JOHNS HOPKINS UNIVERSITY

DEPARTMENT OF MATERIALS SCIENCE & ENGINEERING

UNDERGRADUATE ADVISING MANUAL

2012 - 2013

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ADVISING GUIDE FOR UNDERGRADUATE MAJORS IN MATERIALS SCIENCE AND ENGINEERING

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INTRODUCTION
DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING

Materials are essential to the construction of any engineering structure, from the smallest integrated circuit to the largest bridge. In almost every technology, the performance, reliability, or cost is determined by the materials used. As a result, the drive to develop new materials and processes (or to improve existing ones) makes *materials science and engineering* one of the most important and dynamic engineering disciplines.

The central theme of materials science and engineering is that the relationships among the structure, properties, processing, and performance of materials are crucial to their function in engineering structures. *Materials scientists* seek to understand these fundamental relationships, and use this understanding to develop new ways for making materials or to synthesize new materials. *Materials engineers* design or select materials for particular applications and develop improved processing techniques. Since materials scientists and engineers must understand the properties of materials as well as their applications, the field is inherently interdisciplinary, drawing on aspects of almost every other engineering discipline as well as physics, chemistry, and, most recently, biology. Because the field encompasses so many different areas, it is often categorized according to types of materials (metals, ceramics, polymers, semiconductors) or to their applications (biomaterials, electronic materials, magnetic materials, or structural materials).

The department prepares students for successful careers in materials science and engineering, for advanced study in science or engineering, and for professional education in other fields. The goal of the undergraduate program is to provide a rigorous and comprehensive curriculum in materials science and engineering as well as in mathematics, basic sciences, humanities, and social sciences. Our low student-to-faculty ratio allows students close contact with faculty in both classroom and research environments, as well as with other students and researchers in the department. The student is encouraged to proceed at his or her own rate, and to participate in interdisciplinary, interdepartmental, and interschool programs. In the tradition of Johns Hopkins, all of our undergraduate students participate in research, often beginning in their sophomore year, working closely with faculty and graduate students.

In recognition that biomaterials and nanotechnology represent two of the most rapidly developing areas of materials science and engineering, the Department of Materials Science and Engineering offers challenging specializations in biomaterials or nanotechnology within its undergraduate program.

The field of *biomaterials* is concerned with the science and engineering of materials in biology and medicine. Engineered materials are increasingly used in applications such as drug delivery and gene therapy, scaffolds for tissue engineering, replacement body parts, and biomedical and surgical devices. Biomaterials are an inherently interdisciplinary field that requires deep understanding of the properties of materials in general, and the interactions of materials with the biological environment. The Biomaterials Track is designed to provide a firm grounding in the physics, chemistry, and biology of materials, as well as breadth in general engineering, mathematics, humanities, and social science. In addition, students are encouraged to gain hands-on experience in biomaterials research laboratories. The program seeks to educate students to reach the forefront of leadership in the field of biomaterials engineering. While the fundamental principles of materials science still apply, a complete understanding of biomaterials and their interactions with biological environments requires a greater degree of specialization than the standard undergraduate curriculum provides. In recognition of completion of the biomaterials track, a student may elect to have his or her academic transcript annotated to indicate a specialty in biomaterials.

Nanotechnology advances the utilization of materials and devices with extremely small dimensions. Nanotechnology is a visionary field, as micro and nanostructured devices impact all fields of engineering, from microelectronics (smaller, faster computer chips) to mechanical engineering (micromotors and actuators) to civil engineering ("smart", self-healing nanocomposite materials for buildings and bridges) to biomedical engineering (biosensors and tissue engineering). Materials Science is central to nanotechnology because the properties of materials can change dramatically when things are made extremely small. This observation is not simply that we need to measure such properties or develop new processing tools to fabricate nanodevices. Rather, our vision is that the wide (and sometimes unexpected!) variety of phenomena associated with nanostructured materials allow us to envision radically new devices and applications that can only be made with nanostructured materials. The Nanotechnology Track encompasses a curriculum designed to train students in the fundamental interdisciplinary principles of materials science including physics and chemistry, and also to expose students to the forefront of nanomaterials research through elective classes as well as in research laboratories. Students in the Nanotechnology Track will be well-prepared for successful careers in materials engineering across a wide range of disciplines. In recognition of completion of the nanotechnology track, a student may elect to have his or her academic transcript annotated to indicate a specialty in nanotechnology.

Whether a student chooses to pursue studies following the standard program, the biomaterials track or the nanotechnology track, the coursework specified for the degree will provide a firm grounding in the principles of materials science and engineering. On completion of the undergraduate studies, students majoring in materials science and engineering:

- are well prepared for professional scientific and engineering practice, as well as for advanced study in materials science and engineering or other scientific, engineering or professional areas;
- have acquired a solid grounding in the mathematics, chemistry, biology and the physics that are required for the solution of materials problems related to the structure, properties, processing and performance of materials;
- can utilize modern scientific, engineering and computer tools to analyze problems in materials science and engineering;
- can identify important scientific and engineering problems related to materials and design systems and processes as well as perform and complete relevant experiments to aid the solution of these problems within the constraints provided by social, economic, environmental and cultural factors;
- learn to work both independently and in teams;

- have obtained extensive experience in oral and written communication including science and engineering specific forms of communication such as technical reports, scientific notebooks and technical presentations of research;

- are instilled with an appropriate appreciation of the broad need for life-long learning, the scope and meaning of professional responsibility and the relevance of engineering practice to contemporary economic, environmental and societal issues on local and global levels.

The Materials Science and Engineering faculty strives to maintain the Johns Hopkins University tradition: to train a small number of students of highest quality, whose impact on the scientific and engineering community is large compared with the size of the Department and the University. This institutional aspiration can only be realized with the success of our students as they pursue career directions beyond their time at Hopkins. Our degree program is designed to provide an optimum starting point for students with a diversity of career aspirations providing a solid foundation for future career development. As our graduates develop their paths forward, it is our intent that they will:

1. pursue careers in materials science and engineering including advanced graduate studies in the field. If not in the field, our graduates will pursue careers in related areas of science and engineering or else will enter professional disciplines such as medicine, business or law that benefit from an understanding of materials science and engineering.

2. employ characteristics of the research process in their careers. These include:

   - the use of critical reasoning to identify fundamental issues and establish directions for investigation;
   - the ability to define specific plans for problem solution;
   - the use of analytical thought to interpret results and place them within a broader context.

DEPARTMENTAL AND UNIVERSITY ADVISING PROCEDURES

When entering the Department of Materials Science and Engineering you will be assigned an academic advisor who is a full-time faculty member in the Department. Students will plan their programs of study in consultation with their advisors (see sample programs later in this manual). These programs will be designed to meet the University and Departmental degree requirements as well as reflect the individual interests of the student. An anticipated program of study signed by your advisor should be filed as early as possible during your residence, and as subsequent changes are made to the program, it is your responsibility to see that a revised and signed program is filed with your advisor. You must have an approved program on file no later than the semester before you expect to graduate.

Your assigned academic advisor is your primary resource for information regarding your degree program in Materials Science and Engineering and will ensure that you have accurate information regarding degree program requirements. Your advisor can also assist you in course selections and program scheduling so that courses are completed in an appropriate sequence. <u>You will meet with your advisor at least once a semester to plan your course selections for the next semester. After this meeting, your academic advisor will electronically remove your registration hold allowing you to register for courses online. A similar process is followed for the add-drop period at the beginning of each semester. For situations that cannot be resolved using the online system, paper forms are available and your advisor's signature is required on all course registration and course change forms.</u>

You should consult with your advisor when you are in the process of identifying educational opportunities outside the degree program such as internships and research experiences as well as study abroad programs. Your advisor can also serve as a resource for career planning information especially as it applies to graduate studies in materials science and engineering or in related science and engineering fields. General information on career planning can be obtained from the Johns Hopkins Career Center (*http://www.jhu.edu/~careers/*). Students interested in pursuing advanced professional studies in medicine or in law are encouraged to contact the Office of Pre-professional Advising (*http://www.jhu.edu/~preprof/*) early in their planning process so that entrance requirements for medical and law programs are fulfilled before the fourth year.

While pursuing your degree, you might decide to take selected courses at other universities, transfer the associated credits to Johns Hopkins and use these credits towards completion of your degree requirements. The Whiting School Office of Academic Affairs (*http://eng.jhu.edu/wse/item/academic-advising*) is available to guide you through this process and can provide you with the appropriate forms. This office also provides information on study abroad programs and can assist you in identifying scholarship opportunities associated with special programs that are available to Hopkins students. This office is responsible for monitoring student progress and will notify those students who are not making satisfactory progress towards their degree and will place them on academic probation if their term grade point average falls below 2.0. This office also provides guidance to students who need assistance in improving their academic performance by referring them to programs designed to refine student work habits. These programs are administered by the Undergraduate Academic

Advising Office (*http://www.jhu.edu/~advising/index.html*) and are described in this office's website.

Faculty members in the Department of Materials Science and Engineering are committed to assisting in the development of our students and you should feel comfortable consulting informally with faculty members other than your advisor to obtain ideas and directions for your course choices and career development. If you are inclined to do so, you may formally request a change in faculty advisor by contacting the department chair in writing. Students interested in fulfilling the degree requirements in Materials Science and Engineering in addition to those of another department should consult with the advising coordinator of both departments to determine feasibility. The Advising Coordinator for Materials Science and Engineering is Professor James Spicer, spicer@jhu.edu, Room 101D, Maryland Hall.

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REQUIREMENTS FOR THE BACHELOR OF SCIENCE DEGREE IN MATERIALS SCIENCE AND ENGINEERING

The Department of Materials Science and Engineering offers a program leading to the Bachelor of Science degree. The B.S. for the Materials Science and Engineering degree program is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org. The student must meet the general University requirements for this degree as well as the departmental requirements and must complete the program approved by the student's advisor.

General Degree Requirements for the B.S. Degree

- Complete program of study outlined by concentration (standard, biomaterials or nanotechnology)
- Fulfill the university writing requirement
  Two writing intensive (W) courses, at least 3 credits each
- Fulfill 75 credits earned in courses coded (E), (Q), (N)
- At least 30 credits of this must be counted (N) or (Q) with no course counted twice
- At least 30 additional credits must be taken outside of (E) area, excluding prerequisites for the major
- Fulfill 18 credits of courses coded (H) or (S)
- Take a minimum of 128 credits

Degree Requirements for the Department of Materials Science and Engineering

A convenient course-check off list is provided below. Please note the grade requirements associated with the course requirements.

Three B.S. degree tracks are offered by the Department of Materials Science and Engineering.

(1) **Standard Track**. The Standard Track is intended for those students with general materials science and engineering interests. It permits the student to tailor the degree program to specific interests by allowing a broad range of choices for upper level science and engineering electives.

(2) **Biomaterials Track**. The Biomaterials Track is intended for those students with a focused interest in biomaterials. To receive commendation for completion of the Biomaterials Track, the student must complete two electives whose subject matter is some aspect of Biomaterials, and complete a biomaterials-related senior design project. **Approval of electives must be made by a student's academic advisor prior to taking the courses, and approval of the senior design project must be pre-approved by the senior design instructor.**

An intent to follow the Biomaterials Track in Materials Science and Engineering must be made by the student's 5th semester (1st semester junior year). Students should declare their intent in writing or by e-mail to their department advisors and copy the academic coordinator.

(3) **Nanotechnology Track**. The Nanotechnology Track is intended for those students with a focused interest in nanomaterials. To receive commendation for completion of the Nanotechnology Track, the student must complete two electives whose subject matter is some aspect of Nanotechnology, and complete a nanotechnology-related senior design project. **Approval of electives must be made by a student's academic advisor prior to taking the courses, and approval of the senior design project must be pre-approved by the senior design instructor.**

Students must declare their intent to satisfy the requirements of the Nanotechnology Track in Materials Science and Engineering by their 5th semester (1st semester junior year). Students should declare their intent in writing or by e-mail to their department advisors and copy the academic coordinator.

Students who wish to pursue both the biomaterials and nanotechnology track are permitted to do so, as long as they complete all requirements, and the subject matter of their senior design project fall within the scope of both programs (as approved by the instructor of senior design).

Double Majoring in Materials Science & Engineering

A student whose primary major is in another department (either in Engineering or Arts & Sciences) may elect to fulfill the requirements for a major in Materials Science and Engineering as well. Upon graduation, a notation is placed on the student's academic record acknowledging completion of the requirements for the major in MSE. The student receives the degree (BS or BA) associated with his or her primary major. Completing a second major does not entitle the student to a second degree.

To add or drop a second major, complete the appropriate form (available from the Registrar's office). This form must be signed by the chair of the undergraduate program in MSE before it is submitted to the Registrar.

Students double-majoring in MSE are required to fulfill all of the requirements for the MSE Degree, including successful completion of the year-long senior design project. (See above for a complete listing of the requirements). This includes the minimum grade requirement of earning a letter grade of C or higher for the MSE core courses.

In certain cases, a student may petition the Undergraduate Program Committee for an exception to the requirements. (A common example is that many double majors complete LADE plus another upper-level mathematics course instead of the Linear Algebra plus Differential Equations requirement for MSE). The Undergraduate Program Committee considers each such request on a case-by-case basis, and a student should not necessarily expect that his or her request will be granted if it represents a significant deviation from the prescribed program. Students are therefore encouraged to plan their academic coursework carefully and consult with their academic advisors early to avoid difficulties in completing the degree requirements.

Professor Todd Hufnagel (hufnagel@jhu.edu*)* is the academic advisor for all students from other departments pursuing double majors in MSE. If you have any questions about double majoring, please contact him. (Questions regarding your primary major should be addressed to your academic advisor in the corresponding department.) If you do decide to pursue a double major in Materials Science & Engineering, please make an appointment to meet with Professor Hufnagel as early as possible to plan your program of study.

DESCRIPTION OF THE BIOMATERIALS TRACK

Biomaterials are an exciting and rapidly developing field at the multi-disciplinary interface of Materials Science, Engineering, Biology, Chemistry and Medicine. Our unique biomaterials program is designed to provide a broad educational basis with emphasis on principles and applications of biomaterials. Our biomaterials curriculum covers a variety of topics including biomimetic materials and natural materials, host responses to biomaterials and biocompatibility, and applications of biomaterials, particularly to tissue engineering, drug delivery, and medical devices and implants. The goal of the Biomaterials Track in the Department of Materials Science and Engineering is to train students in the basic principles of materials science and engineering as these principles are applied to develop novel materials that benefit human health.

Biomaterials are an inherently interdisciplinary field that requires deep understanding of the properties of materials in general, and the interactions of materials with the biological environment. The Biomaterials Track is designed to provide a firm grounding in the physics, chemistry, and biology of materials, and well as breath in general engineering, mathematics, humanities and social science. In addition, students are encouraged to gain hands-on experience in biomaterials research laboratories. Students of the Biomaterials Track will be well-prepared for successful careers in biomaterials engineering or any biomedical related field.

Successful completion of the Biomaterials Track will be noted on the student's transcript.

Students interested in satisfying pre-med requirements should coordinate their curriculum with the guidelines offered by the Office of Pre-Professional Advising.

DESCRIPTION OF THE NANOTECHNOLOGY TRACK

Nanotechnology advances the utilization of materials and devices with extremely small dimensions. Nanotechnology is a visionary field, as micro and nanostructured devices impact all fields of engineering, from microelectronics (smaller, faster computer chips) to mechanical engineering (micromotors and actuators) to civil engineering (“smart”, self-healing nanocomposite materials for buildings and bridges) to biomedical engineering (biosensors and tissue engineering).

Materials Science is central to nanotechnology because the properties of materials can change dramatically when things are made extremely small. This observation isn't just that we need to measure such properties or develop new processing tools to fabricate nanodevices. Rather, our vision is that the wide (and sometimes unexpected!) variety of phenomena associated with nanostructured materials allow us to envision radically new devices and applications that can only be made with nanostructured materials.

It is with the goal of developing a broad vision for the application of nanostructured materials that the Department of Materials Science offers a *Nanotechnology Track*, a curriculum designed to train students in the fundamental interdisciplinary principles of materials science including physics and chemistry, and also to expose students to cutting edge nanomaterials research, both in elective classes and in research laboratories. Students in the Nanotechnology Track will be well-prepared for successful careers in materials engineering across a wide range of disciplines. Successful completion of the Nanotechnology Track will be noted on the student's transcript.

Sample Undergraduate Programs for Materials Science and Engineering: Standard Track (For a student beginning with Calculus I)

First Year Fall		
510.101	**Introduction to Materials Chemistry**	**3**
110.108	Calculus I	4
030.105	Intro. Chem. Lab I	1
171.101	General Physics I	4
173.111	General Physics Lab I	1
	Unrestricted Elective	3
Total		16

First Year Spring		
030.106	Intro. Chem. Lab II	1
171.102	General Physics II	4
173.112	General Physics Lab II	1
110.109	Calculus II	4
510.202	Computation and Programming for Materials Scientists and Engineers	3
	Unrestricted Elective	3
Total		16

Second Year Fall		
510.311	**Structure of Materials**	**3**
030.205	Intro. Organic Chem. I	4
030.225	Organic Chem. Lab I	3
110.202	Calculus III	4
520.213	Circuits	4
Total		18

Second Year Spring		
510.313	**Mechanical Properties of Materials**	**3**
510.314	**Electronic Properties of Materials**	**3**
110.201	Linear Algebra	4
	Math/Sci/Eng elective	3
	H/S elective	3
Total		16

Third Year Fall		
510.312	**Physical Chemistry of Materials. I: Thermodynamics**	**3**
510.316	**Biomaterials I**	**3**
510.428	**Materials Science Lab I**	**3**
530.201	Statics and Mechanics of Materials	4
	H/S elective	3
Total		16

Third Year Spring		
510.315	**Physical Chemistry of Materials. II: Kinetics and Phase Transformations**	**3**
510.429	**Materials Science Lab II**	**3**
110.302	Differential Equations	4
	H/S Elective	**3**
	Math/Sci/Eng elective	3
Total		16

Fourth Year Fall		
510.433	**Senior Design I**	**3**
510.4##	**MSE elective**	**3**
510.4##	**MSE elective**	**3**
	Math/Sci/Eng elective	3
	H/S Elective	3
Total		15

Fourth Year Spring		
510.434	**Senior Design II**	**3**
510.4##	**MSE elective**	**3**
510.4##	**MSE elective**	**3**
	H/S elective	3
	H/S elective	3
Total		15
Grand Total		128

* Students must take either “510.101 Introduction to Materials Chemistry”, or “*both* 030.101 Introductory Chemistry I and 030.102 Introductory Chemistry II” to fulfill the introductory chemistry requirement.

Sample Undergraduate Program for Materials Science and Engineering: Biomaterials Track (For a student beginning with Calculus I)

First Year Fall		
510.101	**Introduction to Materials Chemistry**	**3**
110.108	Calculus I	4
030.105	Intro. Chem. Lab I	1
171.101	General Physics I	4
173.111	General Physics Lab I	1
	Unrestricted Elective	
Total		16

First Year Spring		
030.106	Intro. Chem. Lab II	1
171.102	General Physics II	4
173.112	General Physics Lab II	1
110.109	Calculus II	4
510.202	Computation and Programming for Materials Scientists and Engineers	3
	Unrestricted Elective	3
Total		16

Second Year Fall		
510.311	**Structure of Materials**	**3**
030.205	Intro. Organic Chem. I	4
030.225	Organic Chem. Lab I	3
110.202	Calculus III	4
	H/S Elective	3
Total		17

Second Year Spring		
510.313	**Mechanical Properties of Materials**	**3**
510.314	**Electronic Properties of Materials**	**3**
110.201	Linear Algebra	4
	Math/Sci/Eng elective	3
	H/S elective	3
Total		16

Third Year Fall		
510.312	**Physical Chemistry of Materials. I: Thermodynamics**	**3**
510.316	**Biomaterials I**	**3**
510.428	**Materials Science Lab I**	**3**
580.221	Molecules and Cells	4
	H/S elective	3
Total		16

Third Year Spring		
510.315	**Physical Chemistry of Materials. II: Kinetics and Phase Transformations**	**3**
510.429	**Materials Science Lab II**	**3**
510.407	**Biomaterials II**	**3**
110.302	Differential Equations	4
	H/S Elective	**3**
Total		16

Fourth Year Fall		
510.433	**Senior Design I**	**3**
510.4##	**MSE elective**	**3**
510.4##	**MSE elective**	**3**
	H/S Elective	3
530.201	Statics and Mechanics of Materials	4
Total		16

Fourth Year Spring		
510.434	**Senior Design II**	**3**
510.431	**Biocompatibility of Materials**	**3**
	Math/Sci/Eng elective	3
	H/S elective	3
	Unrestricted Elective	3
Total		15
Grand Total		128

Requirement Sign-Off Sheet for B.S. in Materials Science and Engineering

To be filled in by students before meeting with your advisor at the beginning of each semester. For specific classes, place a checkmark on the line. For open electives, fill in the line with the class used to satisfy the requirement.

Student's Name ___________________________Advisor's Name ____________________Date_________

MATERIALS SCIENCE CORE CLASSES

- Must be passed with letter grade of C or higher
- 30 credits

510.311	Structure of Materials (3)	_____
510.312	Physical Chemistry of Materials I: Thermodynamics (3)	_____
510.313	Mechanical Properties(3)	_____
510.314	Electronic Properties (3)	_____
510.315	Physical Chemistry of Materials II: Kinetics and Phase Transformations (3)	_____
510.316	Biomaterials I (3)	_____
510.428	Materials Science Lab I (3)	_____
510.429	Materials Science Lab II (3)	_____
510.433	Senior Design/Research I (3)	_____
510.434	Senior Design/Research II (3)	_____

UPPER LEVEL MATERIALS SCIENCE ELECTIVES

- Grade of C or higher
- 300-level or higher
- relevant courses in other departments with prior permission
- 12 credits

Materials Elective #1 (3)	_____
Materials Elective #2 (3)	_____
Materials Elective #3 (3)	_____
Materials Elective #4 (3)	_____

- *Independent research can only count toward three (3) credits of this requirement.*
- *See above for requirements specific to the Biomaterials and Nanotechnology tracks.*

BASIC SCIENCES

- Grade of C- or higher
- 22 credits
- Both 030.101 and 030.102 may substitute for 510.101. Note: students are required to take both semesters of Introductory Chem. Lab.

171.101	General Physics I (4)	_____
171.102	General Physics II (4)	_____

173.111	General Physics Laboratory I (1)	_____
173.112	General Physics Laboratory II (1)	_____
510.101	Introduction to Materials Chemistry (3)	_____
030.105	Introductory Chem. Lab I (1)	_____
030.106	Introductory Chem. Lab II (1)	_____
030.205	Introductory Organic Chemistry I (4)	_____
030.225	Organic Chemistry Lab (3)	_____

MATHEMATICS

- Grade of C- or higher
- 20 credits

110.108	Calculus I (4)	_____
110.109	Calculus II (4)	_____
110.202	Calculus III (4)	_____
110.201	Linear Algebra (4)	_____
110.302	Differential Equations (4)	_____

BASIC ENGINEERING

- Grade of C- or higher
- 11 credits

General Engineering (8)
Students must complete **two** of the following:

- 520.213 Circuits (4) _____
- 530.201 Statics and Mechanics (4) _____
- 580.221 Molecules and Cells (4) _____

Computer Programming (3) _____

- 510.202 Computation and Programming for Materials Scientists and Engineers (offered Spring, 2012 and following springs)

HUMANITIES (H OR S)

- Letter grade of C- or higher
- 18 credits

Humanities Elective #1 ______
Humanities Elective #2 ______
Humanities Elective #3 ______
Humanities Elective #4 ______
Humanities Elective #5 ______
Humanities Elective #6 ______

SCIENCE AND ENGINEERING ELECTIVES

- Two courses of 200- level or above in engineering, natural sciences or mathematics
- Letter grade of D or higher required
- 6 credits

Science Elective #1 (3) ______
Science Elective #2 (3) ______

UNRESTRICTED ELECTIVES

- 9 credits of unrestricted electives
- Letter grade of D or higher required

Unrestricted Elective #1 (3) ______
Unrestricted Elective #2 (3) ______
Unrestricted Elective #3 (3) ______

- A student who has taken both 030.101 and 030.102 may count one of them toward one unrestricted elective.

TOTAL NUMBER OF REQUIRED CREDITS **128**

This sheet should be updated each semester and reviewed by the student's advisor. See instructions at the top of this document.

MATERIALS SCIENCE & ENGINEERING
UNDERGRADUATE PROGRAM COURSE DESCRIPTIONS

510.101 (E, N) Introduction to Materials Chemistry (3 credits, Fall)
Basic principles of chemistry and how they apply to the behavior of materials in the solid state. The relationship between electronic structure, chemical bonding, and crystal structure is developed. Attention is given to characterization of atomic and molecular arrangements in crystalline and amorphous solids: metals, ceramics, semiconductors and polymers (including proteins). Examples are drawn from industrial practice (including the environmental impact of chemical processes), from energy generation and storage (such as batteries and fuel cells), and from emerging technologies (such as biomaterials).

510.103 (E, N) Foundations of Nanotechnology (3 credits, Spring)
This course will be a survey of the rapidly developing field of nanotechnology from an interdisciplinary point of view. Topics covered will include a general introduction to the nanoworld, fabrication, characterization and applications of hard and soft nanomaterials, as well as examining nanotechnology in terms of its social ethical, economic and environmental impact.

510.107 (E, N) Modern Alchemy (3 credits, Fall)
Can you really turn lead into gold? Converting common substances into useful materials that play important roles in today's technologies is the goal of many modern scientists and engineers. In this course, we will survey selected topics related to modern materials, the processes that are used to make them as well as the inspiration that led to their development. Topics will include the saga of electronic paper, the sticky stuff of gecko feet and the stretchy truth of metal rubber.

510.201 (E,N) Introduction to Engineering Materials (3 credits, Spring)
An introduction to the structure, properties, and processing of materials used in engineering applications. After beginning with the structure of materials on the atomic and microscopic scales, this course explores defects and their role in determining materials properties, the thermodynamics and kinetics of phase transformations, and ways in which structure and properties can be controlled through processing. All major classes of materials (metals, ceramics, polymers, and semiconductors) are considered. Recommended for all engineering majors. Prerequisites: Introductory calculus, chemistry, and physics, or permission of instructor.

510.202 (E,N) Computation and Programming for Materials Scientists and Engineers (3 credits, Spring)
This course will introduce students to the basics of programming in the MATLAB environment. Students will build skills in algorithmic problem solving by programming assignments regarding a range of biological and non-biological materials systems. Students will learn to write function definitions and deploy basic operations of selection and iteration as well as MATLAB specific vectorization methods and the construction of graphical user interfaces. Applications may include materials structure, phase equilibrium, propagating reactions, and other relevant scientific and engineering applications.

The following ten course series, 510.311-316 + Labs 510.428-429 + Senior Design 510.433-434, is devoted to the fundamental principles and engineering applications of materials and the concepts necessary for the design of materials systems. This series is required for all majors in Materials Science and Engineering.

510.311 (E,N) Structure of Materials (3 credits, Fall)
First of the Introduction to Materials Science series, this course is devoted to study of the structure of materials. Lecture topics include bonding, atomic packing, crystal structure, imperfections in crystals, noncrystalline solids, and composite materials. Among the techniques treated are X-ray diffraction, stereographic projection, and optical and electron microscopy. **Prerequisites: Calculus I, freshman/ sophomore chemistry and physics, or permission of instructor.**

510.312 (E,N) Physical Chemistry of Materials I: Thermodynamics (3 credits, Fall)
Second of the Introduction to Materials Science series, this course examines the principles of thermo-dynamics as they apply to materials. Topics include fundamental principles of thermodynamics, equilibrium in homogeneous and heterogeneous systems, thermodynamics of multicomponent systems, phase diagrams, thermodynamics of defects, and elementary statistical thermodynamics. **Prerequisites: Calculus I and II, freshman/sophomore chemistry and physics, or permission of instructor.**

510.313 (E,N) Mechanical Properties of Materials (3 credits, Spring)

Third of the Introduction to Materials Science series, this course is devoted to a study of the mechanical properties of materials. Lecture topics include elasticity, anelasticity, plasticity, and fracture. The concept of dislocations and their interaction with other lattice defects is introduced. Among the materials studied are metals, polymers, ceramics, glasses, and composites. **Prerequisite: 510.311**.

510.314 (E,N) Electronic Properties of Materials (3 credits, Spring)
Fourth of the Introduction to Materials Science series, this course is devoted to a study of the electronic, optical and magnetic properties of materials. Lecture topics include electrical and thermal conductivity, thermoelectricity, transport phenomena, dielectric effects, piezoelectricity, and magnetic phenomena. **Prerequisite: 510.311**.

510.315 (E,N) Physical Chemistry of Materials II: Kinetics and Phase Transformations
(3 credits, Spring)
Fifth of the Introduction to Materials Science series, this course covers diffusion and phase transformations in materials. Topics include Fick's laws of diffusion, atomic theory of diffusion, diffusion in multicomponent systems, solidification, diffusional and diffusionless transformations, and interfacial phenomena. **Prerequisite: 510.312**.

510.316 (E,N) Biomaterials I (3 credits, Fall)
Sixth of the Introduction to Materials Science series, this course offers an overview of principles and properties of biomedical materials. Topics include properties of materials used in medicine, synthesis and properties of polymeric materials, polymeric biomaterials, natural and recombinant biomaterials, biodegradable materials, hydrogels, stimuli-sensitive materials, and characterizations of biomaterials. **Prerequisites: 030.205 Organic Chemistry I.**

510.428 (E,N,W) Materials Science Laboratory I (3 credits, Fall)
This course focuses on characterizing the microstructure and mechanical properties of structural materials that are commonly used in modern technology. A group of A1 alloys, Ti alloys, carbon and alloy steels, and composite materials that are found, for example, in actual bicycles will be selected for examination. Their microstructures will be studied using optical metallography, scanning electron microscopy, X-ray diffraction, and transmission electron microscopy. The mechanical properties of these same materials will be characterized using tension, compression, impact, and hardness tests. The critical ability to vary microstructure and therefore properties through mechanical and heat treatments will also be demonstrated and investigated in the above materials. **Pre- or co-requisites: 510.311 & 510.313**

510.429 (E,N,W) Materials Science Laboratory II (3 credits, Spring)
This laboratory concentrates on the experimental investigation of electronic properties of materials using basic measurement techniques. Topics include thermal conductivity of metal alloys, electrical conductivity of metals/metal alloys and semiconductors, electronic behavior at infrared wavelengths, magnetic behavior of materials, carrier mobility in semiconductors and the Hall effect in metals and semiconductors. Additional topics considered include basic processing of electronic materials and electronic device construction. Prerequisite: 510.311 or permission of instructor. **Pre- or co-requisites: 510.311 & 510.314**

510.433 (E,N,W) Senior Design/Research Experience in Materials Science & Engineering I (3 credits, Fall)
This course is the first half of a two-semester sequence required for seniors majoring or double majoring in materials science and engineering. It is intended to provide a broad exposure to many aspects of planning and conducting independent research. During this semester, students join ongoing graduate research projects for a typical 10-12 hours per week of hands-on research. Classroom activities include discussions, followed by writing of research pre-proposals (white papers), proposals, status reports and lecture critiques of the weekly departmental research seminar. **Prerequisites: 510.311-312, 510.428-429.**

510.434 (E,N,W) Senior Design/Research Experience in Materials Science and Engineering II (3 credits, Spring)
This course is the second half of a two-semester sequence required for seniors majoring or double majoring in materials science and engineering. It is intended to provide a broad exposure to many aspects of planning and conducting independent research. During this semester, verbal reporting of project activities and status is emphasized, culminating in student talks presented to a special session of students and faculty. Written final reports describing the research projects provide lasting mementos of this course. **Prerequisites: 510.311-312, 510.428-429.**

Advanced Materials Undergraduate Electives. Not all electives are offered each academic year.

510.400 (E,N) Introduction to Ceramics (3 credits, Spring)
This course will examine the fundamental structure and property relationships in ceramic materials. Areas to be studied include the chemistry and structure of ceramics and glasses, microstructure and property relationships, ceramic phase relationships, and ceramic properties.
Particular emphasis will be placed on the physical chemistry of particulate systems,

characterization, and the surface and colloid chemistry of ceramics. **Prerequisites: 510.311, 510.312 or permission of the instructor.**

510.403 (E, N) Materials Characterization (3 credits, Fall)
This course will describe a variety of techniques used to characterize the structure and composition of engineering materials, including metals, ceramics, polymers, composites, and semiconductors. The emphasis will be on microstructural characterization techniques, including optical and electron microscopy, x-ray diffraction, and acoustic microscopy. Surface analytical techniques, including Auger electron spectroscopy, secondary ion mass spectroscopy, x-ray photoelectron spectroscopy, and Rutherford backscattering spectroscopy. Real-world examples of materials characterization will be presented throughout the course, including characterization of thin films, surfaces, interfaces, and single crystals.

510.405 (E, N) Energy Engineering: Fundamentals and Future (3 credits, Spring)
This course examines the science and engineering of contemporary and cutting-edge energy technologies. Materials Science and Mechanical Engineering fundamentals in this area will be complemented by case studies that include fuel cells, solar cells, lighting, thermoelectrics, wind turbines, engines, nuclear power, biofuels, and catalysis. Students will consider various alternative energy systems, and also to research and engineering of traditional energy technologies aimed at increased efficiency, conservation, and sustainability. Prerequisite: undergraduate course in thermodynamics

510.407 (E, N) Biomaterials II (3 credits, Spring)
This course focuses on the interaction of biomaterials with the biological system and applications of biomaterials. Topics include host reactions to biomaterials and their evaluation, cell-biomaterials interaction, biomaterials for tissue engineering applications, biomaterials for controlled drug and gene delivery, biomaterials for cardiovascular applications, biomaterials for orthopedic applications, and biomaterials for artificial organs. **Prerequisites: 510.316**

510.408 (E, N) Simulation of Materials & Biological Systems (3 credits, Spring)
This course will review basics of programming in MATLAB environment. Students will build their MATLAB skills by programming assignments regarding a range of biological and materials systems. Integration of time-dependent ODEs and PDEs, solution of eigenvalue problems, Monte Carlo calculations and molecular dynamics simulations will be explored in the context of problems that may include chemical reactions, band structure, phase equilibrium, disease progression, waves in heart tissue, glycolysis, and other relevant scientific and engineering applications.

510.409 (E, N) Melting, Smelting, Refining and Casting (3 credits, Spring)
This is a laboratory class on metal formation, an area that underlies almost all other technologies. We will examine extraction of metals from ore, refining of metals. The kinetics of melting and solidification will be explored in the context of casting and forming.

510.415 (E, N) The Chemistry of Materials Synthesis (3 credits, Fall)
Many of the latest breakthroughs in materials science and engineering have been driven by new approaches to their synthesis, which has allowed the preparation of materials with fanciful structures and fascinating properties. This advanced course will explore synthetic approaches to multifunctional and nanostructured materials, ranging from opals to complex polymers to

nanowires and quantum dots . Applications include electronics, energetics, and drug delivery. Participants will gain sufficient familiarity with synthesis options to be able to design research programs that rely on them. Emphasis will be placed on broad strategies that lead to material functionality, rather than detailed step-by-step sequences. Some topics will be selected “on the fly” from the most exciting current literature. Prerequisites: 030.205 Organic Chemistry I, and 510.312 or equivalent thermodynamics course.

510.416 (E, N) Applications of X-Ray Diffraction (3 credits, Fall)
Practical aspects of structural characterization with x-ray diffraction. Topics include orientation of single crystals; lattice parameter measurement; phase identification; quantitative phase analysis; crystallographic texture determination; stress measurement; diffraction from long-period structures including superlattices, multilayers, and layered molecular solids; and scattering from liquids and amorphous solids. The course will combine lectures with several laboratory exercises intended to give students experience in data collection and analysis for a variety of diffraction techniques.

510.418 (E, N) Electronic and Photonic Processes and Devices (3 credits, Fall)
This course is intended for advanced undergraduates and graduate students and will cover the fundamentals and properties of electronic and optical materials and devices. Subject matter will include a detailed and comprehensive discussion of the physical processes underlying modern electronic and optical devices. Detailed descriptions of modern semiconductor devices such as lasers and detectors used in optical communications and information storage and processing will be presented.

510.419 (E, N) Physical Metallurgy (3 credits, Fall)
This course examines the relationship between microstructure and mechanical properties of metals and alloys. Starting from fundamentals (phase diagrams and phase transformation kinetics), we will explore how the structure of metals and alloys can be manipulated by thermomechanical processing to achieve desired properties. Detailed examples will be drawn from several alloy systems, including steels, aluminum, and titanium. A theme of the course will be the impact of materials processing and materials selection on the environment, including considerations of lightweight materials and processing techniques for minimizing energy consumption. **Prerequisites: 510.311-312, 510.314-315.**

510.422 (E, N) Micro- and Nano-Structured Materials and Devices (3 credits, Spring)
Almost every materials property changes with scale. We will examine ways to make micro- and nano-structured materials and discuss their mechanical, electrical, and chemical properties. Topics include the physics and chemistry of physical vapor deposition, thin film patterning, and microstructural characterization. Particular attention will be paid to current technologies including computer chips and memory, thin film sensors, diffusion barriers, protective coatings, and microelectromechanical devices (MEMS). **Prerequisites: 510.311, 510.312, 510.315**.

510.423 (E, N) Mechanical Properties of Thin Films and Nanostructured Materials
(3 credits, Spring)
The mechanical properties of thin films on substrates and nanomaterials will be discussed. Topics include: elastic, plastic, and diffusional deformation of thin films and nanomaterals; effects of temperature, microstructure, and capillarity on mechanical behavior; mechanical

characterization techniques; mechanics of thin film stresses that develop during thin film growth; experimental methods for measuring thin film stresses; thin film adhesion; strengthening processes in nanomaterials. Prerequisite: 510.313 or equivalent

510.426 (E, N) Biomolecular Materials (3 credits, Fall)
Structure and function of cellular molecules (lipids, nucleic acids, proteins, and carbohydrates). Structure and function of molecular machines (enzymes for biosynthesis, motors, pumps). Protein synthesis using recombinant nucleic acid methods. Advanced materials development. Interactions of biopolymers, lipid membranes, and their complexes. Mean field theories, fluctuation and correlation effects. Self assembly in biomolecular materials. Biomedical applications. Characterization techniques.

510.430 (E,N) Biomaterials Lab (3 credits, Spring)
This laboratory course concentrates on synthesis, processing and characterization of materials for biomedical applications, and characterization of cell-materials interaction. Topics include synthesis of biodegradable polymers and degradation, electrospinning of polymer nanofibers, preparation of polymeric microspheres and drug release, preparation of plasmid DNA, polymer-mediated gene delivery, recombinant protein synthesis and purification, self-assembly of collagen fibril, surface functionalization of biomaterials, cell culture techniques, polymer substrates for cell culture, and mechanical properties of biological materials. **Pre- or co-requisite: 510.407.**

510.431 (E, N) Biocompatibility of Materials (3 credits, Spring)
This course provides a detailed examination of the interaction of surgical implant materials (i.e., metals, polymers, ceramics, and composites) with the body. The effect of the physiological environment on the properties of implant materials is described as well as the cellular tissue response to the implant. Concepts dealing with the design of materials with improved biocompatibility is explored. **Prerequisite: 510.316, or permission of instructor.**

510.435 (E, N) Mechanical Properties of Biomaterials
This course will focus on the mechanical properties of biomaterials and the dependence of these properties on the microstructure of the materials. Organic and inorganic systems will be considered through a combination of lectures and readings and the material systems will range from cells to bones to artificial implants.

510.443 (E, N) Chemistry of Physics & Polymers (3 credits, Spring)
The course will describe and evaluate the synthetic routes, including condensation and addition polymerization, to macromolecules with varied constituents and properties. Factors that affect the efficiencies of the syntheses will be discussed. Properties of polymers that lead to technological applications will be covered, and the physical basis for these properties will be derived. Connections to mechanical, electronic, photonic, and biological applications will be made.
Prerequisites: Organic Chemistry I and one semester of thermodynamics

510.456 (E, N) Introduction to Surface Science (3 credits, Fall)
Introduction to the structure and properties of solid surfaces. Topics include Gibbsian and gradient thermodynamics of surfaces; crystallography and structure of free solid surfaces; characterization methods; surface mobility and phase transitions; gas-solid interactions; crystal growth; electronic structure; solid-solid surfaces; thin film epitaxy. **Prerequisites: 510.311-315** or permission of instructor.

510.457 (E, N) Materials Science of Thin Films (3 credits, Spring)
The processing, structure, and properties of thin films are discussed emphasizing current areas of scientific and technological interest. Topics include elements of vacuum science and technology; chemical and physical vapor deposition processes; film growth and microstructure; chemical and microstructural characterization methods; epitaxy; mechanical properties such as internal stresses, adhesion, and strength; and technological applications such as superlattices, diffusion barriers, and protective coatings.

510.501-502 (E, N) Research in Materials Science and Engineering (1-3 credits)
Student participation in ongoing research activities. Research is conducted under the supervision of a faculty member and often in conjunction with other members of the research group.

510.503-504 (E, N) Independent Study in Materials Science and Engineering (1-3 credits)
Individual programs of study are worked out between students and the professor supervising their independent study project. Topics selected are those not formally listed as regular courses and include a considerable design component. **Prerequisite: permission of instructor.**

510.597 (E, N) Summer Independent Research in Materials Science and Engineering
(1-3 credits)

510.599 (E, N) Summer Independent Study in Materials Science and Engineering
(1-3 credits)

ACADEMIC ETHICS

The strength of the university depends on the integrity of those who engage in its mission. Ethical behavior results in trust providing an atmosphere in which the open and free exchange of ideas can occur. Trust allows us to come together, helping each of us reach levels that we could never achieve alone. The absence of ethical and considerate behavior engenders mistrust among the members of the university community and erodes the quality discourse. It divides us and ultimately degrades what we know and who we are.

The Department of Materials Science and Engineering strives to uphold the ideals of academic integrity and seeks to create an atmosphere in which all members of the Department display the highest degree of ethical conduct. Creating this atmosphere is the responsibility of all members of the Department – students, faculty and staff – and can only be achieved with the consistent education of its members about the standards of academic honesty and ethical behavior.

Briefly, acts of academic dishonesty include cheating on exams, plagiarism, reuse of assignments, improper use of the Internet and electronic devices, unauthorized collaboration, alteration of graded assignments, forgery and falsification, lying, facilitating academic dishonesty, and unfair competition. University approved procedures for addressing academic ethics violations are published in the Undergraduate Academic Ethics Board Constitution (*http://www.jhu.edu/~ethics/constitution.html*). Students accused of academic dishonesty are encouraged to consult the Ethics Board Constitution as well as with the Dean of Student Life in Office of Homewood Student Affairs. More information on academic ethics at Johns Hopkins is available, at *http://www.jhu.edu/~ethics/*, and at *http://www.jhu.edu/~advising/ethics.html*.

Office of the Dean of Student Life
Mattin Center
Offit Building Suite 210
The Johns Hopkins University
3400 N. Charles St.
Baltimore, Md. 21218

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Fax: 410-516-4495

COUNSELING RESOURCES

Making the transition to the university can be difficult and the pressures of coursework, relationships and career decisions can be overwhelming. You are not alone. While your roommate, your friends or your advisor might be able to help you get through difficult times, there are problems that you might face that are best addressed by seeking out counselors who can best guide and advise you on how to handle them. There are trained professional counselors available in the Counseling Center (*http://www.jhu.edu/~ccenter/*) who can confidentially assist you in addressing your problems. Staffed by professional psychologists and consulting psychiatrists, the Counseling Center offers counseling services that are free and confidential, as prescribed by law. Typical concerns may include test anxiety and academic performance, relationship issues, family problems, career concerns, stress, general unhappiness, self-confidence, as well as many other concerns. There also exists a confidential peer counseling program (A Place to Talk – APTT, *http://www.jhu.edu/~aptt/*) staffed by undergraduate students who are familiar with the pressures of undergraduate life at Hopkins and can assist students with those common problems that all undergraduates face during their time here.

The Counseling Center
Garland Hall, 3rd Floor
The Johns Hopkins University
3400 N. Charles St.
Baltimore, MD 21218
http://www.jhu.edu/ccenter/
Voice: 410-516-8278

APTT – A Place to Talk
Voice: 443-823-2459
email: aptt@jhu.edu