School of Engineering and Natural Sciences / Biomedical Engineering (English)

2024 - 2025 Academic Year

BIOMEDICAL MODELING and SIMULATION

Syllabus

Course Description						
Name		**Code**	**Semester**	**T+A Hour**	**Credit**	**ECTS**
BIOMEDICAL MODELING and SIMULATION		BME4113197	Fall Semester	3+0	3	6
Prerequisites Courses	FİZYOLOJİ; LİNEER CEBİR VE DİFERANSİYEL DENKLEMLER; DİFERANSİYEL DENKLEMLER					
Recommended Elective Courses	Programming with MATLAB,Computer-Aided Technical Drawing					
Language of Instruction	English					
Course Level	First Cycle (Bachelor's Degree)					
Course Type	Elective					
Course Coordinator	Assist.Prof. Kevser Banu KÖSE					
Name of Lecturer(s)	Assist.Prof. Kevser Banu KÖSE					
Assistant(s)						
Aim	The aim of this course is to introduce numerical modeling and simulation methods in biomedical systems and to provide practical experience with virtual twin models. The course aims at giving the main methods of applied physics applications of biomedical dynamic systems. The focus is to study methods and applications that are of relevance in biomedical engineering within diagnostic and therapeutic applications as well as for physiological processes and virtual tests.					
Course Content	This course contains; Introduction and general concepts, Overview of the course and, the general insight of modeling and simulation of complex systems,Analogies in Biosystem Modeling and Definition of Multi-Physics Definitions,Partial Differential Equations for Dynamic Systems, Numerical Analysis,Medical Image Analysis, Medikal Görüntü Verisi ile 3B Segmentasyon, Bilgisayar Destekli Tasarım Araçları,ANSYS Design Modeler, ANSYS Meshing Applications,Computational Fluid Dynamics / Nümerical Analysis of Blood Flow,Vascular Device Design, Virtual Operation, and Flow Analysis,Computational Modeling of Musculoskeletal System,Surgical Planning and Simulation, Patient-Specific Implant and Graft Design and Virtual Tests,Applications on Hemodynamic Models,Applications on Injury Mechanism Models and Comparisons with Data Visualisations,Virtual Device Test Applications,Student Presentations,Student Presentations.					

Course Learning Outcomes	**Teaching Methods**	**Assessment Methods**
Visualize biomedical device design and virtual performance tests with numerical methods.	10, 12, 16, 3	F
Outline the concepts used in the modeling of complex biomedical systems.	9	F
Translate a dynamic physiological phenomenon into a mathematical set of equations.	19, 3	F
Defines how numerical solutions can be applied to mathematical models that cannot be resolved analytically and the software tools for them.	10, 12, 19, 21, 3	
Convert medical image data into STL objects and design three-dimensional objects with computer-aided software.	10, 12, 16, 19, 3, 9	F
Can perform fluid dynamics and structural mechanics analysis in biological systems with the finite element method. Simulate three-dimensional differential equations and boundary value problems with finite element analysis.	10, 12, 14, 16, 18, 19, 2, 3, 4, 6	D, E, F, H

Teaching Methods	10: Discussion Method, 12: Problem Solving Method, 14: Self Study Method, 16: Question - Answer Technique, 18: Micro Teaching Technique, 19: Brainstorming Technique, 2: Project Based Learning Model, 21: Simulation Technique, 3: Problem Baded Learning Model, 4: Inquiry-Based Learning, 6: Experiential Learning, 9: Lecture Method
Assessment Methods	D: Oral Exam, E: Homework, F: Project Task, H: Performance Task

Lecture Schedule

Sequence	**Topics**	**Preliminary Preparation**
1	Introduction and general concepts, Overview of the course and, the general insight of modeling and simulation of complex systems	General information is obtained about biomedical modeling applications.
2	Analogies in Biosystem Modeling and Definition of Multi-Physics Definitions	Examples of multi-physics simulation are investigated
3	Partial Differential Equations for Dynamic Systems, Numerical Analysis	Review of the knowledge of differantial equations
4	Medical Image Analysis, Medikal Görüntü Verisi ile 3B Segmentasyon, Bilgisayar Destekli Tasarım Araçları	Students should have 3D Slicer, FreeCAD, MeshMixer and ANSYS Aim software ready on their devices before the lesson.
5	ANSYS Design Modeler, ANSYS Meshing Applications	Installing ANSYS Student sowware to PC.
6	Computational Fluid Dynamics / Nümerical Analysis of Blood Flow	Review the last lecture.
7	Vascular Device Design, Virtual Operation, and Flow Analysis	Review the last lecture.
8	Computational Modeling of Musculoskeletal System	Review biomechanics course notes
9	Surgical Planning and Simulation, Patient-Specific Implant and Graft Design and Virtual Tests	Literature search on virtual surgery
10	Applications on Hemodynamic Models	Literature search on hemodynamics simulations
11	Applications on Injury Mechanism Models and Comparisons with Data Visualisations	
12	Virtual Device Test Applications	Students should create a Simscale account and access the software on the web.
13	Student Presentations	Review of the past presentations
14	Student Presentations	Review of the past presentations

Evaluation Methods	**Weight(%)**
Midterm Exam	30
General Exam	70

Resources
1- Finite Element Analysis for Biomedical Engineering Applications - 2019 -CRC Press, Z. C. Yang , 2- Numerical Methods in Biomedical Engineering - Stanley Dunn, Alkis Constantinides, Prabhas V. Moghe -Academic Press Elsevier, 3- Quantitative Human Physiology: An Introduction (Biomedical Engineering) 2nd Edition - Joseph J Feher -Academic Press ElsevierSoftware: ANSYS, Slicer3D, Inobitec, Geomagic, FreeCAD, Simscale, Autodesk MeshMixer, Materialise Mimics Student Edition