HUMANITAS UNIVERSITY

# MEDTEC SHOOL

## Course: Biomechanics and Thermodynamics

**Year: 3rd**

**Period: 1nd 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);*
- *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.*
- *is able to describe both qualitatively and in mathematical form the principle of operation of the main components of biomedical devices;*
- *is able to describe both qualitatively and in mathematical form the basic aspects of heat transfer.*
- *Is able to calculate the properties of simple substances and mixtures using models of different complexity;is able to analyze thermodynamic systems and processes of medium complexity;*
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## 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 (athmospheric 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 forces 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 ±3 points).*

## Texts

*Introduction Mechanics, Cambridge texts in Biomedical Engineering, CR Ethier and CA Simmpons eds; Fundamentals of Biomechanics; Equilibrium, Motion and Deformation, N. Özkaya, M. Nordin, D. Goldsheyder, D. Leger, eds, 3rd 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.*