



## **MEDTEC SHOOL**

**Course: Biomechanics and Thermodynamics**

**Year: 3<sup>rd</sup>**

**Period: 2<sup>nd</sup> semester**

**Credits: 11 (Biomechanics 8 + Thermodynamics 3)**

### **Objectives**

The Biomechanics Module aims to provide the students with fundamental knowledge about description and interpretation of biomechanical phenomena, with the aim to acquire ability to set and solve simple problems related to biological systems and tissues. Furthermore the course introduces to fundamentals of materials and fluid properties, statics of structures, tissue mechanics and fluid motion.

The Thermodynamics module aims to provide the physical and engineering bases of energy transformation processes, a prerequisite for the design of biomedical devices.

The student:

- Can solve simple static of structure problems;
- Has knowledge of tissue mechanics (DD1);
- Is able to recognize which tissue components influence the tissue behaviour;
- Is able to calculate stress and strain in a tissue subjected to external loads (DD2);
- Is able to calculate pressures and flows in a hydraulic systems representing biological fluids circulation (DD2,DD3);
- The student knows the principles of thermodynamics in the various formulations and shows that he has fully understood the logical and mathematical connections among the quantities that appear there.
- The student is able to describe both qualitatively and in mathematical form the principle of operation of the main components of biomedical devices;
- The student is able to describe both qualitatively and in mathematical form the basic aspects of heat transfer.
- calculate the properties of simple substances and mixtures using models of different complexity; analyze thermodynamic systems and processes of medium complexity;



## Prerequisites

The course requires the knowledge of the mathematical instruments developed in the course of Mathematics. He is also assumed to be acquainted with the Fundamentals of Experimental Physics and Chemistry and Organic Chemistry.

## Contents

### Biomechanics module

1. Biomechanics of solids:

Vectors, forces, momenta and torque: recall

Statics: theory

Application to body articulations

Structure and composition of tissues

Mechanical properties of materials: constitutive laws and mechanical tests

Tissue mechanics: theory

Applications

2. Biomechanics of fluids:

Statics

Viscosity

Fluid motion

Flow instability

Hemodynamics examples and applications

Blood rheology and microcirculation

Lymphatics

### Thermodynamics Module

1. Basic concepts of thermodynamics

Systems and control volume

State and equilibrium

Energy and energy transfer: work and heat

The first principle of thermodynamics: internal energy.

Second principle of thermodynamics: entropy balance

Energy conversion efficiency

2. Properties of pure substances

Thermodynamic properties of Ideal gas

Thermodynamic properties of Ideal liquid and solid

Mixtures of gas and vapor (atmospheric air)

3. Systems analysis

Closed systems: energy and entropy balances

Control volume: mass, energy and entropy

Bernoulli and Energy equations

4. Mechanism of heat transfer



Conduction: steady state analysis

Natural and forced convection: Dimensionless analysis

Radiation heat transfer

Heat exchanger

## **Teaching Methods**

Teaching will consist in frontal lessons on theory and numerical exercises.

## **Verification of learning**

The exam will consist of a written test concerning the whole program (both open theory questions and numerical exercises). The students may take an optional oral exam, for written evaluations starting from 18/30 (maximum change  $\pm 3$  points).

## **Texts**

Introduction Mechanics, Cambridge texts in Biomedical Engineering, CR Ethier and CA Simmonds eds; Fundamentals of Biomechanics; Equilibrium, Motion and Deformation, N. Özkaya, M. Nordin, D. Goldsheyder, D. Leger, eds, 3<sup>rd</sup> edition, Springer Science+Business Media, LCC, part of Springer Nature; Y.A. Cengel, J.M. Cimbala, R.H. Turner, Fundamentals of Thermal-Fluid Sciences, Fifth Edition, Mc Graw Hill; lecture notes.