

(BM-313) - Biomaterials

Course Outline:

Theory

1. Course Overview and Introduction

1. Introduction to biomaterials science
2. Brief history of biomaterials (generations of biomaterials)
3. Today's biomaterials applications: overview of types of implantable biomaterials and devices

2. Properties of Biomaterials: General Concepts

1. Bonding, interatomic, intermolecular, surface interactions
2. Introduction to bulk properties: microstructure, strength, deformation, thermal and optical properties
3. Techniques: Introduction to surface Characterization of Biomaterials
4. Electron spectroscopy for chemical analysis
5. Attenuated total internal reflectance Fourier transform-infrared spectroscopy.
6. Composite biomaterials
7. 3D structure of biomaterials by bio X-ray diffraction, application of chitosan and other biopolymers in biomedical

3. Classes of Materials Used in Medicine

1. Polymeric biomaterials (chitosan, collagen, elastin, proteoglycan and glycoprotein)
2. basic principles: molecular and chemical structure, molecular weight and polydispersity
3. physical behavior
4. synthesis: addition, free-radical, condensation polymerization
5. Hydrogels: structure and synthesis
6. examples of biomedical hydrogels: acrylic, PVA, PEG, degradable, smart hydrogels
7. Biological materials: structure and properties, hard tissues: tooth and bone, soft tissues: skin, blood vessel, tendon.

4. Introduction to Mechanical Properties of Biomaterials

1. Review of static and dynamic properties: tensile, compressive, flexural, torsional, viscoelasticity, creep, dynamic modulus
2. Deformation and fracture of engineering materials
3. Biomechanics of arthroplasty
4. Introduction to finite element analysis.

5. Biomaterials Degradation in the Biological Environment

1. Review of clinical cases of implant failure
2. Mechanisms of metallic corrosion
3. Fatigue failure
4. Wear
5. Polymer degradation
6. Ceramic degradation

6. Biocompatibility

1. Biological responses to biomaterials
2. Toxicity and hypersensitivity
3. Blood-material interactions
4. Tumours associated with biomaterials and implants
5. Biofilms

7. Special Considerations for Implants, Devices and Biomaterials

1. Sterility and patient safety
2. Device Failure Mode Analysis/Risk Analysis
3. Voluntary consensus standards and regulatory compliance
4. Legal aspects of biomaterials, clinical trials and case studies in regulations

8. Tissue Engineering, gene therapy using viral vector materials for scaffolding.

9. Biomaterial implantation and Acute inflammation

10. **Wound healing and the presence of biomaterials**
11. **Immune response to biomaterials**
12. **Biomaterials and thrombosis**
13. **Infection, tumorogenesis and calcification of biomaterials**

List of Practicals:

1. To build molecular model of a biopolymer from basic repeating peptide units
2. Molecular graphics of basic repeating units of biopolymer
3. Interpretation of bio X-ray diffraction of a biomaterial expected diffraction pattern
4. Calculate R-value for structural analysis of biopolymers
5. To build model of CHITOSAN (bio-materials) from basic repeating units.
6. Molecular graphics of basic repeating units of CHITOSAN.
7. Demonstration of features of dental chair & dental operatory.
8. Demonstration of bio-materials (bioceramics, porcelain & metals) its composition & properties
9. Demonstration of the process of sterilization, autoclave & X-ray unit (dental).
10. Separation of bio-material (protein) by electrophoresis method involved in various diseases.
11. Demonstration of different types of sutures.
12. Fabricate a biomaterial for bone tissue
13. Fabricate a biomaterial for dental tissues
14. Tension and compression analysis for fabricated biomaterials.
15. Open ended lab 1
16. Open ended lab 2

Suggested Teaching Methodology:

- Lecturing
- Written Assignments Report Writing

Suggested Assessment:

Theory (100%)

- Sessional (20%)
- Quiz (12%)
- Assignment (8%)
- Midterm (30%)
- Final Term (50%)

Laboratory (100%)

Recommended Texts and Reference Books:

1. Buddy D. Ratner, et al, Biomaterials Science, Second Edition: An Introduction to Materials in Medicine
2. Handbook of Biomaterial Properties (*Second Edition) edited by William Murphy, Jonathan Black, Garth Hastings.
3. Michael N. Helmus (Editor), Biomaterials in the Design and Reliability of Medical Devices
4. David Hill, Design Engineering of Biomaterials for Medical Devices
5. Jos Vander Sloten (Editor), Computer Technology in Biomaterials Science and Engineering (Biomaterials Science & Engineering)
6. Kay C. Dee, et al, An Introduction to Tissue-Biomaterial Interactions
7. Joon B. Park, Joseph D. Bronzino, Biomaterials Principles and Application
8. Xian, Wujing, A laboratory course in biomaterials, 2009.
9. Mahapatro, Anil, Polymers for biomedical applications, 2008.

10. Temenoff, J. S, Biomaterials: The intersection of biology & materials science, 2008.
-