BIO-MATERIALS AND BIO-MANUFACTURING

Module 1: Fundamentals of Bio-materials
Material Properties: Atomic bonding, crystal structures, and physical characteristics of solids. Material Classes: Metals (e.g., Titanium, Co-Cr alloys), ceramics (e.g., Hydroxyapatite, Alumina), polymers, and composites. Degradation & Bio-corrosion: Bio-degradation, bioresorbability, and biofilm formation.

Module 2: Bio-compatibility and Host Response
Host Reactions: Protein-surface interactions, tissue inflammation, blood compatibility, and cytotoxicity. Cell-Material Interactions: Cell adhesion, proliferation, and differentiation. Implant Sterilization & Testing: Methods of sterilization (autoclaving, gamma radiation) and *in vitro/in vivo* biological testing.

Module 3: Advanced Bio manufacturing Techniques
Cell Culture Technology: Mammalian cell culture, bioreactor kinetics, and medium development. Scaffold Fabrication: Techniques for artificial extracellular matrix (ECM) generation. Bio- printing: 3D printing of hydro-gels, bio-inks, and living cells. Microfluidics: Lab-on-a-chip systems and point-of-care manufacturing technologies

Module 4: Tissue Engineering & Drug Delivery, Ethics, and Regulation
Tissue Engineering: Engineering artificial organs, skin, and bone replacement scaffolds. Drug Delivery Systems: Encapsulation and controlled release of therapeutic agents. Quality & Regulatory Guidelines and GMP (Good Manufacturing Practice) in bio pharmaceutical production. Bio-safety and Bioethics: Ethical considerations in clinical trials and engineered medical devices.

Course Outcomes (COs)
Upon successful completion of this course, students will be able to:

CO-1: Identify and classify different types of bio-materials based on their structural properties and biomedical applications.
CO-2: Analyze the mechanical behavior, surface characteristics, and degradation profiles of engineered bio-materials.
CO-3: Evaluate host-tissue responses, bio-compatibility risks, and appropriate sterilization methods for medical implants.
CO-4: Design and optimize upstream/downstream bio-manufacturing processes, including bioreactors for bio-product scaling.

Program Outcomes (POs)
These represent the broad knowledge and skills engineering students should possess upon graduation:

PO-1: Engineering and Biological Sciences Foundation: Apply foundational knowledge of mathematics, material sciences, cellular biology, and transport phenomena to solve complex bioengineering problems.
PO-2: Bio-process and Implant Design: Design medical implants, tissue engineering scaffolds, or upstream/downstream bio manufacturing processes that meet strict bio-safety, health, and economic regulations.
PO-3: Analytical and Modern Tool Usage: Select and operate advanced analytical tools, simulation software, bioreactors, and material characterization instruments to evaluate bio-substances.
PO-4: Bio-Safety and Societal Impact: Assess the clinical, ethical, legal, and environmental impacts of introducing synthetic biomaterials or genetically modified organisms into society.

Core Textbooks for Biomaterials and Bio manufacturing

1. Biomaterials Science: An Introduction to Materials in Medicine, Authors: Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen, Jack E. Lemons, Publisher: Academic Press
2. Bioprocess Engineering: Basic Concepts, Authors: Michael L. Shuler, Fikret Kargi, Matthew DeLisa, Publisher: Prentice Hall
3. Biomaterials Science and Tissue Engineering: Principles and Methods, Author: Bikramjit Basu, Publisher: Cambridge University Press
4. Introduction to Biomanufacturing, Publisher: Northeast Biomanufacturing Center and Collaborative (NBC2), Publisher: Kendall Hunt Publishing
5. Introduction to Biomaterials: Basic Theory with Engineering Applications, Authors: C. Mauli Agrawal, Joo L. Ong, Mark R. Appleford, Gopinath Mani, Publisher: Cambridge University Press