American University of Beirut

School of Engineering and Architecture
Mechanical Engineering Department

Office: 113- Office Hours: MW 9H30-11H
Exams: March 15th, 1h-2h30
Final: To be announced

MECH 634: Biomaterials, artificial organs and tissue engineering

Course Instructor: Mohamad Nasser-Eddin, Ph.D.
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Course Hours/Credits: T, TH: 12-13H15.

Office hours: T, TH 11-12

COURSE DESCRIPTION: This course provides an understanding of the needs, use and limitations of materials and devices to repair, replace or augment the living tissues and organs of the human body. The topics (i) establish the biomedical principles and biological factors involved in achieving long term stability of replacement parts of the body (ii) examine the industrial and ethical issues involved in use of artificial materials and devices in humans (iii) analyze the principles and applications of engineering of tissues to replace body parts. This course will help to enhance the reader’s awareness of the complex multi-disciplinary nature of the fields of biomedical materials, biomechanics, total joint replacement, and the importance and methods of communication with a broad range of people including patients, clinicians, environmental and governmental personnel.

Prerequisites:

COURSE OBJECTIVES:

Course objectives

Part One: Biocompatibility, Clinical needs and concepts of repair

1. Define the concept of biocompatibility and describe how it is tested.

2. Explain the mechanism and relevance of inflammatory changes to tissues in contact with biomaterials and their importance in wound healing and long-term prognosis for implants and artificial organs.

3. Define and compare the differences between implants and transplants and their relative advantages and disadvantages.
4. Identify the various categories of implant materials and devices, and the means of their fixations to various physiological organs

5. Classify the types of tissues and organs in the body and their function in relation to replacement by artificial materials.

Part II. Artificial Organs

1. Describe the repair mechanisms of the skeletal tissues as a function of the mode of failure and age of patient.

2. Compare the relative merits of different total hip, total knee, shoulder and spine systems on long term survivability.

3. Understand how mechanical devices can replace the function of organs in the body, including the heart, blood vessels, lungs, kidneys and sensory organs.

4. Describe the engineering design principles for effective function of artificial organs, including their performance in term of their material properties, exchange processes, maintenance of appropriate blood flow and compatibility with the overall function in body.

5. Be capable of describing to healthcare professionals and patients the advantages and disadvantages of artificial organs.

Part III. Tissue Engineering

1. Discuss the basic principles of cell culture and characterize the various cell types using methods such as immunochemistry, scanning electron and confocal microscopy to identify cell-type specific markers and genes.

2. Understand the importance of translating data derived from monolayer cell cultures into clinically usable cells/tissues type.

3. Discuss interactions between cells and scaffolds and understand how scaffold composition and architecture can influence cell attachment, growth and differentiation.
4. Discuss several examples where tissue engineering strategies are being developed first to promote repair and regeneration with emphasis on bone, cartilage and skin.

**Required Textbook:**

Hench L. and Jones J. Biomaterials, artificial organs and tissue engineering. CRC Press. 2005

**Suggested Readings:**


**GRADING:**

Midterm I exam 20%
Midterm II exam 20%
Final exam 30%
Project 20%
Attendance/participation: 10%

**Course prerequisites:**

Graduate or senior standing in engineering or permission of instructor
## COURSE OUTLINE

<table>
<thead>
<tr>
<th>Week</th>
<th>Topic</th>
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<tbody>
<tr>
<td>1-2</td>
<td><strong>Introduction to materials (Living and non-living)</strong>. Metals, Ceramics Polymers, Biocomposites, cells and tissues, Inflammation and wound healing.</td>
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<tr>
<td>3-4</td>
<td><strong>Clinical needs and concepts of repair</strong>: Skeletal system: The components of bone, biomechanics of bone, effect of age on bone, fatigue failure of bone. Cardiovascular system: Pathology, control and treatment of pathologies, Biomedical polymers, Biomedical Hydrogels.</td>
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<td>5</td>
<td><strong>Applications of biomaterials I</strong>. Repair of skeletal tissues (bone repair, fixation, orthopedic metals, bone graft supplements)</td>
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<td>6-7</td>
<td><strong>Applications of biomaterials II</strong>. Joint replacement (Knee, Ankle, shoulder, elbow, finger and intervertebral disc)</td>
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<td>8-9</td>
<td><strong>Artificial organs</strong>. Kidney, heart, lung, liver, pancreas, skin, the ear, the eye, the nose, the voice box,</td>
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<td>10</td>
<td><strong>Mass transport process in artificial organs</strong>. Convective transport, diffusional transport, interaction of convection and diffusion.</td>
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<td>11</td>
<td><strong>Cardiovascular assist systems</strong>. Heart valves, pumps, vascular prosthesis, LVAD.</td>
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<td>12</td>
<td><strong>Introduction to tissue engineering</strong>. The challenge, cell sources, culture conditions, cell reprogramming, interactions.</td>
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<td>13</td>
<td><strong>Scaffolds for tissue engineering</strong>: Classes of potential scaffold materials, polymer scaffolds, bioactive ceramic scaffolds, bioactive glass scaffolds, composites.</td>
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<td>14</td>
<td><strong>Immunochemical techniques in tissue engineering</strong>. Basic immunology principles, common techniques of immunology used in biomaterials, applications in biomaterials sciences and research.</td>
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<td>15</td>
<td><strong>Clinical applications of tissue engineering</strong>: Skin, cartilage, tendons, ligaments, Islets of Pancreas, liver, nerves and cardiovascular system</td>
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