

ME5M19 BIOMECHANICS – [5 Credits]

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Semester: 1

Module Organisation

The module runs for 12 weeks of the academic year and comprises three lectures and one tutorial per week (except the study week). Total contact time is 44 hours.

Start Week	End Week	Lectures per week	Lectures total	Tutorials per week	Tutorials total
1	12	3	33	1	6

Module Description

This module explores the biomechanics of human cells, tissues and joints, how they change with age and disease and how implants can be used to either replace or repair tissues and joints following injury or degeneration. A strong focus is placed on understanding the biomechanics of the musculoskeletal and cardiovascular system. The module begins with an introduction to the forces and moments that act on the musculoskeletal system and goes on to explain how the mechanical properties of different tissues are derived from their structure and composition. Concepts of tissue remodelling and repair are explored. Next, the biomechanics of the main joints of the body are studied. Finally the student is introduced to the use of implants and medical devices for reconstruction and repair of human tissues and systems. Throughout the module students will use engineering principles to analyse tissues, organs and implants, from the use of solid mechanics theory to analyse bone-implant interfaces, to the use of fluid mechanics theory to model blood flow through the cardiovascular system. The module aims to promote independent and lifelong learning through the use of individualised assignments.

Learning Outcomes

On successful completion of this module, students will be able to:

1. Apply the principles of statics to analyze the musculoskeletal system (e.g. determination of muscle forces and joint loads).
2. Understand how the structure and composition of hard tissues (e.g. bone, teeth) determine their mechanical properties. This will be facilitated by laboratory assignment where students will determine the aggregate modulus of articular cartilage using a stress relaxation test.
3. Explain how tissues such as bone and cartilage grow, develop, adapt and repair.
4. Understand how the structure and composition of soft tissues (e.g. cartilage, ligament, tendon, muscle, vascular tissue) determine their mechanical properties.
5. Explain how synovial joints function and how they are replaced with artificial prostheses.
6. Design implants to aid in the repair of hard and soft tissues.
7. Analyse the performance of joint replacement prostheses.

8. Have completed an independent learning assignment unique to them. This requires researching a specific bioengineering problem and producing an electronic report.
9. Understand the anatomy of joints, soft tissues and the cardiovascular system
10. Model the cardiovascular system based on mathematical models

Module Content

- Biomaterial classifications
- Loads and Motion in the in the Musculoskeletal System
- Bone Development, Growth and Biomechanics
- Articular Cartilage Biomechanics
- Intervertebral Disc Biomechanics
- Ligament and Tendon Biomechanics
- Muscle Biomechanics
- Vascular Tissue Mechanics
- Dental Biomechanics and Implants
- Middle Ear Biomechanics
- Biofluid Mechanics
- Friction and lubrication in synovial joints
- Biomechanics of the Hip
- Biomechanics of the Knee
- Biomechanics of the Spine
- Biomechanics of the Shoulder and Elbow
- Total Hip Replacements
- Total Knee Replacements
- Fracture Fixation Devices
- Soft tissue repair
- Repair and restoration of the cardiovascular system
- Cell Biomechanics

Module Notes

Provided via blackboard

Teaching Strategies

The module is taught using a combination of lectures, laboratories and tutorials. Each student is given an independent learning assignment which introduces the student to research skills necessary for life-long learning.

Assessment Modes

Written Exam and assignment (case-study report)

Recommended Texts

- Orthopaedic Biomechanics, Bartel, Davy & Keaveny (Pearson Prentice Hall)
- Basic Orthopaedic Biomechanics, Mow & Huiskes (Lippencot-Raven)
- Biomechanics: Mechanical Properties of Living Tissues, Y.C. Fung (Springer)

Laboratory

Cartilage Stress Relaxation Test