

GUJARAT TECHNOLOGICAL UNIVERSITY

BIO MEDICAL ENGINEERING (31)

ADVANCE BIOMATERIALS

SUBJECT CODE: 2713110

SEMESTER: I

Type of course: Major Elective

Prerequisite: Material Science

Rationale: The primary objective of this course is to gain the knowledge of different materials used in medicine to augment or replace the non-functional part of the body. It gives the introduction to the field of biomaterials used in the design of medical devices, and to support or replace soft and hard tissues. Discussion of bulk properties, applications, and *in vivo* behavior of different classes of natural and synthetic biomaterials. Analysis of biological response and biocompatibility, degradation and failure processes of implantable biomaterials/devices are also done. Overview of regulatory compliance and performance requirements for commercialization of biomaterials and medical devices is studied

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P		Theory Marks		Practical Marks				
			ESE (E)	PA (M)	PA (V)		PA (I)			
					ESE	OEP	PA	RP		
3	2	2	5	70	30	20	10	20	0	150

Content:

Sr. No.	Topics	Teaching Hrs.	Module Weightage
1	INTRODUCTION Definition Of Biomaterials, Mechanical Properties, Surface Chemistry Of Materials, Surface Modification, Tissue Reaction, Wound Kinetics, And Bio Compatibility, Physical And Mechanical Properties Of Biomaterials	2	
2	MATERIALS IN MEDICAL DEVICES Metals, Ceramics, Polymers And Composites And Biological Materials. Material Preparation, Chemical Composition, Properties, Uses In Medicine And Biosciences And Failure Mechanisms.	6	
3	STERILIZATION OF BIOMATERIALS Sterilization Techniques: – Process And Mechanism Of Action Of Steam Sterilization, Radiation, Sterilization, Electron Beam Sterilization, Ethylene Oxide, Chlorine Dioxide And Plasma Gas, Sterilization.	4	
4	TESTING OF MATERIALS Testing With Tissue Culture – In Vitro And In Vivo Assessment Of Biocompatibility, Testing With Soft, Tissues And Testing At Non Thrombogenic Surface – Blood Compatibility And Thrombogenicity. Biomaterials Degradation In The Biological Environment	6	
5	Biocompatibility Biocompatibility And Tissue Response: Biocompatibility Hierarchy-Ramifications In Implant Design And Applications. Host Reactions To	6	

	Particulate Biomaterials: Type Of Reactions, Particle Surface; Cell Surface And Signaling Mechanism, Chemical Mediators. Protein And Cell Interactions With Biomaterials. Protein Conformations, The Conformation Stabilization Forces.		
6	Biodegradability Biodegradability, Resorption And Stability: Biodegradable Suture Materials, Factors Affecting Biodegradation Phenomena, Intrinsic Factors –Substituent Effect, Morphological Effect, Annealing Effect. Extrinsic Factors – Effect Of Media Ph, Effect Of Electrolytes, Effect Of External Stress Applied.	6	
7	Applications Of Biomaterials ,Nanomaterials And Nanotechnology Orthopedics Applications: Upper Extremities, Lower Extremities And Spine, Dental Implantation, Tissue Engineering Scaffolds , Bone Tissue Engineering, Trauma, Cardiovascular, Plastic Surgery, Ophthalmology, Drug-Delivery, Advance Nanomaterial Applications, Bio MEMS , Magnetic Particles For Biomedical Applications.	6	
8	Special Considerations For Implants, Devices And Biomaterials 8.1. Regulatory Compliance 8.2. Commercialization: What It Takes To Get A Product To The Market 8.3. Legal Aspects Of Biomaterials, Clinical Trials And Case Studies In Regulation.	6	

Reference Books:

1. Buddy D.Ratner, Allan S. Hoffman, Frederick J. Schoen, Jack E. Lemons, Eds, Biomaterials Science – An Introduction to Materials in Medicine, Academic Press, 1996.
2. Donald L. Wise, Debra J. Trantolo, David E. Altobelli, Michael J. Yaszemski, Joseph D. Gresser, Edith R. Schwartz (Editors), Hand book of Biomaterials and Bioengineering, Parts A&B, Marcel Dekker Inc, 1995.
3. J.H.U.Brown (Ed), Advances in Bio Medical Engineering, Academic Press 1975.
4. Andrew F.Von Racum, Hand Book of Bio Medical Evaluation, Mc-Millan Publishers, 1980.
5. Jacob Cline, Hand Book of Bio Medical Engineering, Academic Press in Sandiego, 1988.
6. Jonathan Black, Biological Performance of Materials- Fundamentals of bio compatibility,4th edition, CRC Press 2005.
7. Larry L. Hench and Julian R.Jones, Biomaterials, Artificial organs and Tissue Engineering, 2005

Course Outcome:

1. Understand the field of biomaterials in medicine and their use in specific implant designs focusing on: Material and implant requirements, structure-property relationships for synthetic and biological materials, and static and dynamics properties of biomaterials.
2. Understand biology and physiology, and apply math, science and engineering to solve the problems at the interface of engineering and biology
3. Understand the concept of Biocompatibility, Biodegradability and its effect on Biomaterial Design
4. Knowledge of contemporary issues;
5. Evaluate design considerations, experimental techniques and data interpretation;
6. Understand professional and ethical responsibility;
7. Use techniques, skills and tools necessary for engineering practice.
8. Discuss the process of successful integration as well as problems that may lead to dysfunction of biomaterials employed to replace or support tissues or structures of the human body.
9. Refer to the regulatory standards for approval of biomaterials.

Suggested List of Experiments:

1. To study introduction of Biomaterials used in Medicine and their general Properties.
2. To study different types of Biomaterials used in Medical Implants.
3. To study Different Sterilization Processes.
4. To study different Testing Mechanisms for Biomaterials Following their application.
5. To study Biocompatibility testing along with Tissue Implant interaction at surface.
6. To study Nanomaterial applications in Medicine
7. To study Biomem Applications in Medicine.
8. To study application of Biomaterials in Trauma, Cardiovascular and tissue scaffolds.

Suggested Open Ended Problems:

Problems associated with Biomaterials used in the design of medical devices:

Implant design problem study:

- The goal of this activity is to identify problems associated with medical implant designs and to propose methods to minimize or resolve it.
- Each Student will select a specific problem of interest with a medical implant design.
- Individual has to give a presentation as well as a report of the selected implant at the end of the semester.
- Presentation & Report Content:-
 - Objective
 - Problem statement
 - Extensive literature review
 - Alternative materials/design/processing
 - Design, development, performance requirements and regulatory aspects
 - Conclusion & Future Work