulatory system and its relevance to biomechanics. The cardiac contraction cycle will be examined in-depth from the biomechanics perspective.

Lecture 23: 课程项目汇报 Project presentations (2 学时)

每个项目团队 (3 名学生) 将展示他们的作品。每个团队有 10 分钟的时间做报告, 2 分钟的时间的提问与解答。

Project teams of 3 student each will present their work. Each team has 10 minutes to present their work and 2 minutes for questions.

Lecture 24: 研究现状及复习 Current research and review (2 学时) 课程项目报告上交 project report

介绍生物力学领域的当前发展, 强调在生物医学工程中的应用。将讨论近期重要的科学期刊文章。

Current developments in the field of biomechanics will be presented with emphasis on applications in biomedical engineering. Major scientific journal articles will be discussed.

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

1. Introduction to Biomedical Engineering (3rd Ed.), Enderle JD, Bronzino J (eds.), Academic Press, 2011
2. Introductory Biomechanics From Cells to Organisms, 1st Edition, Cambridge University Press

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 Performance				
小测验 Quiz				
课程项目 Projects		20		
平时作业 Assignments				
期中考试 Mid-Term Test		20		
期末考试 Final Exam		60		
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