School of Interdisciplinary Engineering and Sciences (SINES)
National University of Sciences & Technology (NUST)

Title : Biomedical Engineering
Code : CSE-847
Credit Hours: 3-0

Course Brief:

Biomedical Engineering is an exciting and multidisciplinary course. It combines expertise in a wide range of engineering techniques, methods and principles. However, these techniques cannot be used until a basic understanding of biological systems is acquired. This course therefore aims to provide an overview of the engineering biological systems for example, organs, organ systems and their relevant engineering design to address complicated problems in health care. The course will provide an awareness of the diverse challenges that form the background to research. The course can be really fruitful for the development and use of Healthcare technologies with an understanding of human systems for engineers.

Objectives:

The course provides a detailed insight in modeling approaches, virtual reconstruction of natural systems and their mathematical description

Course Learning outcomes

1. The course will provide students with a guide to mathematical modeling techniques and tools for simulation of physiological systems.
2. Students will be able to classify modeling approaches and select appropriate models as research and development tools.
3. By using various mechanical models, students will be able to quantify etiology of each at multiple levels
4. Students will be able to demonstrate their understanding of cellular force development and tissue mechanics.
5. Students will be able to integrate electrochemical, physiological and mechanical phenomena into designing models to assess their inter-dependencies.
6. Student will be able to develop vocabulary and context for understanding recent literature in computational modeling and simulation

Course Contents (General)

1. Introduction
2. Engineering Design of Human Systems
3. Structure to Function Theorems
4. Geometrical and Physical modeling of structures.
5. Dynamics of human systems.
6. 3D Models vs. Clinical data
7. Abstract level briefing of algorithm designing techniques for analysis of different medical data.
8. Introduction about state of the art imagining and diagnostics machines.

9. Case Studies using software's – Visualization (Maya, Zbrush, Blender, 3D Slicer, GaitSym, AutoCAD, Pro-E and Free surfer).

Week Wise Contents:

Sr No	Topics and Week-wise break down
Week 1, 2 and 3	Introduction to Biomedical Engineering
	Biomedical Engineering Applications in healthcare. Robotic Surgeons and Rehabilitation
Week 4 - 5	Organ Systems and Engineering Design
	Structures – Bones Head Models Limb Models Pressure vessels
	Engineering design - basics Implementation – Brainstorming
Week 6	OHT1
Week 7	Introduction about state of the art imagining and diagnostics machines
	Medical Technology Digital Health and AI in Health Application Telemedicine & Application areas
Week 8 – 10	Structure to Function Study for Device Design
	Functional studies of structures including: Bones - Head Models - Heart Models and Pressure vessels *Associated phenomena's including* Fracture/breakage - Flow of fluids - Pressure Control
Week 11	Biomedical Tech-Industrial Analysis Strategy Management in Innovative device design.
Week 12	OHT2
Week 13	Abstract level briefing of algorithm designing techniques for analysis of different medical data. Moving Image Analysis – Case Study
Week 14	Dynamics of Biological phenomena's in organ systems –System Dynamics
	Dynamics: Dynamics of modeling various systems. Multi-body dynamics in organ systems Understanding connectivity in dynamics:
Week 15	3D Models vs. Clinical data
	Understanding clinical data. Introduction to mathematical representations. 3D Modeling concepts. Building 3D volumes, and applications
Week 16-17	Case Studies using software's (Maya, Zbrush, Blender, 3D Slicer, GaitSym, AutoCAD, Pro-E and Free surfer) (One of any)
	Hands on various tools, for rendering, reconstructions, volume meshing and visualization

Week 18	Machine Learning and Signals in Medicines: Signal Processing
	Applications of Biomedical Engineering Presentations
	End Semester Exams
Additional	Suggested topics from Students

Text Books/Reference Material:

1. Fazel-Rezai, Reza, ed. *Biomedical engineering: from theory to applications*. BoD– Books on Demand, 2011.
2. Saltzman, W. Mark. *Biomedical engineering: bridging medicine and technology*. Cambridge University Press, 2009.
3. Paul, Sudip, ed. *Biomedical engineering and its applications in healthcare*. Berlin, Germany:: Springer, 2019.
4. Marieb, Elaine Nicpon, and Katja Hoehn. *Human anatomy & physiology*. Pearson Education, 2007.
5. Hole, John W., and Nancy Ann Corbett. *Essentials of Human Anatomy & Physiology*. Wm. C. Brown Publishers, 1995.
6. Enderle, J., & Bronzino, J. (2012). *Introduction to biomedical engineering*. Academic press.
7. Harris, Thomas R., John D. Bransford, and Sean P. Brophy. "Roles for learning sciences and learning technologies in biomedical engineering education: A review of recent advances." *Annual Review of Biomedical Engineering* 4, no. 1 (2002): 29-48.
8. Cooney, David O., and David O. Cooney. *Biomedical engineering principles: an introduction to fluid, heat, and mass transport processes*. New York [ua]: Dekker, 197
9. Bronzino JD. Biomedical Engineering handbook. CRC press; 1999 Dec 28.

Nature of Assessments

Course format will include a lot of readings, lectures, active learning exercises, discussion, group activities, in-class quizzes, a mid-term exam, and a final exam.