Jordan University of Science and Technology
Faculty of Engineering
Biomedical Engineering Department

BME 442 Introduction to Biomedical Materials

Course Description

3 Credit hours (3 h lectures). Survey of materials intended for biological applications; Materials for both medical implants and dental restoration and appliances will be covered. Discussions of various aspects pertaining to the selection, processing, testing (in vitro and in vivo) and performance of biomedical materials. The biocompatibility and surgical applicability of metallic, polymeric, ceramic, and other implants and prosthetic devices are discussed.

Text Book(s)

Title	Biomaterials Science; An Introduction to Materials in Medicine
Author(s)	Ratner, B.; Hoffman, A.; Schoen, F.; Lemons, J.
Publisher	Academic Press
Year	2004
Edition	2nd Edition

References

Books	Park J.,& Lakes R. (992)" Biomaterials: An Introduction", 2nd Edition, Plenum Public Corporation. Silver F. H.,& Christiansen D.L.(1999) Biomaterials Science and Biocompatibility, Springer- Verlag. Park J. B., & Bronzino J. D.(eds.) (2003) "Biomaterials Principles and Applications", CRC Press Beer F., Johnston E., & Dewolf J. (2001) "Mechanics of Materials" 3rd Edition, McGraw- Hill Cheng F.(1996) "Statics and Strength of Materials" 2nd Edition, McGraw- Hill Budinski K. G., & Budinski M. K.(2001) Edition, "Engineering Materials Properties and Selection" 7th Edition, Prentice Hall. Benham P. P., Crawford R. J., & Armstrong C. G.(1996) "Mechanics of Engineering Materials" 2nd Edition, Addison Wesley Longman LTD Bronzino J. D. (Ed) (1999), "The Biomedical Engineering Handbook", 2nd Edition, CRC Press.
Journals	- Biomaterials - International Journal of Biomaterials - Journal of Biomedical Materials Research - Journal of Biomaterials Applications - Journal of Biomaterials Science

Prerequisites	
Prerequisites by topic	Engineering Mechanics, Biochemistry
Prerequisites by course	ME 215, CHEM362
Co-requisites by course	N/A
Prerequisite for	Prosthetics and Orthotics, BioMEMS and Nanotechnology, Artificial Organs

Objectives and Outcomes[1]	
Objectives	**Outcomes**
1. Appreciate the role of biomaterials in biomedical engineering [f, h, j]	1.1. Appreciate the role of biomaterials in the biomedical industry and in biotechnology [f, h, i, j]
2. Introduce bulk and surface material properties essential to the understanding of biomaterials design, and application [a, e, g]	2.1. Explain the role of state and bonding, materials, microstructures, mechanical properties, mechanical testing, other important properties on material behavior and function [g] 2.2. Differentiate between different surface characterization techniques of biomaterial surfaces, measurement techniques (contact angle, electron spectroscopy, ion mass spectroscopy, SEM, IR, other methods) and the type and significance of information obtained from each technique [a]
3. Analyze the different classes of materials used in biomedical applications and the characteristics of each class [a,e,g,j,k]	3.1. Evaluate the use of metal s as biomaterials by addressing the steps involved in the fabrication of implants, the microstructure and properties of implant metals. [a,c,e,g,j,k] 3.2. Explain the application of specific types of metals in biomaterials: stainless steel, cobalt- based alloys, titanium based alloys. [a,e,g,j,k] 3.3. Evaluate the use of polymers as biomaterials, by studying weight, synthesis, solid state characteristics, characterization techniques, and classes of polymers used in medicine. [a,e,g,j,k] 3.4. Evaluate the use of hydrogels as biomaterials, by studying their classification and basic structure characteristics, and examining biomedically and pharmaceutically important hydrogels. [a,e,g,j,k] 3.5. Evaluate the use of bioresorbable and bioerodible materials as biomaterials, by studying different types of implants, definitions, currently available degradable polymers such as: Poly(lactic Acid), and Poly(glycolic Acid), Physical mechanisms of bioerosion, mechanisms of chemical degradation, rate of bioerosion, storage and stability. [a,e,g,j,k] 3.6. Evaluate the use of ceramics, glasses, and glass-ceramics as biomaterials, by studying the different types of bioceramic –tissue attachment, characteristic and processing. [a,e,g,j,k] 3.7. Differentiate between the different types of ceramics, glasses, and glass-ceramics; inert crystalline ceramics, porous ceramics, bioactive glasses and glass-ceramics, calcium phosphate ceramics, and resorbable calcium phosphates. [a,e,j,k]
4. Study the types of host reaction to biomaterials and biocompatibility [a,c,e,g,j,k]	4.1. Identify the types of host reaction to biomaterials (inflammation, and foreign body response). [a,e,g,j,k] 4.2. Differentialte between the different types of host reaction: chronic and acute inflammation, granulation, fibrosis and fibrous encapsulation [a,e,j,k,l]
5. Consider the application of various biomaterial testing	5.1. Perfrom in-vitro assessment of tissue compatibility using: assay methods, agar diffusion, and elution. Followed by interpretation of

[1] Lower-case letters in brackets refer to the Program outcomes

protocols for both in-vitro and in-vivo assessment [a,c,e,g,j,k]	results and assessment of clinical use. [a,e,g,j,k] 5.2. Preform in-vivo assessment of tissue compatibility by studying: implant site, surgical protocol, controls, and the evaluation of tissue reaction [a,e,g,j,k]
6. Correlate the properties of the different biomaterials to their applications in medicine and dentistry [a,c,e]	6.1. Identify the various applications of biomaterials in medicine and dentistry: cardiovascular applications (cardiopulmonary bypass, heart valves, vascular grafts, drug administration systems, stents, catheter anc cannulas, pacemakers, IVCF, IABP, ventricular assist, and blood substitutes. [a,j,k]
7. Encourage life long learning, foster teamwork and enhance student's communication skills. [d,g,h,I,k]	7.1. Write a technical report and give an oral presentation on team project [g,h,I,k]

Topics Covered		
Week	**Topics**	**References**
1-2	- Introduction to Biomaterials: History of biomaterials, biomaterial science, examples of biomaterial applications, and characteristics of biomaterials science. - -Bulk Properties of Materials: solid state and bonding, materials, microstructure, mechanical properties, mechanical testing, other important properties of materials	Chapter 1.1 Chapter 1.2
3	- Surface Properties of materials: Characterization of biomaterial surfaces, measurement techniques (Contact angle, electron spectroscopy, ion mass spectroscopy, SEM, IR, Other methods)	Chapter 1.4
4	- Metals: Steps in the fabrication of implants, microstructure and properties of implant metals, stainless steel, cobalt-based alloys, titanium based alloys.	Chapter 2.9
5	- Polymers: Molecular weight, synthesis, the solid state, characterization techniques, classes of polymers used in medicine.	Chapter 2.2
6	- - Hydrogels: Classification and basic structure, preparation, swelling behavior determination of structural characteristics, biomedically and pharmaceutically important hydrogels - Bioresorbable and bioerodible materials: types of implants, definitions, currently available degradable polymers such as: Poly(lactic Acid), and Poly(glycolic Acid), Physical mechanisms of bioerosion, mechanisms of chemical degradation, rate of bioerosion, storage and stability	Chapter 2.5 Chapter 2.7
First Exam (See Dept. Schedule)		
7	- Ceramics, glasses, and glass-ceramics: Types of bioceramics- tissue attachment, characteristics and processing; inert crystalline ceramics, porous ceramics, bioactive glasses and glass-ceramics, calcium phosphate ceramics, and resorbable calcium phosphates	Chapter 2.10
8	- Pyrolitic Carbon: structure, mechanical properties, fabrication, and biocompatibility issues.	Chapter 2.11
9	- Biological materials: definition, advantages and disadvantages in comparison with synthetic biomaterials, structure and modifications of collagen, proteoglycans & glycosaminoglycans, elastin, and an overview of grafting techniques	Chapter 2.8
Second (See Dept. Schedule)		
10-11	- Host Reaction to biomaterials (inflammation and foreign body reponse): chronic and acute inflammation, granulation, fibrosis & fibrous encapsulation	Chapter 4.1 Chapter 4.2
12- 13	- Testing Biomaterials (in vitro assessment of tissue compatibility): background, assay methods, agar diffusion, elution, interpretation of results, and clinical use - In vivo assessment of tissue compatibility: Implant sites, surgical protocol, controls, evaluation of tissue reaction	Chapter 5.1 Chapter 5.2 Chapter 5.3
14- 15	- Application of materials in medicine and dentistry: Introduction, cardiovascular applications (cardiopulmonary bypass, heart valves, vascular grafts, drug administration, systems stents, catheters and cannulas, pacemakers, IVCF, IABP, ventricular assist, blood substritutes	Chapter 7
Final Exam		

Evaluation		
Assessment Tool	**Expected Due Date**	**Weight**
Quizzes & project	End of the Semester	10%
First Exam	(See Dept. Schedule)	25 %
Second Exam	(See Dept. Schedule)	25 %
Final Exam	According to the University final examination schedule	40 %

Teaching & Learning Methods

- Active learning, where students should be active and involved in the learning process inside the classroom, will be emphasized in the delivery of this course.
- Different active learning methods/approaches such as: Engaged Learning, Project-Based Learning, Cooperative Learning, Problem-based Learning, Structured Problem-solving, will be used.
- The teaching method that will be used in this course will be composed of a series of mini lectures interrupted with frequent discussions and brainstorming exercises. PowerPoint presentations will be prepared for the course materials.
- A typical lecture would start with a short review (~ 5 minutes) using both PowerPoint presentations and the blackboard. This review will also depend on discussions which will gauge the students' digestion of the previous material. Then, the students would have a lecture on new materials using PowerPoint presentations and blackboard. The lecture presentation will be paused every 15 – 20 minutes with brainstorming questions and discussions that will allow the students to reflect and think in more depth about what they learned in that presentation. Then, some example problems will be presented and discussed with the students to illustrate the appropriate problem solving skills that the students should learn. The lecture will be continued for another 15 – 20 minutes, followed by examples and/or a quiz covering the materials taught in the previous two weeks.

Policy	
Attendance	Attendance will be checked at the beginning of each class. University regulations will be strictly followed for students exceeding the maximum number of absences. In addition, points will be deducted from the participation grade for excessive absence.
Term Project	Term projects will be conducted by a group of 3- 4 students. The team should share and distribute responsibility. The group will submit a professional report and make an oral presentation. Making use of all resources, e.g., patents, journal publications, internet, labs, etc., is encouraged. The report must be typed. Hand-written reports are not accepted. The report should not exceed 10 pages. Late Reports will not be accepted.
Student Conduct	It is the responsibility of each student to adhere to the principles of academic integrity. Academic integrity means that a student is honest with him/herself, fellow students, instructors, and the University in matters concerning his or her educational endeavors. Cheating will not be tolerated in this course. University regulations will be pursued and enforced on any cheating student.

Contribution of Course to Meeting the Professional Component
The course contributes to building the fundamental basic concepts and applications of physiological fluid mechanics in Biomedical Engineering.

ABET Category Content	
Engineering Science	3.0 Credits
Engineering Design	