**San José State University**

# Biomedical Engineering Department BME 068, Biomedical Applications of Metals and Ceramics, Fall 2022

## Course and Contact Information

Instructor(s): Charles Deng

Email: [charles.deng@sjsu.edu](mailto:charles.deng@sjsu.edu)

Class Days/Time: Monday and Wednesday 15:00 – 16:15

Classroom: Engineering Building 341

Office Hours: Tuesday 15:00 – 16:00 (via Zoom)

Office Zoom Link: <https://sjsu.zoom.us/j/84118044021?pwd=Z3ZjNFVseUFOWnBUamFjYlIzMEt6Zz09>

Prerequisites: PHYS 50, MATH 31 or MATH 31X, CHEM 1A

## Course Description

## This course covers the fundamentals of the structure, processing, and properties of metals and ceramics used in

## medical technology. Emphasis is placed on using metals and ceramics for implantable and non-implantable

biomedical devices. Recent trends in biomaterials are also explored.

## Course Format

**Course**

In class and Zoom meetings. Zoom meetings will require the use of an internet-connected device (phone, tablet, or laptop).

## Canvas

## Course materials such as syllabus, handouts, notes, assignment instructions, etc. can be found on the Canvas

## Learning Management System course login website at http://sjsu.instructure.com. You will be responsible for enrolling yourself using the signup link provided on Canvas, regularly checking with the messaging system through Canvas to learn of any updates.

## Course Goals

## The fundamental objective of this course is to educate engineers on the importance of understanding the

## interaction between engineering metals, ceramics, and biological materials, especially the human body. Of

## particular importance here is the role of the structure-processing-property relationship, and how these play a key

## role in the design, manufacture, clinical performance, long-term reliability, and quality/regulatory assurance of

medical and implant devices.

## Course Learning Outcomes (CLO)

## Upon successful completion of this course, students will be able to:

## 1. Define short-and long-term medical applications for metals and ceramics in biomedical engineering.

## 2. Demonstrate knowledge of how metals and ceramics are used in biomedical implants devices.

## 3. Define, synthesize, and apply course principles towards materials selection; including trade-off issues and

## evaluations, for biomedical implants and devices.

## 4. Explain how mechanical and surface properties, including surface chemistry and topography, are affected

## by atomic structure and processing techniques.

## 5. Identify candidate materials and processing techniques required to meet the performance criteria for

## specific biomedical applications or devices.

## 6. Comprehend the design principles involved in biomedical implants and devices, especially issues of

## biocompatibility with living tissue, and principal mechanisms of material/implant interaction with tissues.

## 7. Explain, how the host response upon metals and ceramics impacts the design of implanted devices.

## 8. Explain the physical and chemical degradation of metal and ceramic materials in the biological

## environment.

## 9. Define and describe the steps in the fabrication, and the properties of: stainless steels, titanium alloys,

## Nitinol, and other metallic implants and their applications as biomaterials.

## 10. Describe the types of ceramics used for biomedical implants, and the reasons for using ceramics,

## processing requirements, and the effect of chemical composition of ceramics and bio-glasses on

## biocompatibility.

## 11. Define and describe the steps in the fabrication and the properties of porous and bioactive ceramic

implants and their applications as biomaterials

## Required Texts/Readings

### Textbook

### Chen, Q. Thouas, G. Biomaterials: a basic introduction. CRC Press Taylor and Francis Group. Boca

### Raton, FL. 2015.

### Ratner et al. Biomaterials science: an introduction to materials in medicine. Elsevier. Kidlington,

### Oxford. 2013.

### Pruitt, L. et al. Mechanics of Biomaterials: Fundamental Principles for Implant Design. Cambridge

### University Press. Cambridge. 2011.

### All course texts are available in online format through the SJSU Library. Texts can be accessed using the

Leganto tool in Canvas.

### Other Readings

Selected publications provided in Canvas.

## Library Liaison

## Megwalu, Anamika

## Phone: 408-808-2089

Email: [anamika.megwalu@sjsu.edu](mailto:anamika.megwalu@sjsu.edu)

## Course Requirements and Assignments

“Success in this course is based on the expectation that students will spend, for each unit of credit, a minimum of 45 hours over the length of the course (normally three hours per unit per week) for instruction, preparation/studying, or course related activities, including but not limited to internships, labs, and clinical practice. Other course structures will have equivalent workload expectations as described in the syllabus.”

**Homework Assignments**

Students are expected and encouraged to work together on assignments. However, submitted homework should

be individual work. Homework must be submitted no later than the beginning of class on the due date. Late submissions will not be accepted.

**In-Class Activities**

Students will work in groups during the lecture periods to work on activities designed to reinforce lecture concepts. These activities will be scored based on their completion and correctness.

**Term Paper**

Students will select a topic in the medical device industry. A final research paper needs to be submitted no later than the due date.

### Examinations

### There will be two mid-semester examinations and one final examination. The midterm examinations will cover the entire course material covered until the time of each examination. The final examination will cover the entire course material covered during the entire semester. Examinations may include multiple-choice questions, open-ended questions, and problems. During the exam, students can have only a non-programmable scientific calculator. Internet-connected devices, books and notes are not allowed. Furthermore, the instructor reserves the right to enforce seating assignments for all exams.

## Grading Information

Determination of Grades:

Grades will be assigned based on correct completion of the assigned course material, including homework, In-Class Activities, Term (research) Paper, and Examinations. The following percentage weights will be used for each category.

Homework 20%

In-Class Activities 5%

Term Paper 15%

Midterm 1 15%

Midterm 2 15%

Final Exam 30%

Final grades will be assigned using the following scoring system:

| *Grade* | *Points* | *Percentage* |
| --- | --- | --- |
| *A plus* | *960 to 1000* | *96 to 100%* |
| *A* | *930 to 959* | *93 to 95%* |
| *A minus* | *900 to 929* | *90 to 92%* |
| *B plus* | *860 to 899* | *86 to 89 %* |
| *B* | *830 to 859* | *83 to 85%* |
| *B minus* | *800 to 829* | *80 to 82%* |
| *C plus* | *760 to 799* | *76 to 79%* |
| *C* | *730 to 759* | *73 to 75%* |
| *C minus* | *700 to 729* | *70 to 72%* |
| *D plus* | *660 to 699* | *66 to 69%* |
| *D* | *630 to 659* | *63 to 65%* |
| *D minus* | *600 to 629* | *60 to 62%* |
| *F* | *599 or lower* | *59% or lower* |

## Classroom Protocol

Students are expected to be in class and Zoom meetings by the time the class begins. Attendance in class is not mandatory and shall not be used per se as a criterion for grading. However, class attendance and participation are highly recommended and will contribute towards the In-Class Activity score. Students should always remain respectful of each other. Interruptive or disruptive attitudes are discouraged. Students will

respect a diversity of opinions, ethnicities, cultures, and religious backgrounds.

**Webcams and Recording Lectures**

Students are prohibited from recording class activities (including class lectures, office hours, advising sessions,

etc.), distributing class recordings, or posting class recordings. Materials created by the instructor for the course

(syllabi, lectures and lecture notes, presentations, etc.) are copyrighted by the instructor. The university policy

(S12-7) is in place to protect the privacy of students in the course, as well as to maintain academic integrity

through reducing the instances of cheating. Students who record, distribute, or post these materials will be referred to the Student Conduct and Ethical Development office. Unauthorized recording may violate university and state law. It is the responsibility of students that require special accommodations or assistive technology due to a disability to notify the instructor.

**Technical Support for Canvas**

Email: ecampus@sjsu.edu

Phone: (408) 924-2337

https://www.sjsu.edu/ecampus/support

## University Policies

Per [University Policy S16-9](http://www.sjsu.edu/senate/docs/S16-9.pdf) , relevant university policy concerning all courses, such as student responsibilities, academic integrity, accommodations, dropping and adding, consent for recording of class, etc. and available student services (e.g. learning assistance, counseling, and other resources) are listed on [Syllabus Information web page](https://www.sjsu.edu/curriculum/courses/syllabus-info.php) (https://www.sjsu.edu/curriculum/courses/syllabus-info.php). Make sure to visit this page to review and be aware of these university policies and resources.

**Academic Integrity**

Students who are suspected of cheating during an exam will be referred to the Student Conduct and Ethical

Development office and depending on the severity of the conduct, will receive a zero on the assignment or a

grade of F in the course. Grade Forgiveness does not apply to courses for which the original grade was the

result of a finding of academic dishonesty.

# BME 068, Biomedical Applications of Metals and Ceramics, Fall 2021

## Course Schedule (subject to change with fair notice)

| **Week** | **Date** | **Topics** |
| --- | --- | --- |
| 1 | Mon 8/22  Wed 8/24 | Biomaterials, Medical Devices, Standards  Interatomic Bonding |
| 2 | Mon 8/29  Wed 8/31 | Crystal Structures  Imperfections |
| 3 | Mon 9/5  Wed 9/7 | **Labor Day – No Class**  Bulk Material Processing |
| 4 | Mon 9/12  Wed 9/14 | Phases and Phase Diagrams (1)  Phase Diagrams (2) |
| 5 | Mon 9/19  Wed 9/21 | Corrosion Types  Corrosion Testing and Standards |
| 6 | Mon 9/26  Wed 9/28 | **Midterm Review 1**  **Midterm Exam 1** |
| 7 | Mon 10/3  Wed 10/5 | Mechanical Properties  Stress, Stain, and Deformation Types |
| 8 | Mon 10/10  Wed 10/12 | Failure Modes and Failure Cases Analysis  Surface Processes, Properties, and Characterization |
| 9 | Mon 10/17  Wed 10/19 | Biocompatibility, Sterilization, and Toxicity  Stainless Steel Structure, Processing, Properties, Applications, and Design Considerations |
| 10 | Mon 10/24  Wed 10/26 | Cobalt-Chrome Alloys  Cobalt Alloys Applications |
| 11 | Mon 10/31  Wed 11/2 | Titanium and Titanium Alloys  NiTi Shape-Memory Alloys |
| 12 | Mon 11/7  Wed 11/9 | **Midterm Review 2**  **Midterm Exam 2** |
| 13 | Mon 11/14  Wed 11/16 | Biodegradable Metals, Magnesium Alloys  Biomedical Ceramics (inert, active, resorbable) |
| 14 | Mon 11/21  Wed 11/23 | **Non-Instructional Day – No Class**  Biomedical Polymers (inert, resorbable) |
| 15 | Mon 11/28  Wed 11/30 | Cardiovascular Disease, Drugs, Medical Devices, Dental Devices, and Implants  Term Paper Presentation |
| 16 | Mon 12/5 | **Final Review** |
| **Final Exam** | Thu 12/8 | Thursday, December 8, 12:15 – 2:30 pm |