BIOMEDICAL MATERIALS SCIENCE PROGRAM

Amol V. Janorkar, PhD, Director

FACULTY

Professors:

Jason A. Griggs, PhD

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Instructor:

Susana M. Salazar, BDS, PhD

BMS 701A. Fundamentals of Materials Science A. This is the first part of a 2-semester course. An introductory graduate level course dealing with the fundamental concepts of bonding, crystalline structure, crystal defects and short range order as they relate to polymers, metals and ceramics. Nucleation and growth, equilibrium and non-equilibrium phase transformations and solidification on non-crystalline systems will be discussed. This will be followed by discussion of the mechanical properties of materials (fatigue, creep, elastic and plastic behavior, stress relaxation, etc.) and their relationship to structure. Alloy theory and other strengthening mechanisms, including composite theory, will be dealt with at an introductory level. The thermodynamics and kinetics of surfaces undergoing oxidation and aqueous corrosion will be discussed. Prerequisite: BMS 708 or consent of instructor. (Lecture) (3 semester hours)

BMS 701B. Fundamentals of Materials Science B. This is the second part of a 2-semester course. An introductory graduate level course dealing with the fundamental concepts of bonding, crystalline structure, crystal defects and short range order as they relate to polymers, metals and ceramics. Nucleation and growth, equilibrium and non-equilibrium phase transformations and solidification on non-crystalline systems will be discussed. This will be followed by discussion of the mechanical properties of materials (fatigue, creep, elastic and plastic behavior, stress relaxation, etc.) and their relationship to structure. Alloy theory and other strengthening mechanisms, including composite theory, will be dealt with at an introductory level. The thermodynamics and kinetics of surfaces undergoing oxidation and aqueous corrosion will be discussed. Prerequisite: BMS 701A or consent of instructor. (Lecture) (3 semester hours)

BMS 702A. Fundamentals of Biomaterials A. This is the first part of a 2-semester course. This course will deal with metals, ceramics and polymers used for dental and medical applications. The physical, mechanical and biological interactions of these materials will be topics for discussion. The history of materials use in medicine, some of the pitfalls encountered and the current state of the art will be presented in detail. Tissue engineered medical products and guided tissue regeneration will also be covered. There will be an introduction to the methods used to assess the appropriateness of materials for use in contact with living tissues. Prerequisite: Consent of Instructor. (Lecture) (3 semester hours)

BMS 702B. Fundamentals of Biomaterials B. This is the second part of a 2-semester course. This course will deal with metals, ceramics and polymers used for dental and medical applications. The physical, mechanical and biological interactions of these materials will be topics for discussion. The history of materials use in medicine, some of the pitfalls encountered and the current state of the art will be presented in detail. Tissue engineered medical products and guided tissue regeneration will also be covered. There will be an introduction to the methods used to assess the appropriateness of materials for use in contact with living tissues. Prerequisite: BMS 702A or Consent of Instructor. (Lecture) (3 semester hours)

BMS 703A. Experimental Methods in Materials Science A. This is the first part of a 2-semester course. An introductory theory and laboratory course designed to acquaint students with the variety of equipment used to evaluate the structure and properties of materials. Scanning electron microscopy, mechanical testing, thermal analysis, light microscopy, x-ray scattering and other chemical and physical characterization techniques will be covered. The course will include both didactic and laboratory exercises and will meet an average of once per week for two semesters. Prerequisite: Consent of Instructor. (Lecture/Lab) (1 semester hour)

BMS 703B. Experimental Methods in Materials Science B. This is the second part of a 2-semester course. An introductory theory and laboratory course designed to acquaint students with the variety of equipment used to evaluate the structure and properties of materials. Scanning electron microscopy, mechanical testing, thermal analysis, light microscopy, x-ray scattering and other chemical and physical characterization techniques will be covered. The course will include both didactic and laboratory exercises and will meet an average of once per week for two semesters. Prerequisite: BMS 703A or Consent of Instructor. (Lecture/Lab) (1 semester hour)

BMS 704. Crystallography and X-Ray Diffraction. Principles of crystallography, including point groups, space groups, stereographic projections and reciprocal lattice, will be discussed. Topics in x-ray diffraction, with special emphasis on application of x-ray diffraction techniques to materials analysis, will be covered during lecture and laboratory. Prerequisite: Consent of Instructor. (Lecture) (3 semester hours)

BMS 705. Materials Thermodynamics. A graduate level course dealing with the principles of energetic equilibrium as applied to materials science. Materials thermodynamics provides a foundation for many other materials science courses. The first part of this course will introduce the apparatus of thermodynamics through classical steam engine calculations. The second part will apply that apparatus to predict the behavior of chemical solutions and mixtures. The following topics will be covered: the first, second, and third laws of thermodynamics; state functions and process variables; criteria for equilibrium; enthalpy of mixing; free energy basis for unary and binary phase diagrams; capillarity and surface energy; electrochemistry. This course will involve intensive application of algebra and differential and integral calculus. Prerequisite: BMS 701A/B and BMS 708 or Consent of Instructor. (Lecture) (4 semester hours)

BMS 708. Mathematics for Materials Study. This introductory graduate level course is for students who have a biological science background or who have not taken didactic study for some time. For such students, BMS708 is a prerequisite for many courses in the Biomedical Materials Science program. This course provides or refreshes the mathematical foundation necessary to study engineering. This course covers the following topics: orientation to MathCAD software, precision and accuracy, vector algebra, matrix algebra, complex/imaginary numbers, polar coordinates, trigonometry, differential calculus with emphasis on applications (curve sketching, design optimization, related rates, propagation of error, successive approximations, curvilinear motion), integral calculus with emphasis on applications (calculation of irregular areas, volumes, centroids, and moments of inertia; function approximation using Taylor series; spectrum analysis using Fourier series), and a brief introduction to differential equations. (Lecture) (4 semester hours)

BMS 710. Fundamentals of Polymer Science. An in-depth course in polymer chemistry and physics. Areas to be covered include polymerization mechanisms, methods of polymer analysis, mechanics of amorphous and crystalline polymers (including time-dependent mechanical behavior), thermodynamics and kinetics of polymer crystallization, and thermal and optical behavior of polymers. Prerequisite: BMS 701A/B or Consent of Instructor. (Lecture) (3 semester hours)

BMS 711. Fundamentals of Ceramics. This graduate level course provides advanced information on ceramic compositions, processing methods, material properties, and applications. The topics will mirror those already covered in BMS 701, but they will be covered in greater depth and with emphasis on practical examples, commercially available products, and quantitative prediction of material properties. Prerequisite: BMS 701A/B or Consent of Instructor. (Lecture) (3 semester hours)

BMS 712. Fundamentals of Metals. An advanced study of the principles governing the properties of metals. Principles of structure and their relationship to mechanical, thermal, electrical, optical and surface properties will be discussed. Prerequisite: BMS 701A/B or Consent of Instructor. (Lecture) (3 semester hours)

BMS 713. Introduction to Electron Microscopy. After participation in this course, a student should be able to understand the theories and mechanics of electron microscopy, prepare specimens for EM observation, align the column and observe specimens with the EM, and produce high quality EM photomicrographs. The use of both the Scanning Electron Microscope (SEM) and the Transmission Electron Microscope (TEM) will be included. The theory and practical aspects of performing compositional analysis and mapping using the energy dispersive and wavelength dispersive x-ray spectrometers will be covered. At completion of the course, the student should be able to use the integrated SEM/EDS/WDS system to qualitatively determine composition, as well as understand the use of calibration to produce quantitative results. Use of the system for digital image acquisition and elemental mapping will be covered. The student will learn appropriate methods for preparing samples for observation in the SEM and TEM, and learn to recognize artifacts of sample preparation. The student will select a project for analysis and prepare a portfolio of photomicrographs and/or analyses demonstrating proficiency with either microscope. Prerequisite: Consent of Instructor. (Lecture) (3 semester hours)

BMS 721. Polymer Processing. Methods used to fabricate polymer biomaterials will be presented and the parameters important to each method, the equipment and control mechanisms will be discussed with the advantages and disadvantages of the different methods. Among the topics to be included are injection molding, extrusion, machining, reactive injection molding and pultrusion. Prerequisite: BMS 701A/B, BMS710, or Consent of Instructor. (Lecture) (3 semester hours)

BMS 723. Degradation Mechanisms in Materials. . The student will learn the various mechanisms of environmentally induced material degradation (e.g., oxidation and hydrolysis) for the three major classes of materials (metals, polymers, ceramics). The course will focus on the unique aspects of the biological environment which can alter conventional degradation mechanisms. Prerequisite: BMS 701A/B or Consent of Instructor. (Lecture) (2 semester hours)

BMS 724. Electrochemistry & Corrosion of Implant Materials. This course on electrochemistry/corrosion will provide a detailed description of the electrochemical kinetic and thermodynamic processes that govern corrosion. Particular attention will be given to the metals and alloys systems used in current implant devices. Prerequisite: BMS 701A/B or Consent of Instructor. (Lecture) (3 semester hours)

BMS 725. Environmentaly Assisted Fracture of Implant Materials. One of the principal failure mechanisms of metallic implants is environmentally assisted fracture (EAF). EAF includes the mechanisms of stress corrosion cracking (SCC) and corrosion fatigue (CF). The synergistic interaction of stress and corrosion will be discussed with particular attention to implant alloy systems. The role of EAF in the failure of other material systems (e.g., polymers) will also be discussed. Prerequisite: BMS 701A/B or Consent of Instructor. (Lecture) (2 semester hours)

BMS 727. Surface Science. The material interface represents the single-most important aspect of a material in the determination of the host response. The student will learn about the basic elements of surface characterization and the various physio-chemical phenomena that govern their properties. The theories of surface interactions with the biological environment will be discussed. Also covered, will be methods for altering surface properties. Prerequisite: BMS 701A/B or Consent of Instructor. (Lecture) (3 semester hours)

BMS 728. Failure Analysis of Medical Implants. This is an advanced graduate level course in which students will learn the protocol and will begin practicing the practical skills necessary to analyze failures of medical implants and prostheses following in vitro testing or clinical use. A brief review of structure, mechanical and electrochemical properties of materials used for biomedical applications will be provided. Methods used to determine appropriate material characteristics, such as grain structure, secondary phases, pores, inclusions, and mechanical and corrosion properties will be covered. Failures of metallic, polymeric, and ceramic materials will be analyzed with emphasis on methods for specimen cleaning and preservation, visual inspection, documentation, and optical and electron microscopy techniques. Prerequisite: BMS 701A/B and BMS 702A/B or Consent of Instructor. (Lecture) (3 semester hours)

BMS 730. Grant Writing and Management. This graduate level course provides an introduction to acquiring and managing extramural funding for sponsored projects with emphasis on NIH research grants. The following topics will be covered: searching for sponsors, including an overview of NIH funding mechanisms; grant writing, including development of specific aims and hypothesis, writing a literature review, presenting preliminary data, describing methods and timelines, and making a budget; the submission and review process; revising unsuccessful applications; starting a new laboratory; and submitting progress reports and competing continuations. Students will write and revise a grant application during this course. Prerequisite: Consent of Instructor. (Lecture) (2 semester hours)

BMS 750. Special Topics in Biomedical Materials Science. Treatment of specific subjects not dealt with fully in other courses. This course may cover any area of interest to the student(s) and at least one faculty member. Prerequisite: Consent of Instructor. (Lecture) (1-9 semester hours)

BMS 798. Dissertation and Dissertation Research. (Dissertation) (1-9 semester hours)

BMS 799. Thesis and Thesis Research. (Thesis) (1-9 semester hours)

TYPICAL COURSE OF STUDY – MASTER OF SCIENCE (MS)

YEAR 1 - FALL		
BMS 701A	Fundamentals of Materials Science A	3
BMS 702A	Fundamentals of Biomaterials A	3
BMS 703A	Experimental Methods in Materials Science A	1
BMS 708	Mathematics for Materials Study (For students without adequate preparation in mathematics) OR	4
ID 740	Statistical Methods in Research I (For students who do not enroll in BMS 708)	3
BMS 799	Thesis and Thesis Research	1 or 2
		12
YEAR 1 - SPRING		
BMS 701B	Fundamentals of Materials Science B	3
BMS 702B	Fundamentals of Biomaterials B	3
BMS 703B	Experimental Methods in Materials Science B	1
ID 709	Responsible Conduct in Research	1
BMS 799	Thesis and Thesis Research	4
		12
YEAR 2 - SUMMER		
BMS 799	Thesis and Thesis Research	9
		9
YEAR 2 - FALL		
ID 740	Statistical Methods in Research (if not already taken)	3

Electives	TBA	TBA
BMS 799	Thesis and Thesis Research	TBA
		9

YEAR 2 - SPRING

Electives	TBA	TBA
BMS 799	Thesis and Thesis Research	TBA
		9

YEAR 3+ - SUMMER

BMS 799	Thesis and Thesis Research	9
		9

YEAR 3+ - FALL

Electives	TBA	TBA
BMS 799	Thesis and Thesis Research	TBA
		9

YEAR 3+ - SPRING

Electives	TBA	TBA
BMS 799	Thesis and Thesis Research	TBA
		9

Elective courses will be chosen from the courses offered in the Department, courses offered by other UMMC Graduate Departments, and/or courses offered in conjunction with the School of Engineering at the main campus of the University of Mississippi. For MS students, these electives will usually include at least one of the material-specific courses (BMS 710, BMS 711, or BMS 712). Courses offered by other schools may be included with approval of the student's advisor, the Director of the Graduate Program, and the Dean of the School of Graduate Studies in the Health Sciences. **Upon recommendation of the student's advisor, one or more off-campus internships may be required, for which the student will receive academic credit as BMS 750 (Special Topics in Biomedical Materials Science). Such internships will be individually arranged to meet the goals of the research and plan of study for the student.**

TYPICAL COURSE OF STUDY – DOCTOR OF PHILOSOPHY (PhD)

Students in the PhD program will select their coursework in consultation with the advisor and advisory committee and will usually be required to include the following in their coursework selection, if they have not previously been included in the MS program:

ID 715	Teaching in Higher Education
BMS 703A/B	Experimental Methods in Materials Science A/B
BMS 710	Fundamentals of Polymer Science
	OR
BMS 711	Fundamentals of Ceramics
	OR
BMS 712	Fundamentals of Metals
BMS 728	Failure Analysis of Medical Implants
BMS 730	Grant Writing and Management

Students must have taken and passed ID 714 (Professional Skills for Graduate Students and Postdoctoral Fellows), usually taken in the year prior to the awarding of the degree.

For students being admitted from another MS program or directly from a BS program, a typical course of study might be as follows (Please note that many elective courses may only be offered in alternate years):

YEAR 1 - FALL

BMS 701A	Fundamentals of Materials Science A	3
BMS 701A	Fundamentals of Biomaterials A	3
BMS 703A	Experimental Methods in Materials Science A	1
BMS 708	Mathematics for Materials Study (For Students without adequate preparation in mathematics)	4
ID 740	Statistical Methods in Research I (For Students not enrolled in BMS 708)	3
BMS 798	Dissertation and Dissertation Research	1 or 2
		12

YEAR 1 - SPRING

BMS 701B	Fundamentals of Materials Science B	3
BMS 702B	Fundamental of Biomaterials B	3
BMS 703B	Experimental Methods in Materials Science B	1
ID 709	Responsible Conduct in Research	1
BMS 798	Dissertation and Dissertation Research	4
		12

YEAR 2 - SUMMER

BMS 798	Dissertation and Dissertation Research	9
		9

YEAR 2 - FALL

ID 740	Statistical Methods in Research (if not already taken)	3
ID 715	Teaching in Higher Education	3
Electives	TBA	TBA
BMS 798	Dissertation and Dissertation Research	TBA
		9+

YEAR 2 - SPRING

Electives	TBA	TBA
BMS 798	Dissertation and Dissertation Research	TBA
		9

YEARS 3+ - SUMMER

BMS 798	Dissertation and Dissertation Research	9
		9

YEARS 3+ - FALL

Electives	TBA	TBA
BMS 798	Dissertation and Dissertation Research	TBA
		9

YEARS 3+ - SPRING

ID 714	Professional Skills for Graduate Students and Postdoctoral Fellows (once)	3
Electives	TBA	TBA
BMS 798	Dissertation and Dissertation Research	TBA
		9

Similar courses taken at other universities in pursuit of the MS may be considered for substitution on a case-by case basis. Students entering the program having received an MS degree at another university or who have taken graduate level courses as a part of a BS degree program may submit information about coursework that may be eligible for transfer to partially fulfill requirements for coursework toward the PhD. The courses may complement or substitute for courses in the BMS program. Up to 15 semester hours may be transferred with the approval of the student's advisor, the Director of the Graduate Program and the Dean of the School of Graduate Studies in the Health Sciences.

Upon recommendation of the student's advisor, one or more off-campus internships may be required, for which the student will receive academic credit as BMS 750 (Special Topics in Biomedical Materials Science). Such internships will be individually arranged to meet the goals of the research and plan of study for the student.

For students being admitted after having completed their MS degree at UMMC, a typical course of study might be as follows (Students entering directly from the MS program in the department will have taken a majority of their core courses previously and will rather begin taking elective courses in the area of specialization in their first semester. Please note that many elective courses may only be offered in alternate years):

YEAR 1 - FALL

Electives	TBA	TBA
BMS 798	Dissertation and Dissertation Research	TBA
		9

YEAR 1 - SPRING

ID 715	Teaching in Higher Education	3
Electives	TBA	TBA

BMS 798	Dissertation and Dissertation Research	TBA
		9
YEAR 2 - SUMMER		
BMS 798	Dissertation and Dissertation Research	9
		9
YEAR 2 - FALL		
Electives	TBA	TBA
BMS 798	Dissertation and Dissertation Research	TBA
		9
YEAR 2 - SPRING		
Electives	TBA	TBA
ID 714	Professional Skills for Graduate Students and Postdoctoral Fellows	3
BMS 798	Dissertation and Dissertation Research	TBA
		9
YEAR 3+ - SUMMER		
BMS 798	Dissertation and Dissertation Research	9
		9
YEAR 3+ - FALL		
Electives	TBA	TBA
BMS 798	Dissertation and Dissertation Research	TBA
		9
YEAR 3+ - SPRING		
Electives	TBA	TBA
BMS 798	Dissertation and Dissertation Research	TBA
		9

Among other electives from outside the department that are available to interested students are the following:

ID 767	Fundamental Histology and Cell Biology
CHS 720	Essentials of Pathophysiology
CHS 728	Histopathology
BIOCH 742	Experimental Methods in Molecular Biology

Elective courses will be chosen from the courses offered in the Department, courses offered by other UMMC graduate departments, and/or courses offered in conjunction with the School of Engineering at the main campus of the University of Mississippi. Courses offered by other schools may be included with approval of the student's advisor, the Director of the Graduate Program, and the Dean of the School of Graduate Studies in the Health Sciences. **Upon recommendation of the student's advisor, one or more off-campus internships may be required, for which the student will receive academic credit as BMS 750 (Special Topics in Biomedical Materials Science). Such internships will be individually arranged to meet the goals of the research and plan of study for the student.**