JOHNS HOPKINS
UNIVERSITY

Mechanical Engineering
Department

Undergraduate Advising Manual

for Bachelor of Science Degrees in Mechanical Engineering and Engineering Mechanics

2008-2009

- Updated September 25, 2009

Department of Mechanical Engineering

The Johns Hopkins University

Accredited Undergraduate Programs in

Mechanical Engineering and Engineering Mechanics

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1 INTRODUCTION

Our time has already seen once-diverse engineering fields merge and new technologies redefine industries. The pace of these developments will become even faster in this new century. To keep abreast of rapid technological innovation, engineers must be able to continually update and renew their knowledge throughout their careers.

The task of preparing students for this environment is facilitated by our focus on fundamentals and the low student-to-faculty ratio of the Department of Mechanical Engineering. Educating a small, select group of students has permitted the development of a number of distinctive educational features such as a "capstone" design course that closely simulates professional practice, student participation in faculty research, close faculty-student interaction, and effective advising. By means of flexible programs grounded in fundamentals, we enable our graduates to pursue the lifelong education needed to excel in a rapidly changing world.

1.1 Objectives

In fulfilling our mission of preparing our graduates for the future, we start with the recognition that, at the root of the ever-growing variety of technological innovations lie scientific, engineering, and professional principles that are both a foundation for the student's understanding and a compass throughout his or her career.

A primary objective of the Mechanical Engineering curriculum is, therefore, to emphasize the importance of these fundamental principles and to help students understand them and master their application. Laboratory experience is invaluable for this purpose and we provide meaningful hands-on experience in modern instructional and research laboratories, so that students gain the skills of acquiring, analyzing, and interpreting data.

Fundamental principles are as vital today as when they were first discovered. This aspect is illustrated by showing them "in action" in the more advanced courses devoted to contemporary applications.

The demands of advanced technology, economy, and efficiency put an ever-increasing premium on the quantitative aspects of engineering. For this reason, students must also be educated in the application of advanced mathematical and computational techniques in engineering analysis and design.

1.2 Programs

1.2.1 Academic Programs

The Department of Mechanical Engineering offers two distinct programs of study for undergraduates at Johns Hopkins: Mechanical Engineering and Engineering Mechanics.

The **Mechanical Engineering** program places an emphasis on mechanical and thermal-fluid systems analysis and design. Students develop a wide range of fundamental skills required of the mechanical engineering professional and choose upper-level technical electives for further in-depth study.

The **Engineering Mechanics** program is designed to provide students with a highly flexible but rigorous foundation in solid and fluid mechanics. Students choose an area of specialization in preparation for technical careers or graduate and professional school.

The objectives indicated before are common to the two programs. In addition, they share the following features:

Flexibility. While the Engineering Mechanics curriculum is, by design, very flexible, both curricula offer several technical electives and allow students to pursue special interests in engineering, physics, biology, mathematics, management, and humanities. Double-majors and a 5-year Master's degree are also possible.

Interdisciplinary approach. Both programs require courses in the basic sciences and mathematics and other engineering disciplines (including electrical, civil and materials). Each program also offers elective opportunities in diverse areas such as the physical and mathematical sciences, aerospace engineering, biomedical engineering, and environmental engineering. Students have the opportunity to interact with a multidisciplinary faculty both in the classroom and in research laboratories.

Preparation for professional practice. The modern engineer must be well versed in communication and teamwork skills. These are developed in a number of courses that involve laboratory exercises, report writing, and oral presentations. In addition to the two-semester freshman introductory and senior capstone design courses, the students' development in solving design problems is cultivated and encouraged through design electives and special design projects assigned in many of the courses.

The requirements described in this guide are intended to ensure an excellent foundation in science, humanities and social sciences, engineering sciences and engineering design methods, as well as preparation in the specializations of Mechanical Engineering and Engineering Mechanics. Both programs are accredited by the Accreditation Board for Engineering and Technology (ABET). For further details, see www.abet.org.

1.2.2 Mechanical Engineering Program Objectives

Educate a select group of engineers who, after graduation, will be successful and on track to become leaders among their peers as (1) engineers in industry, government laboratories and other organizations, or (2) advanced students in the best graduate programs. In these endeavors, they will:

- Apply and cultivate their understanding and mastery of the fundamental scientific, engineering, and professional principles at the foundation of Mechanical Engineering,
- Apply advanced mathematical, computational and experimental techniques to respond to demands of advanced technology, economy, and efficiency that put an ever-increasing premium on the quantitative aspects of engineering,
- Contribute to society as broadly educated, articulate, and ethical citizens, who are at ease in multidisciplinary teams, and
- Strive to continually update and renew their knowledge throughout their careers, to excel in a rapidly changing world.

Mechanical Engineering Program Outcomes

Students graduating from the B.S. in Mechanical Engineering will have demonstrated the ability to

- Understand and apply the fundamentals of mathematics (through linear algebra and multivariate calculus), numerical methods, statistical analysis and physical sciences (physics and chemistry) necessary to attain competence in the mechanical engineering disciplines,
- Design, conduct, evaluate and report experiments including analysis and statistical interpretation of data,
- Identify, formulate and solve engineering problems in the areas of thermo-fluid and mechanical systems,
- Use basic concepts from the mechanical engineering sciences, modern engineering tools (machine-tools, laboratory instrumentation, and computer

hardware and software), and related subjects to design mechanical engineering components and processes, taking into account constraints such as manufacturability, cost, safety, environmental and socio-political impacts,

- Enter professional practice and/or graduate school, with the recognition of the need for life-long learning and the ability to pursue it,
- Use effective communication, multidisciplinary teamwork, and possess awareness of professional and ethical responsibilities, and an appreciation of the societal, economic, and environmental impacts of engineering.

1.2.3 Engineering Mechanics Program Objectives

Educate a select group of science-oriented engineers who, after graduation, will be successful and on track to become leaders among their peers as 1) advanced students in the best graduate programs in engineering, science, medical schools, or law schools, or 2) as engineers in industry, government laboratories and other organizations. In these endeavors, they will:

- Apply and cultivate their understanding and mastery of the fundamental scientific, engineering, and professional principles at the foundation of Mechanics,
- Apply advanced mathematical, computational and experimental techniques to respond to demands of advanced technology, economy, and efficiency that put an ever-increasing premium on the quantitative aspects of engineering,
- Contribute to society as broadly educated, articulate, and ethical citizens, who are at ease in cross-disciplinary and multidisciplinary teams, and
- Strive to continually update and renew their knowledge throughout their careers, to excel in a rapidly changing world.

Engineering Mechanics Program Outcomes

Students graduating from the B.S. in Engineering Mechanics will have demonstrated the ability to

- Understand and apply the fundamentals of mathematics (through linear algebra and multivariate calculus), numerical methods, statistical analysis and physical sciences (physics and chemistry) necessary to attain competence in the mechanics or related disciplines such as applied physics, bioengineering or other scientific/engineering disciplines.

- Understand the interplay between engineering science and the design, evaluation and reporting of experiments including analysis and statistical interpretation of data.
- Identify, formulate and solve engineering problems in the mechanical sciences.
- Use basic concepts from the mechanical sciences, mathematics, the basic sciences and related subjects, as well as modern engineering tools, to design mechanical engineering components and processes, taking into account constraints such as manufacturability, cost, safety, environmental and socio-political impacts,
- Enter graduate school and/or professional practice with the tools needed for life-long learning and the recognition of its importance.
- Use effective communication, multidisciplinary teamwork, and possess awareness of professional and ethical responsibilities, and an appreciation of the societal, economic, and environmental impacts of engineering.

1.2.4 Research Programs

The research programs of the Department of Mechanical Engineering are grouped broadly into the research areas listed below. The names of the faculty members working in each research area are also listed (faculty with primary appointments in other Departments are listed in a smaller font).

- *Micro/Nanoscale Science and Engineering:* Chen, Chirikjian, Knio, Herman, Hemker, Sharpe, Ramesh, Prosperetti, Wang; Weihs, Cammarata
- *Computational Engineering:* Chen, Meneveau, Knio, Douglas, Chirikjian, Okamura, Prosperetti, Sun
- *Mechanical Engineering in Biology and Medicine:* Ramesh, Douglas, Chirikjian, Whitcomb, Okamura, Sun, Wang; Chao, Popel, Taylor, Thakor
- *Energy and the Environment:* Chen, Herman, Meneveau, Katz, Prosperetti, Knio, Su; Parlange, Osborn
- *Robotics and Human-Machine Interaction:* Chirikjian, Whitcomb, Okamura, Cowan; Hager, Stoianovici, Taylor, Thakor
- *Aerospace and Marine Systems:* Katz, Hemker, Meneveau, Prosperetti, Ramesh, Herman, Knio, Chirikjian, Whitcomb, Okamura, Su; Osborn

The entire faculty welcomes undergraduate student participation in their research activities. Participation in research may occur through formalized independent study and research courses or through paid research assistantships during the

academic semesters, intersession or the summer. Undergraduates at all levels are encouraged to contact faculty members directly if they wish to participate in the Department's research programs.

1.3 Advising

The Department's coordinator for undergraduate advising is Professor Shiyi Chen. His office is in Latrobe 124, telephone 410-516-7754, e-mail syc@jhu.edu.

All undergraduate students in Mechanical Engineering and Engineering Mechanics must follow a program approved by a faculty member in the Department who is appointed as the student's advisor.

Each student should see his or her faculty advisor to plan a course schedule, change courses if necessary, and discuss requirements for the major. It is important to determine a general outline of the total four years of courses as early as possible. In addition, students can discuss problems related to academics or academic performance at anytime.

The student is required to meet with his/her advisor at least once – and preferably more – each semester. It is the responsibility of the student to initiate these meetings with the advisor.

For example, a meeting approximately four weeks after classes begin provides a useful time to inform the advisor of potential difficulties or problems in individual courses. The second and required meeting would typically occur towards the end of the semester during Advising Week, when decisions must be made on course registration for the following semester.

Advising Holds are placed on your registration record, which your advisor must release before you can register for classes. Note that Advising Week is the week just before registration begins and your Advising Hold will not be released until you have reviewed your course plans with your advisor. Please arrange an appointment with your advisor, since he or she will likely have a particularly busy schedule during Advising Week.

2 GENERAL REGULATIONS

2.1 Course Grading – Letter Grades vs. S/U grades

The Department of Mechanical Engineering requires that all courses taken after the first semester of the freshman year and counted toward the 126 credits required for Mechanical Engineering, or the 127 credits required for Engineering Mechanics, be

taken for a letter grade. (That is, they may not be taken with the Satisfactory/ Unsatisfactory option.)

The University regulations are located on the web at http://www.jhu.edu/advising/academic_manual/BA_BS.html.

Whereas the University allows one S/U course each semester outside the student's major, the Department does not allow any S/U courses (except those in the first semester of the Freshman year) to count toward the requirements for graduation.

Further, the Department of Mechanical Engineering requires that grades of C- or better be obtained in all required Engineering, Mathematics and Science and related required elective courses of those areas. Grades of D, D+, or F will not be accepted.

No more than ten D or D+ credits may be counted toward graduation requirements in the Humanities and Social Sciences course designations.

2.2 WSE Course-Level Guidelines

In an effort to promote consistent course labeling, the course numbering guidelines found below are used throughout the University and the Whiting School of Engineering:

- 100: introductory/freshman-level coursework
- 200: sophomore-level coursework
- 300: junior-level coursework
- 400: senior-level coursework; typically permitted to apply to graduate degrees (at the discretion of the student's department)
- 500: undergraduate independent study, undergraduate research, and senior thesis coursework
- 600: graduate coursework; typically graded with letter grades
- 700: advanced graduate and topics courses; often offered P/F
- 800: graduate seminars, graduate independent study, graduate research and dissertation research coursework; nearly always offered P/F

2.3 Courses taken at other Universities

According to University regulations, no more than 12 credits completed prior to matriculation or in summer sessions at other accredited colleges or universities will be accepted.

Transfer students are not subject to this restriction. They must obtain credit for courses they wish to transfer during their first year at Hopkins. University regulations also require a minimum of two years' residence for a Hopkins degree.

2.4 *Course Waivers – No Credits Earned*

As a result of mathematics placement testing or prior course experience in high school, some students may be allowed to begin their course sequences at a higher level than in the initially prescribed curriculum. For example, some students may initiate the math sequence at Calculus II instead of the traditional Calculus I start.

No academic credit is given for waivers. A waiver merely shifts the beginning level of course work. Students must earn the prescribed number of credits for each portion of their degree program, and work with their advisors to select appropriate classes.

2.5 *Advanced Placement*

Johns Hopkins University grants credit for many Advanced Placement (AP) examinations. Official records of advanced placement examinations should be submitted to the Office of Academic Advising, 103 Shaffer Hall. AP scores will be entered on academic records upon receipt.

- CALCULUS: A score of 4 or 5 on the Calculus AB exam, or a score of 3 on the Calculus BC exam exempts a student from taking Calculus I (110.108). A score of 4 or 5 on Calculus BC exempts Calculus I and II (110.108, 110.109).
- CHEMISTRY: A score of 4 or 5 on the AP Chemistry exam exempts a student from taking the Intro Chemistry I and II sequence (030.101, 030.102) or Introduction to Materials Chemistry (510.101).
- ECONOMICS: A score of 4 or 5 on the Economics exam exempts a student from taking the required economics course, either Macroeconomics (180.101) or Microeconomics (180.102).
- PHYSICS: A score of 4 or 5 on Physics C (mechanics) exempts a student from 530.103/.104 Intro to Mechanics I / II or 171.101 Physics I.
  A score of four or five on Physics C (electricity and magnetism) exempts a student from 171.102 Physics II. No AP credit is awarded for Physics B.

PHYSICS LABS MUST BE TAKEN EVEN WITH AP CREDIT!

While the University does not require the labs, departments can require them, which Mechanical Engineering does.

All Mechanical Engineering or Engineering Mechanics students must take either the Mechanical Engineering Freshman Lab I and II (530.105/.106) or Physics Lab I (173.111) as appropriate to the freshman introductory course track one is taking.

Also, the Physics Lab II (173.112) laboratory course is required for all Mechanical Engineering or Engineering Mechanics students.

For additional information about AP credits, please consult the JHU Undergraduate Student Handbook.

2.6 Student Classification and First Semester Grades

The Whiting School of Engineering stipulates that students entering JHU from high school will be classified as "freshmen," regardless of the number of credits earned through Advanced Placement or other pre-college programs.

First-semester grades for all students entering JHU will be "covered." In other words, grades of "Satisfactory" or "Unsatisfactory" will be granted for all first semester classes.

3 DOUBLE MAJORS AND MINORS

Both Mechanical Engineering and Engineering Mechanics majors may elect to double major or to complete a minor from any department in the School of Engineering or the School of Arts and Sciences that offers one. The flexibility of the Engineering Mechanics curriculum makes it possible to double major in Biomedical Engineering, Materials Science and Engineering, Physics, and Applied Mathematics and Statistics among other fields.

Students wishing to pursue a double major should inform the Whiting School's Office of Academic Advising. It is the student's responsibility to ensure that all appropriate requirements are met. It is recommended that a faculty advisor from each major be asked to sign off on the student's planned academic program. Students wishing to pursue a minor should confer with the department through which the minor is offered to ascertain the exact requirements.

Entrepreneurship and Management minor

The minor in Entrepreneurship and Management focuses on business and management from a multidisciplinary viewpoint and is designed to provide Hopkins engineering students with the knowledge and skills to become leaders in technology companies.

Students may opt to take these courses separately from their major course requirements, but most can be incorporated into the course requirements so that only two extra courses would be required to complete the Mechanical Engineering or Engineering Mechanics major plus the Entrepreneurship and Management minor.

It is important to work with your academic advisor to appropriately plan your course work plan so you can complete all courses for the minor, as you will take these courses over multiple years.

The following table illustrates how a student can simultaneously complete the Mechanical Engineering or Engineering Mechanics major and the Entrepreneurship and Management minor with minimal additional courses.

This course…	…counts toward both this E&M minor requirement…	…and this Mechanical Engineering or Engineering Mechanics requirement.
660.105 Introduction to Business	Business and Finance #1	One allowed "S" course from a Whiting School department
660.xxx	Business and Finance #2	Extra course #1
660.3xx	Business and Finance #3	Technical Elective #1
550.310 or 560.435 Probability and Statistics	Statistics Option #3 in the Calculus and Statistics group	Statistics
530.454 Manufacturing Engineering	Operations Management #1	Core Engineering Course
530.461 Engineering Business and Management	Three credits of the Business and Finance group	Core Engineering Course
660.xxx	Leadership and Organizational Behavior	Extra course #2

Contact Professor John C. Wierman, Center for Leadership Education at wierman@jhu.edu or Senior Academic Program Coordinator Kristen Ittner at kittner@jhu.edu for further information. The center's website is located at http://web.jhu.edu/leadership.

Other Minors

More traditional subspecialty minors are available through the departments of Civil Engineering, Computer Science, Environmental Engineering, Mathematics, and Applied Mathematics and Statistics. For additional information, please contact those departments directly or view their websites, which are linked on the Departments page at the Whiting School of Engineering site at http://engineering.jhu.edu.

4 FREQUENCY OF COURSE ELECTIVE OFFERINGS

Some courses are offered exclusively in specific semesters, and sometimes in alternating years. Required core engineering courses are offered every year. Below is the standard timeframe of elective course offerings. These offerings are subject to change without

notice. Please confirm these offerings with your advisor or the Senior Academic Program Coordinator when planning your course schedule.

COURSE	INTERVAL	NEXT EXPECTED
530.328 Fluid Mechanics II	Spring	Spring 2010
530.405 Mechanics of Solids and Structures	Spring	To be determined
530.410 Biomechanics of the Cell	Spring	Spring 2010
530.414 Computer Aided Design	Fall	Fall 2009
530.415 Energy Engineering: Fundamentals and Future	Fall	Fall 2009
530.416 Advanced Mechanical Design	variable	To be determined
530.418 Aerospace Structures and Materials	variable	Fall 2009 / Fall 2011
530.420 Robot Sensors and Actuators	Spring or Fall	Fall 2009
530.421 Mechatronics	variable	To be determined
530.424 Dynamics of Robots and Spacecraft	Spring / Even Years	To be determined
530.425 Mechanics of Flight	variable	Spring 2011
530.432 Jet and Rocket Propulsion	variable	Fall 2010 or Spring 2011
530.435 Refrigeration and HVAC	Fall / Even Years	Fall 2010
530.440 Computational Mechanical of Biological Macromolecules	variable	To be determined
530.445 Introduction to Biomechanics	variable	To be determined
530.446 Experimental Biomechanics	variable	To be determined
530.448 Biomechanics I	Spring	Spring 2010
530.449 Compressible Flow	Fall / Odd Years	To be determined
530.451 Cell and Tissue Engineering Laboratory	variable	Fall 2009
530.457 Introduction to Acoustics	variable	To be determined
530.467 Thermal Design Issues for Aerospace Systems	variable	To be determined
530.470 Space Vehicle Dynamics and Control	Fall	To be determined
530.487 Introduction to Microelectromechanical Systems	Spring	To be determined
530.495 Microfabrication Laboratory	Fall	Fall 2009
530.496 Micro/Nanoscience and Biotechnology	Fall / Even Years	Fall 2010

5 HUMANITIES AND SOCIAL SCIENCE REQUIREMENTS

The Humanities and Social Sciences play an important role in an individual's education. The Whiting School of Engineering requires a minimum of six courses (each of at least three credits, 18 credits) in the Humanities or Social Sciences (catalog code H or S) areas.

While the Engineering Mechanics program uses these minimum requirements, the Mechanical Engineering program requires an additional full course in either area (a minimum of seven courses, 21 H/S credits). Both programs require one writing course, one course in economics, and two courses at the 300 level or above.

5.1 Foreign Language Credit

Students taking elements of a foreign language (xxx.101) are granted an H area designator for both semesters only if the second semester course (xxx.102) is successfully completed.

For example, a student successfully completing 090.101 and 090.102 *Elementary German* would receive eight H credits. *Note that while four H credits would be given for 090.102 if taken alone, no H credits are given for 090.101 "elements" if taken alone.*

5.2 Economics Requirement

To help the student gain an appreciation of the broad economic context in which he or she will operate one introductory course in economics, either 180.101 *Elements of Macroeconomics*, 180.102 *Elements of Microeconomics*, or 570.334 *Engineering Microeconomics* is required.

IMPORTANT: A student taking either 180.101 Elements of Macroeconomics or 180.102 Elements of Microeconomics should complete the course in the freshman or sophomore year.

Note that 570.334 is designated (E, S) and is taught in the Whiting School of Engineering, while the Elements courses are taught in the Krieger School of Arts and Sciences. If you take 570.334, your remaining H&S courses must be taken in the Krieger School. See Section 5.4 for additional information.

5.3 Writing Requirement

Whiting School graduates must take two courses (6 credits) that carry the writing intensive (W) designation. Since competence in written communication is essential for an engineering graduate, Mechanical Engineering and Engineering Mechanics majors must take at least one course that specifically develops writing skills. Although this course must also be designated as a writing intensive course (designation code "W"), this designation is not sufficient to guarantee the desirable level of intensity in writing instruction.

Two courses that do satisfy this requirement are: 060.113 or 060.114 Expository Writing (either one; both cannot be counted for H/S credit) and 220.105 Introduction to Fiction and Poetry I (220.106 may also be counted for H/S credit). Students wishing to use any other course to satisfy this writing requirement must have written permission from their advisor.

Students who take 661.110 Technical Communication will not be able to use it to satisfy graduation requirements.

5.4 Distribution and Depth Requirements

Although not directly related to the major field of study, the Humanities and Social Science portion of the program is also of great importance in broadening the

student's education and in stimulating the development of an inquisitive and critical mind. In order to best attain these objectives, the free electives in Humanities and Social Science courses must be chosen to obtain sufficient depth. Departmental regulations require that at least six H/S credits (two courses) be taken at the 300 level or higher. With the approval of the student's advisor, intermediate level language courses may be taken to satisfy this depth requirement. Note that the Whiting School (and the Department) allow the first two semesters of any elementary course in a foreign language to count toward the fulfillment of the H/S requirement, as stated in Section 5.1, as long as both semesters are successfully completed.

Mechanical Engineering majors may count one course that is taught in the Whiting School with an H and/or S designation towards this requirement. The accounting courses, 660.203 and 660.204, may not count towards this requirement. The philosophy behind these limitations is that H&S courses should be taught or supervised by fulltime faculty in the Krieger School.

5.5 Summary

In summary, the Mechanical Engineering program requires a minimum of seven full courses (21 credits) in Humanities and Social Sciences. The Engineering Mechanics program requires six full courses (18 credits) in Humanities and Social Sciences. Both programs require one writing course (as defined above), one course in economics, and two courses at the 300 level or above.

Bachelor of Science Degree in the Mechanical Engineering major

6 MECHANICAL ENGINEERING CURRICULUM

6.1 Our Mission

The mission of the B.S. in Mechanical Engineering degree program is to provide a rigorous educational experience that prepares a select group of students for leadership positions in the profession and a lifetime of learning. The faculty is committed to maintaining a modern and flexible curriculum which, building on a foundation of basic sciences and mathematics, develops a solid education in the mechanical engineering sciences. The aim of the Mechanical Engineering program is to build competence in the analysis, design and development of thermal, fluid, and mechanical systems; to promote a broad knowledge of the contemporary social and economic context, and to develop the communication skills necessary to excel.

6.2 Introduction

The program provides fundamental courses in thermal and mechanical systems. Both laboratory instruction and the senior design project allow all students hands-on experience. Each student's program of study is planned in consultation with his or her faculty advisor. Students are encouraged to develop depth in one or two areas chosen from:

- Aerospace Engineering concentration
- Biomechanical Engineering concentration
- Robotics
- Mechanics and Design
- Thermo-fluids and Thermo-fluid Systems

The choice of concentration is typically decided in the junior year after consultation with the faculty advisor. If you are ready to choose a concentration prior to your junior year, please discuss your intentions with your advisor.

6.3 Educational Objectives

The Educational Objectives for the B.S. in Mechanical Engineering degree program are designed to provide a high-quality educational experience that is tailored to the needs and interests of the student. Each student must follow a program of study that enables him/her to:

1. Understand and master the fundamentals of mathematics (through linear algebra and multivariate calculus), numerical methods, statistical analysis and physical sciences (physics and chemistry) necessary to attain competence in the mechanical engineering disciplines.
2. Design, conduct, evaluate and report experiments including analysis and statistical interpretation of data.
3. Identify, formulate and solve engineering problems.
4. Use basic concepts from the mechanical engineering sciences, modern engineering tools (instrumentation and computer hardware and software), and related subjects to design mechanical engineering components and processes.
5. Develop the ability to design, develop, and work professionally in the areas of fluid, thermal, and mechanical systems.
6. Prepare for professional practice, including recognition of the need for life-long learning, effective communication, teamwork, and awareness of professional and ethical responsibilities.

6.4 Mechanical Engineering Curriculum

The Mechanical Engineering curriculum is structured as follows:

Mathematics (19 credits; grades of D or D+ not accepted)

- 110.108 Calculus I
- 110.109 Calculus II
- 110.202 Calculus III (or 110.211 Honors Multivariable Calculus)
- 550.291 Linear Algebra/Differential Equations (or 110.201 Linear Algebra and 110.302 Differential Equations)
- Statistics Elective at the 300 level or above (e.g. 560.435 Probability and Statistics in Civil Engineering or 550.310 Probability and Statistics)

Science (12 credits; grades of D or D+ not accepted)

- 530.103/104 Introduction to Mechanics I/II (These are required for all students, even those with AP credit. Note that 530.105/106 Mechanical Engineering Freshman Laboratory I/II is a co-requisite)

- 171.102 Physics II
- 173.112 Physics Lab II
  (required for all students, including those with AP credit)
- 510.101 Introduction to Materials Chemistry or 030.101 Chemistry I

Humanities (21 credits)

- See Humanities, Section 5

Required Engineering Courses (48 credits; grades of D or D+ not accepted)

- 530.101/102 Freshman Experiences in Mechanical Engineering I/II
- 530.105/106 Mechanical Engineering Freshman Laboratory I/II
  530.201 Statics and Mechanics of Materials
- 560.202 Dynamics
- 530.215 Mechanics Based Design
- 530.231 Mechanical Engineering Thermodynamics
- 530.241 Electronics and Instrumentation
  [or 520.213 Circuits followed by 520.345 Electrical and Computer Engineering Laboratory (which can be used as a Technical Elective) or 525.134 Electrical Engineering Laboratory II]
- 530.327 Introduction to Fluid Mechanics
- 530.334 Heat Transfer
- 530.343 Design and Analysis of Dynamic Systems (and 530.344 Dynamic Systems Laboratory only for students who take an equivalent substitute course.)
- 530.352 Materials Selection
- 530.454 Manufacturing Engineering
- 530.461 Engineering Business & Management
  [or 551.105 Introduction to Business **and** 551.341 Business Process and Quality Management.]

Capstone Design (8 credits)

- 530.403 and 530.404 Engineering Design Project I and II

Mechanical Engineering Electives (9 credits)

- Three courses (300 level or higher) in mechanical engineering

Technical Electives (9 credits)

- Three (E), (Q), or (N) courses at or above the 300 level, chosen from any combination of courses in engineering, basic sciences, or mathematics chosen in consultation with the student's advisor. These courses are intended to complement the Mechanical Engineering Electives. Because of the importance of computer languages in modern technical society, one of

the three technical electives may be any computer language course taken at any level.

A program of no fewer than **126 credits** must be completed to be eligible for the bachelor's degree. All undergraduate students must follow a program approved by a faculty member in the department who is selected as the student's advisor.

Course Frequency

Listed in Section 4 of this manual are courses offered and the frequency of those offerings in the Mechanical Engineering department. It is important to plan all four years of your coursework as early as possible, keeping in mind the frequency of courses offered so you can enroll in all courses required for your degree requirements.

6.4.1 Choosing Mechanical Engineering Electives

Students are encouraged to develop depth in one or two areas within mechanical engineering. Note that Mechanical Engineering courses may also be used as Technical Electives provided they are at the appropriate level. Some examples of courses that could form the basis of concentrations are provided below. Note that many of the elective courses below are taught in alternate years. The student should check with the advisor or the Academic Program Coordinator for the schedule. (Electives are in *italics*):

Mechanics and Design

- 530.215 Mechanics-Based Design
- 530.352 Materials Selection
- *530.405 Mechanics of Solids and Structures*
- *530.414 Computer-Aided Design*
- *530.416 Advanced Mechanical Design*
- *580.450 Mechanics of Living Tissues*
- *530.730 Finite Element Methods*

Thermo-fluids and Thermo-fluid Systems

- 530.327 Introduction to Fluid Mechanics
- *530.328 Fluid Mechanics II*
- 530.334 Heat Transfer
- *530.425 Mechanics of Flight*
- *530.432 Jet and Rocket Propulsion*
- *530.435 Refrigeration and Heating, Ventilation and Air Conditioning*
- *530.467 Thermal Design Issues for Aerospace Systems*

Robotics

- 530.202 Dynamics
- 530.343 Design and Analysis of Dynamic Systems

- *530.414 Computer-Aided Design*
- *530.420 Robot Actuators and Sensors*
- *530.421 Mechatronics*
- *530.424 Dynamics of Robots and Spacecraft*

6.4.2 Aerospace Engineering Concentration

A student may specialize in Aerospace Engineering once a solid background in the fundamentals of Mechanical Engineering has been developed through the basic ME courses. This Concentration requires knowledge and background in several fields including advanced dynamics, flight mechanics, propulsion, aerospace materials and structures, signal processing, control systems, astrophysics and space systems. Students pursuing the Aerospace Engineering Concentration are required to take **at least five** of the following courses (which can be counted toward the Mechanical Engineering elective and Technical Elective requirements in the general Mechanical Engineering program):

- 530.328 Fluid Mechanics II
- 530.418 Aerospace Structures and Materials
- 530.424 Dynamics of Robots and Spacecraft
- 530.425 Mechanics of Flight
- 530.432 Jet and Rocket Propulsion
- 530.467 Thermal Design Issues for Aerospace Systems
- 530.470 Space Vehicle Dynamics and Control
- 535.442 Control Systems for ME Applications
- 615.444 Space Systems I
- 615.445 Space Systems II

Any five of the courses listed above are required. A sixth course amongst this list, though not required is highly recommended.

Other courses relevant to (but do not count toward) the Aerospace Concentration include:

- 171.118 Stars and the Universe
- 520.214 Signals and Systems
- 520.401 Basic Communications
- 525.445 Modern Navigation Systems

For information on these courses and the frequency of course offerings, please consult the Registrar's course listings at http://www.jhu.edu/%7Eregistr/schedule.html or the courses' department websites:

- 171.xxx Physics and Astronomy, http://pha.jhu.edu/acad/ugrad/ugradcourses.html
- 520.xxx Electrical and Computer Engineering, http://www.ece.jhu.edu/Undergraduate/ugrad_desc.shtml
- Engineering and Applied Science Program for Professionals (525.xxx, 535.xxx, 615.xxx): http://www.epp.jhu.edu/schedule

6.4.2.1 Internships in Aerospace Engineering

Students in the Aerospace Engineering Concentration are encouraged to participate in internships in organizations involved with aerospace engineering. Opportunities within the university include the Applied Physics Laboratory (Satellites), the Center for Astrophysical Sciences (CAS) and the Space Telescope Science Institute (Hubble Space Telescope). In addition, local companies and institutions, such as Northrop Grumman (which is formally affiliated with the Mechanical Engineering department as an Industrial Partner), NASA Goddard, Lockheed Martin, Orbital Sciences and other private corporations offer excellent opportunities for internships.

See Section 9 for further information on internships, scholarships, jobs, and careers.

6.4.3 Mechanical Engineering Biomechanics Concentration

A student may specialize in Biomechanics once a solid background in the fundamentals of Mechanical Engineering has been developed through the basic ME courses. Students pursuing the Biomechanics Concentration within Mechanical Engineering are required to take at least four of the following courses (which can be counted toward the Mechanical Engineering elective and technical elective requirements in the general Mechanical Engineering program):

- 530.410 Biomechanics of the Cell
- 530.440 Computational Biomechanics of Biological Macromolecules
- 540.440 MicroNanotechnology (Chemical and Biomolecular Engineering)
- 530.445 Introduction to Biomechanics
- 530.446 Experimental Biomechanics
- 530.448 Biomechanics II
- 580.455 Introduction to Orthopaedic Biomechanics
- 530/580.496 Micro/Nanoscience and Biotechnology
- 530/580.672 Biosensing and BioMEMS

There are other courses relevant to this biomechanics, but are not counted toward the requirements of the concentration. They include:

- 020.386 Macromolecular Machines
- 530/580.495 Microfabrication Lab
- 530/580.452 Cellular and Tissue Engineering Laboratory
- 580.221 Molecules and Cells (Prerequisites: 030.101 Introductory Chemistry and 030.104 Introductory Organic Chemistry)
- 580.42x Systems Bioengineering I w/lab: Cells and Membranes, Cardiovascular Systems (Prerequisite: 580.221 Molecules and Cells)
- 580.440 Cellular and Tissue Engineering
- 510.431 Biocompatibility of Materials

For information on these courses and the frequency of course offerings, please consult the Registrar's course listings at http://www.jhu.edu/%7Eregistr/schedule.html.

6.5 Sample Mechanical Engineering Programs

Sample *Mechanical Engineering* Program for students beginning with Calculus I

Total Credits for a B.S. Degree in Mechanical Engineering - 126

✧ - Students should take the Microeconomics or Macroeconomics course in either Freshman or Sophomore year.

* - Students are encouraged to take 110.302 Differential Equations (4) and 110.201 Linear Algebra (4) instead of the combined 550.291 L.A./D.E. course (4) if they can work the additional four credits into their schedule. An advantage of taking the courses separately is that 110.302 Differential Equations can be counted as a Technical Elective.

** - Students must take either
A) 530.461 Engineering Business and Management or
B) 660.105 Introduction to Business and Management and 660.341 Business Process and Quality Management.

▲ - 530.343 Design and Analysis of Dynamic Systems requires concurrent enrollment in or prior completion of 560.202 Dynamics with a minimum C- grade.

The Mechanical Engineering program requires a minimum of seven full courses (21 credits) in Humanities and Social Sciences, and requires one writing course, one course in economics, and two courses at the 300 level or above.

FRESHMAN YEAR			
110.108 Calculus I	4	110.109 Calculus II	4
530.101 Freshman Exper in ME I	2	530.102 Freshman Exper in ME II	2
530.103 Intro to Mechanics I	2	530.104 Intro to Mechanics II	2
530.105 MechE Freshman Lab I	1	530.106 MechE Freshman Lab II	1
510.101 Intro to Materials Chemistry	3	H/S (2) Elective: Economics ✧	3
H/S (1) Elective	3	H/S (3) Elective	3
Total credits	**15**	**Total credits**	**15**
SOPHOMORE YEAR			
110.202 Calculus III	4	550.291 L.A./D.E. *	4
530.201 Statics and Mechanics	3+1	560.202 Dynamics	3+1
530.231 Thermodynamics	3+1	530.215 Mechanics Based Design	3+1
171.102 General Physics II	4	530.241 Electronics Laboratory	3+1
173.112 General Physics II Lab	1		
Total credits	**17**	**Total credits**	**16**
JUNIOR YEAR			
530.327 Intro. Fluid Mechanics	3+1	530.334 Heat Transfer	3+1
530.352 Materials Selection	3+1	530.343 D. & A. Dynamic Systems ▲	3+1
H/S (4) Writing Elective	3	M. E. Elective (1)	3
Statistics elective	3	Technical Elective (1)	3
H/S (5) Elective	3		
Total credits	**17**	**Total credits**	**14**
SENIOR YEAR			
530.403 Eng. Design Project I	4	530.404 Eng. Design Project II	4
530.454 Manufacturing Engineering	3	M. E. Elective (2)	3
Eng. Business & Mgmt. options**	3	M. E. Elective (3)	3
Technical Elective (2)	3	Technical Elective (3)	3
xxx.3xx or .4xx H/S (6) Elective	3	xxx.3xx or .4xx H/S (7) Elective	3
Total credits	**16**	**Total credits**	**16**

Sample *Mechanical Engineering* Program for students beginning with Calculus II

Total Credits for a B.S. Degree in Mechanical Engineering – 126

✧ - Students should take the Microeconomics or Macroeconomics course in either the Freshman or Sophomore year.

* - Students are encouraged to take 110.302 Differential Equations (4) and 110.201 Linear Algebra (4) instead of the combined 550.291 L.A./D.E. course (4) if they can work the additional four credits into their schedule. An advantage of taking the courses separately is that 110.302 Differential Equations can be counted as a Technical Elective.

** - Students must take either
A) 530.461 Engineering Business and Management or
B) 660.105 Introduction to Business and Management and 660.341 Business Process and Quality Management.

▲ - 530.343 Design and Analysis of Dynamic Systems requires concurrent enrollment in or prior completion of 560.202 Dynamics with a minimum C- grade.

The Mechanical Engineering program requires a minimum of seven full courses (21 credits) in Humanities and Social Sciences, and requires one writing course, one course in economics, and two courses at the 300 level or above.

FRESHMAN YEAR			
110.109 Calculus II	4	110.202 Calculus III	4
530.101 Freshman Exper in ME I	2	530.102 Freshman Exper in ME II	2
530.103 Intro to Mechanics I	2	530.104 Intro to Mechanics II	2
530.105 MechE Freshman Lab I	1	530.106 MechE Freshman Lab II	1
510.101 Intro to Materials Chemistry	3	H/S (2) Elective: Economics ✧	3
H/S (1) Elective	3	H/S (3) Elective	3
Total credits	**15**	**Total credits**	**15**
SOPHOMORE YEAR			
530.201 Statics and Mechanics	3+1	550.291 L.A./D.E. *	4
530.231 Thermodynamics	3+1	560.202 Dynamics	3+1
H/S (4) Writing Elective	3	530.215 Mechanics Based Design	3+1
171.102 General Physics II	4	530.241 Electronics Laboratory	3+1
173.112 General Physics II Lab	1		
Total credits	**16**	**Total credits**	**16**
JUNIOR YEAR			
530.327 Intro. Fluid Mechanics	3+1	530.334 Heat Transfer	3+1
530.352 Materials Selection	3+1	530.343 D. & A. Dynamic Systems ▲	3+1
H/S (5) Elective	3	M. E. Elective (1)	3
xxx.3xx or .4xx H/S (6) Elective	3	Technical Elective (1)	3
Statistics elective	3	Mathematics elective	4
Total credits	**17**	**Total credits**	**18**
SENIOR YEAR			
530.403 Eng. Design Project I	4	530.404 Eng. Design Project II	4
530.454 Manufacturing Engineering	3	M. E. Elective (2)	3
Eng. Business and Mgmt. options**	3	M. E. Elective (3)	3
Technical Elective (2)	3	Technical Elective (3)	3
xxx.3xx or .4xx H/S (7) Elective	3		
Total credits	**16**	**Total credits**	**13**

Bachelor of Science Degree in the Engineering Mechanics major

7 ENGINEERING MECHANICS CURRICULUM

7.1 Our Mission

The mission of the B.S. in Engineering Mechanics degree program is to provide a rigorous educational experience that prepares a select group of students for leadership positions in the profession and a lifetime of learning. The faculty is committed to maintaining a modern and flexible curriculum which, building on a foundation of basic sciences and mathematics, develops a solid education in the mechanical engineering sciences. The aim of the Engineering Mechanics program is to build competence in the analysis, design and modeling of fluid and mechanical systems, to promote a broad knowledge of the contemporary social and economic context, and to develop the communication skills necessary to excel.

7.2 Introduction

The Engineering Mechanics program concentrates on the scientific fundamentals of the behavior of solids and fluids. The program is designed to be highly flexible while providing the student with a broad scientific and technical background in the mechanical sciences.

The curriculum is intended to enable graduates to explore fundamental questions in many fields of engineering. Emphasis is placed on the basic sciences (mathematics, physics, and chemistry) and on the analysis, modeling, and design aspects of solid and fluid engineering systems. Although specific core courses are required, the student is encouraged and guided by his or her advisor to select an individual program of study, within ABET guidelines, according to the student's particular goals. This program of study may range from a general study of mechanics or engineering science to more specialized programs in a variety of areas, such as robotics, fluid dynamics, environmental engineering, mechanics of solids, experimental mechanics, dynamical systems, mechanics of materials, or biomechanics.

This flexibility makes the program ideal for double-majors and for those wishing to tailor a strong foundation for graduate work in a wide range of disciplines. All mathematics elective and technical elective courses must be at the 300 level or higher, unless approved by your faculty advisor.

7.3 Engineering Mechanics Educational Objectives

The Educational Objectives for the B.S. in Engineering Mechanics Degree are designed to provide a high quality educational experience that is tailored to the needs and interests of the student. Each student's program of study is planned in consultation with his or her faculty advisor. Each student must follow a program of study that enables him or her to:

1. Understand and master the fundamentals of mathematics (through linear algebra and multivariate calculus), numerical methods, statistical analysis and physical sciences (physics and chemistry) necessary to acquire competence in the engineering mechanics disciplines.
2. Design, conduct, evaluate, and report experiments including analysis and statistical interpretation of data.
3. Identify, formulate and solve engineering problems.
4. Use basic concepts from the engineering mechanics, modern engineering tools (instrumentation and computer hardware and software), and related subjects to analyze, model, and design physical systems consisting of solid and fluid components under steady state and transient conditions.
5. Prepare for professional practice, including recognition of the need for life-long learning, effective communication, teamwork, and awareness of professional and ethical responsibilities.

7.3.1 Engineering Mechanics Biomechanics Concentration

Engineering Mechanics (EM) is a highly flexible program offered by the Department of Mechanical Engineering, which is ideal for students who want to specialize in any area of mechanics, including biomechanics. The essence of mechanics is the interplay between forces and motion.

In biology, mechanics is important at the macroscopic, cellular, and subcellular levels. At the macroscopic length scale biomechanics of both soft and hard tissues plays an important role in computer-integrated surgical systems and technologies (e.g., medical robotics). At the cellular level, issues such as cell motility and chemotaxis can be modeled as mechanical phenomena. At the subcellular level, conformational transitions in biological macromolecules can be modeled using molecular dynamics simulation (which is nothing more than computational Newtonian mechanics), statistical mechanics, or using coarse-grained techniques that rely on principles from the mechanics of materials. In addition, much of structural biology can be viewed

from the perspective of Kinematics (e.g., finding spatial relationships in data from the Protein Data Bank).

Each student who pursues the Biomechanics concentration within the EM major will, in consultation with his or her EM advisor, choose a set of six elective bio-oriented courses that best matches the student's interests. Many electives from other departments are acceptable. The electives for the EM major are structured as follows:

Engineering Science Electives (12 credits)

- One course in solid mechanics
- One course in fluid mechanics
- One course in mechanics of either solids or fluids
- One course in either materials or dynamics

Engineering Mechanics Electives (6 credits)

- Two additional courses in the same area of mechanics (i.e., fluids, solids, or dynamics)

Technical Electives (18 credits)

- Chosen from 300 level courses in engineering and the sciences in consultation with the student's faculty advisor.

Example bio-oriented courses which can be applied to the above three categories include (but are not limited to):

- 020.346 Immunobiology
- 020.363 Developmental Biology
- 020.380 Molecular Biology
- 250.353 Computational Biology
- 530.440 Computational Mechanics of Biological Macromolecules
- 530.445 Introductory Biomechanics
- 530.571 Statistical Mechanics in Biological Systems
- 530.495 Microfabrication Laboratory
- 540.409 Modeling Dynamics and Control for Chemical and Biological Systems
- 540.426 Introduction to Macromolecules
- 550.435 Bioinformatics and Statistical Genetics
- 580.455 Introduction to Orthopaedic Biomechanics
- 580.460 Physiological Fluid Mechanics
- 600.671 Special Topics of Bio-Nano Computing

This is not a complete list of possible courses that can be taken, and not all of these courses must be taken. Rather, students who wish to pursue the Biomechanics concentration will take at least six courses such as those listed above. These six should be concentrated either at the cellular/subcellular length scale or in macroscopic biomechanics.

Note that given the flexibility of the Engineering Mechanics program, it would be possible for students to satisfy both of these kinds of concentrations simultaneously if they apply all 12 of their elective courses towards this end.

7.4 Engineering Mechanics Course Requirements

The specific requirements for the engineering mechanics program are either "Mathematics with a focus on ***applications***" or "Mathematics with a focus on ***fundamentals***."

*Mathematics with a focus on **applications**: (23 credits; grades of D or D+ not accepted)*

- 110.108 Calculus I
- 110.109 Calculus II
- 110.202 Calculus III, (or 110.211 Honors Multivariable Calculus and Linear Algebra)
- 550.291 Linear Algebra/Differential Equations, (or 110.212 Honors Multivariable Calculus and Linear Algebra, or 110.201 Linear Algebra and 110.302 Differential Equations, the latter which can count as a technical elective)
- Another Mathematics Elective
- Statistics Elective at the 300 level or above (e.g. 560.435 Probability and Statistics in Civil Engineering or 550.310 Probability and Statistics)

*Mathematics with a focus on **fundamentals**: (23 credits; grades of D or D+ not accepted)*

- 110.108 Calculus I
- 110.109 Calculus II
- 110.211-212 Honors Multivariable Calculus and Linear Algebra
- 110.302 Differential Equations with Applications
- Statistics Elective at the 300 level or above (e.g. 560.435 Probability and Statistics in Civil Engineering or 550.310 Probability and Statistics)

Basic Science (16 credits; grades of D or D+ not accepted)

- A Physics course suite that covers mechanics:
  (a) 171.101 Physics I and 173.111 Physics Lab I
  or
  (b) 530.103/104 Introduction to Mechanics I/II and
  530.105/106 Mechanical Engineering Freshman Laboratory I/II

- 171.102 Physics II and 173.112 Physics Lab II
- 510.101 Introduction to Materials Chemistry (or 030.101 Chemistry I)
- Another basic science elective

Humanities: (18 credits)

- See Humanities, Section 5 (page 11)

Required Engineering Courses (minimum of 26 credits; grades of D or D+ not accepted)

- Introductory course in computing
- Introductory course for freshmen: students must choose **one** of the following
  (♣ =strongly recommended, ♠=recommended)∗:
  530.101/102 Freshman Experiences in Mechanical Engineering and
  530. 105/106 Mechanical Engineering Freshman Laboratory I/II♣
  510.101 Introduction to Materials Chemistry♠ (if not taken to complete the Basic Science requirement)
  520.137 Introduction to Electrical and Computer Engineering
  500.101 Introduction to Engineering♣
  570.108 Introduction to Environmental Engineering
- 530.201 Statics and Mechanics of Materials
- 560.202 Dynamics
- 530.231 Mechanical Engineering Thermodynamics
- 530.405 Mechanics of Solids and Structures
  or 530.215 Mechanics Based Design
- 530.327 Introduction to Fluid Mechanics

Capstone Design (8 credits)

- 530.403 and 530.404 Senior Design Project I and II

Engineering Science Electives (12 credits; grades of D or D+ not accepted)

- One course in each of these disciplines:
  - mechanics of solids
  - mechanics of fluids
- An additional course in mechanics of either solids or fluids
- One course in either materials or dynamics

Engineering Mechanics Electives (6 credits; grades of D or D+ not accepted)

- Two additional elective courses in the same area of engineering mechanics (solid mechanics, fluid mechanics or dynamics)

∗ Students double majoring in Biomedical Engineering may use 580.202 *Biomedical Engineering in the Real World* to provide one credit towards this requirement.

Technical Electives (minimum of 18 credits; grades of D or D+ not accepted)

A minimum of five (E), (Q), or (N) courses at or above the 300 level totaling at least 18 credits, chosen from any combination of courses in engineering, basic sciences, or mathematics chosen in consultation with the student's advisor are required.

Appropriate choices from the social sciences and philosophy may also be used to fulfill this requirement (for example, 180.305 *Game Theory*, or 150.420 *Logic*), if approved by the student's advisor.

Because of the importance of computer languages in modern technical society, students may take any computer language courses at any level.

Course Frequency

Listed in Section 4 of this manual are courses offered and the frequency of those offerings in the Mechanical Engineering department. It is important to plan all four years of your coursework as early as possible, keeping in mind the frequency of courses offered so you can enroll in all courses required for your degree requirements.

7.5 Engineering Mechanics Elective Courses

Fluid mechanics courses may be chosen from courses such as:

- 530.328 Fluid Mechanics II
- 530.425 Mechanics of Flight
- 570.301 Environmental Engineering I: Fundamentals
- 580.460 Physiological Fluid Mechanics
- 580.461 Biological Transport

Solid mechanics courses may be chosen from courses such as:

- 530.215 Mechanics Based Design*
- 530.405 Mechanics of Solids and Structures*
- 530.414 Computer-Aided Design
- 530.416 Advanced Mechanical Design
- 530.730 Finite Element Methods
- 560.320 Steel Structures
- 560.330 Foundation Design

* If not used to satisfy the Required Engineering Courses.

Dynamics courses may be chosen from courses such as:

- 530.343 Design and Analysis of Dynamic Systems
- 530.424 Dynamics of Robots and Spacecraft
- 530.420 Robot Sensors and Actuators
- 550.391 Dynamical Systems

Materials courses may be chosen from courses such as:

- 580.440 Cellular and Tissue Engineering
- 510.311 Structure of Materials
- 510.312 Thermodynamics of Materials
- 510.313 Mechanical Properties of Materials
- 510.314 Electronic Properties of Materials
- 510.315 Kinetics and Phase Transformations in Materials
- 510.426 Biomolecular Materials
- 510.431 Biocompatibility of Materials

A program of no fewer than 127 credits must be completed to be eligible for the bachelor's degree. All undergraduate students must follow a program approved by a faculty member in the department who is selected as the student's advisor.

7.6 Sample Engineering Mechanics Programs

Sample *Engineering Mechanics* Program for students beginning with Calculus I

Total Credits for a B.S. Degree in Engineering Mechanics – 127

✧ - Students should take the Microeconomics or the Macroeconomics course in either the Freshman or Sophomore year.

* - Students are encouraged to take 110.302 Differential Equations (4) and 110.201 Linear Algebra (4) instead of the combined 550.291 L.A./D.E. course (4) if the additional four credits can fit into the schedule. An advantage of taking the courses separately is that 110.302 Differential Equations can count as a Technical Elective.

★ - If 530.101/102 Freshman Experiences I/II are taken, they will be split between the Fall and Spring semesters.

The Engineering Mechanics program requires six full courses (18 credits) in Humanities and Social Sciences, and requires one writing course one course in economics, and two courses at the 300 level or above.

FRESHMAN YEAR			
110.108 Calculus I	4	110.109 Calculus II	4
510.101 Intro to Materials Chemistry	3	171.101 / 173.111 Physics I/Lab	5/6
Intro to Engineering Elective ★	3/4	*or* 530.104/106 & science elective	
H/S Elective (1)	3	Intro to Computing Elective	3
Basic Science Elective	3	H/S (2) Economics Elective ✧	3
Total credits	**16/17**	**Total credits**	**15/16**
SOPHOMORE YEAR			
110.202 or .211 Calculus options	4	550.291 LA/DE *	4
530.201 Statics and Mechanics	3+1	560.202 Dynamics	3+1
530.231 Mech. Eng. Thermodynamics	3+1	530.215 or .405 Mechanics course	4
171.102 General Physics II	4	Technical Elective (1)	4
173.112 General Physics II Lab.	1		
Total credits	**17**	**Total credits**	**16**
JUNIOR YEAR			
530.327 Intro. Fluid Mechanics	3+1	E. S. Elective (fluids)	3
E. S. Elective (solids)	3	E. S. Elective (solids or fluids)	3
Technical Elective (2)	3	Technical Elective (3)	3
Statistics Elective	3	Mathematics Elective	4
H/S Elective (3)	3	H/S Elective (4)	3
Total credits	**16**	**Total credits**	**16**
SENIOR YEAR			
530.403 Senior Design Project I	4	530.404 Senior Design Project II	4
E. M. Elective (solids, fluids, dynamics)	3	Technical Elective (4)	4
E. S. Elective (materials/dynamics)	3	Technical Elective (5)	4
E. M. Elective (solids, fluids, dynamics)	3	xxx.3xx or .4xx H/S Elective (6)	3
xxx.3xx or .4xx H/S Elective (5)	3		
Total credits	**16**	**Total credits**	**15**

Sample *Engineering Mechanics* Program for students beginning with Calculus II

Total Credits for a B.S. Degree in Engineering Mechanics – 127

✧ - Students should take the Microeconomics or the Macroeconomics course in either the Freshman or Sophomore year.

* - Students are encouraged to take 110.302 Differential Equations (4) and 110.201 Linear Algebra (4) instead of the combined 550.291 L.A./D.E. course (4) if the additional four credits can fit into the schedule. An advantage of taking the courses separately is that 110.302 Differential Equations can count as a Technical Elective

★ - If 530.101/102 Freshman Experiences I/II are taken, they will be split between the Fall and Spring semesters.

The Engineering Mechanics program requires six full courses (18 credits) in Humanities and Social Sciences, and requires one writing course one course in economics, and two courses at the 300 level or above.

FRESHMAN YEAR			
110.109 Calculus II	4	110.202 or .211 Calculus options	4
171.101 / 173.111 Physics I/Lab	5/3	171.102 / 173.112 Physics II/Lab	5
or 530.103/105		& 530.104/106 (*if* 103/105 taken)	0/3
510.101 Intro to Materials Chemistry	3	Intro to Computing Elective	3
Intro. to Eng. Elective ★	3/4	H/S (1) Economics Elective ✧	3
Total credits	**15/13**	**Total credits**	**15/18**
SOPHOMORE YEAR			
550.291 LA/DE *	4	Statistics Elective	3
530.201 Statics & Mechanics	3+1	560.202 Dynamics	3+1
530.231 Mech. Eng. Thermodynamics	3+1	530.215 or .405 Mechanics course	4
H/S Elective (2)	3	Technical Elective (1)	4
Total credits	**15**	**Total credits**	**15**
JUNIOR YEAR			
530.327 Intro. Fluid Mechanics	3+1	E. S. Elective (fluids)	3
E. S. Elective (solids)	3	E. S. Elective (solids/fluids)	3
Basic Science Elective	3	Technical Elective (3)	3
H/S Elective (3)	4	Mathematics Elective	4
Technical Elective (2)	3	H/S Elective (4)	3
Total credits	**17**	**Total credits**	**16**
SENIOR YEAR			
530.403 Eng. Design Project I	4	530.404 Eng. Design Project II	4
E. M. Elective (solids, fluids, dynamics)	3	Technical Elective (4)	4
E. S. Elective (materials/dynamics)	3	Technical Elective (5)	4
E. M. Elective (solids, fluids, dynamics)	3	xxx.3xx or .4xx H/S Elective (6)	3
xxx.3xx or .4xx H/S Elective (5)	3		
Total credits	**16**	**Total credits**	**15**

7.7 Engineering Mechanics - Degree Requirements Checkout Sheet

Student:		**Advisor:**				
Basic Science: 16 Credits.	**Credits**	**Semester**	**Grade or AP**	**Credits Earned**	**Credit Type**	**Towards Minor?**
171.101 General Physics 1 (or 530.103/104)	4					
173.111 General Physics Lab 1 (or 530.105/106)	1 / 2					
171.102 General Physics 2	4					
171.112 General Physics Lab 2	1					
510.101 Intro to Materials Chemistry	3					
___.___ Basic Science elective	3					
	16					
Mathematics: 23 Credits.	**Credits**	**Semester**	**Grade or AP**	**Credits Earned**	**Credit Type**	**Towards Minor?**
110.108 Calculus 1	4					
110.109 Calculus 2	4					
110.202 or 110.211 Calculus options	4					
550.291 or 110.212 or 110.201+.302 LA/DE	4					
___.___ Mathematics elective	4					
___.3__ Statistics elective	3					
	23					
H & S Electives*: 18 Credits, two at 300 level or above. One Economics, one Writing Intensive.	**Credits**	**Semester**	**Grade or AP**	**Credits Earned**	**Credit Type**	**Towards Minor?**
181.10_ _____economics	3					
(Writing)	3					
	3					
	3					
___.3__	3					
___.3__	3					
	18					
Required Engineering: 26 Credits.	**Credits**	**Semester**	**Grade**	**Credits Earned**	**Credit Type**	**Towards Minor?**
___.___ Intro to Engineering elective	3 or 4					
___.___ Intro to Computing elective	3					
530.201 Statics and Mechanics of Materials	4					
560.202 Dynamics	4					
530.231 Thermodynamics	4					
530.215 Mechanics Based Design or 530.405 Mechanics of Solids and Structures	3 or 4					
530.327 Introduction to Fluid Mechanics	4					
	26					
Engineering Science and Mechanics Electives: 18 Credits, all 300 level or above.	**Credits**	**Semester**	**Grade**	**Credits Earned**	**Credit Type**	**Towards Minor?**
___.___ ES Solids	3				E	
___.___ ES Fluids	3				E	
___.___ ES Dynamics/Materials	3				E	
___.___ ES Solids/Fluids	3				E	
___.___ EM Elective 1	3				E	
___.___ EM Elective 2	3				E	
	18					***(please turn over)***

Engineering Mechanics - Degree Requirements Checkout Sheet, p. 2

Technical Electives: 18 Credits ** any E, Q, or N courses, 300 level or above (One programming course can be <300 level).	Credits	Semester	Grade	Credits Earned	Credit Type	Towards Minor?
____.____						
____.____						
____.____						
____.____						
____.____						
____.____						
	18					

Others: Courses for a Minor Requirement, Etc.	Credits	Semester	Grade	Credits Earned	Credit Type	Towards Minor?
____.____						
____.____						
____.____						
____.____						
____.____						

Capstone Design Project: 8 Credits.	Credits	Semester	Grade	Credits Earned	Credit Type	Towards Minor?
530.403 Engineering Design Project 1	4				E	
530.404 Engineering Design Project 2	4				E	
	8					
Total: Should be 127 or above.	127					

** Note: In some cases there will not be five technical electives courses. A student might take all 3-credit courses in which case one would need six courses to earn 18 credits. Or if a student takes certain 400-level math classes or engineering graduate courses, these could be 4.5 credits for each class, in which case only four courses would give the 18 credits.

I certify that this information is correct and verified from University records.

Academic Program Coordinator _____ Date _____

I certify that the student has met the requirements for the Bachelor of Science degree in Mechanical Engineering.

Academic Advisor _____ Date _____

Chair, Department of Mechanical Engineering _____ Date _____

8 The Concurrent Five-Year Bachelor's / Master's Program

The Mechanical Engineering department offers a concurrent five-year Bachelor's / Master's (BS/MSE) program for Mechanical Engineering and Engineering Mechanics majors.

This is an excellent program for individuals who would like to earn their Master's Degrees quickly. The degree will generally increase a student's chances for higher quality employment than would a Bachelor's Degree.

8.1 Eligibility and Application Process

This program is available *only* to Mechanical Engineering or Engineering Mechanics majors at the Johns Hopkins University.

Applications to the BS/MSE program must be submitted during the junior year.

There are two application deadlines during the course of the year:

- January 5 – applicants will be notified of decisions by January 20
- June 15 – applicants will be notified of decisions by June 30

To apply for admission, the student must submit a college transcript and a formal graduate application. In addition, the student will need to present a statement of purpose that describes their career plans and rationale for advanced study at JHU. Three letters of recommendation are required for the application; two of the letters should be from Mechanical Engineering faculty.

These items can be delivered to the administrative office in Latrobe 223. Upon acceptance into the program, students will be asked to develop an outline of his or her proposed academic program with his or her advisor.

8.2 Requirements

The requirements for an M.S.E. in Mechanical Engineering are as follows:

Satisfactory completion of eight one-semester advanced courses approved by your advisor, as follows:

- No more than two courses may be chosen from the Part-Time Programs.
- No more than four courses may be at the intermediate/advanced undergraduate (xxx.300 – xxx.499) level.
- At least two courses should be in applied mathematics, numerical analysis, or computational methods. (This requirement can be waived in writing by your advisor, if sufficient prior preparation in these areas can be demonstrated).

- These courses *cannot* include Independent Study, Graduate Research, MSE Graduate Student Research, or Special Studies.

Plus either:

- Two additional one-semester graduate courses (xxx.600–xxx.799) approved by your advisor, only one of which can be 530.600 MSE Graduate Student Research, *or*
- An M.S.E. Thesis acceptable to your advisor and one other reader. According to the Graduate Board's Procedures for Administration of Approved Policies for the Award of Advanced Degrees, "Thesis readers are selected and appointed by the chair or appropriate faculty of the sponsoring department or committee. Any duly appointed member of a department or committee holding the rank of assistant professor or higher (excluding lecturers) is eligible for selection as a referee without prior approval. The Graduate Board Office must approve readers from outside the University, or from any non-Ph.D. sponsoring department, laboratory or institute within the University."

  Additional information is available at
  http://www.graduateboard.jhu.edu/procedures.htm.

8.3 Bachelor's/Master's Double Counting of Courses

Students either in a bachelor's/master's program or seeking a master's degree in the Whiting School, after having earned a Whiting School or Krieger School of Arts and Sciences bachelor's degree may double-count two courses (400-level or higher) to both programs with the permission of the master's faculty advisor.

Students may not double-count courses applied to a bachelor's degree earned at a different institution.

For coursework not applied to a bachelor's degree, any graduate-level coursework (as defined by the Whiting School graduate program) not applied to the undergraduate degree may be applied to the graduate degree, regardless of when that course was taken (i.e., before or after the undergraduate degree has been conferred) with the permission of the master's faculty advisor.

9 Internships, Scholarships, Jobs, and Careers

The Johns Hopkins University and the Whiting School of Engineering offer significant resources to help you find internships during the summer months, assistance in the process of searching for jobs before and after graduation, and help in determining

your career path and identifying opportunities. The department often receives information on opportunities and will forward them to you as they are received.

You are strongly encouraged to take advantage of these resources, as successful career and opportunity planning begins with you.

9.1 Internships, Research Positions, and Jobs

Information regarding research positions and how to find them, internships, study abroad, career planning, scholarships, grants, and fellowships are linked to the Whiting School of Engineering "Opportunities" site at http://engineering.jhu.edu/academicaffairs/ug_student_opps/.

9.2 Scholarships

Information on scholarships is available from the Office of Academic Advising at the website http://www.jhu.edu/~advising/scholarships/index.html.

9.3 Careers and Career Planning

The Career Center, located on the third floor of Garland Hall offers practical advice on determining a career path, resume preparation, interviewing, appropriate dress, and on-campus recruiting by companies. Their website is http://www.jhu.edu/~careers/.

You can set up a Career Center account to receive information on the latest career recruiting events and surf their site for the other services offered. The Career Center also welcomes you to make an appointment to visit with them or drop by at available drop-in hours to discuss your questions and get help with your career planning decisions.

10 Mechanical Engineering Undergraduate Student Council (MUSC)

The MUSC is a student-run organization that focuses on improvements to the department as it applies to the undergraduate students. It is comprised of nine members: two students from each of the four class levels and an appointed faculty member to act as liaison. Professor Jeff Wang, whose office is in Latrobe 108, is the faculty liaison and can be reached at x6-7086 or by e-mail at thwang@jhu.edu. The MUSC website is located at http://www.me.jhu.edu/musc.html.

10.1 MUSC Services and Activities

Projects include planning recreational activities for the department, suggesting improvements and additions to the curriculum, requesting updates in department

resources, and so on. Every year, the student representatives generally choose one major issue that they believe requires immediate attention. For example, recent years' issues led to the creation of a new Mechanical Engineering electronics course, a new intersession CAD course, and annual updates to this advising manual.

Any student who believes that any aspect of the department needs to be updated, changed, or improved is strongly encouraged to speak to the class representatives. Freshman appointments for class representatives are made in the Fall by the department's faculty advisors. To be considered for one of these appointments please speak to your advisor.

11 Student Groups

There are many opportunities to participate in student professional engineering clubs, team projects, and competitions. Among these organizations are events, along with their websites are:

- ASME, the American Society of Mechanical Engineers: http://www.jhu.edu/~asme/ and http://www.asme.org/
- AIAA, the American Institute of Aeronautics and Astronautics: http://www.aiaa.org
- Mini-Baja: http://www.jhu.edu/~asme/about.html
- National Society of Black Engineers: http://www.jhu.edu/homes/
- Pi Tau Sigma: http://www.me.jhu.edu/pts.html
- SWE, the Society of Women Engineers: http://www.jhu.edu/~swe/
- Tau Beta Pi: http://www.jhu.edu/~tbp/

Additional campus-wide student groups, clubs, athletics, and activities are listed at http://webapps.jhu.edu/jhuniverse/admissions/student_activities_organizations/

12 Laboratory Safety

Lab Safety is the responsibility of all who use, maintain, or visit the labs within the ME department. Those persons assigned to work within the labs are responsible for familiarizing themselves with the appropriate directives and instructions, prior to engaging in any work. The Johns Hopkins Health, Safety and Environment Department maintains a website to ensure updated information on policies, issues, and concerns are available to all.

Visit: http://www.hopkinsmedicine.org/hse/manuals.htm to view the directives concerning the following topics:

- Safety Responsibilities

- Safety Policies
- Environmental Monitoring
- Fire Safety
- Chemical Safety
- Laboratory Safety
- Radiation Safety

For each lab, a Principal Investigator (PI) is assigned. That person is responsible for the safe operation of the lab, the training of the persons on the equipment within the lab, and is a ready source to answer any questions on a specific lab with regards to its operation and all safety aspects. The PI's for each lab are listed on the entrance door to each lab. The Departmental Safety Officer can also be contacted at x6-6752 for any assistance required.

13 Latrobe Hall Machine Shop (Latrobe 3)

The Latrobe Hall Machine Shop is located in Latrobe Hall, Room 3. An informal orientation regarding shop safety, shop rules, and equipment operations is available.

This orientation is required to be allowed to work in the Machine Shop. Please contact the department Machinist, Mr. Rich Middlestadt at x6-7710 or rmiddle4@jhu.edu to arrange your orientation.

14 Mechanical Engineering Computer CAD Lab (Latrobe 113)

14.1 Services/Equipment

Located in Latrobe 113 are ten Dell/Pentium desktop computers. The machines are available for use seven days a week, 24 hours a day to any person with access to the space and login information. In order to gain access to the lab, a key to Latrobe 113 must be signed out from the Administrative office in Latrobe 223. To gain access to the computers, each user must be assigned login information to the server. This process normally takes less than a day for the server information to be updated. Contact lab administrator Mike Johnson at x6-6752 or rjohns94@jhu.edu to gain access to the computers.

14.2 Technical Information

The computers are primarily for use in conjunction with the Senior Design class, and as such, are oriented in software towards that goal. PRO-E, ANSYS, and FEMLAB are but a few of the programs available on the computers. Other software is available for installation on an as needed basis.

14.3 Procedures for Reserving Time/Space

The computers are available on a first come, first served basis, however, priority is given to those students involved with the Senior Design Class. So long as a computer is available, anyone with access may use them. Once all ten computers are in use, then persons not involved in the Senior Design Class will be asked to make room for those that are. Conflicts in this matter will be resolved by the lab administrator.

14.4 Safety Procedures

There are no special safety procedures involved with the use of the computers. All persons using the computers are asked to keep the lab administrator informed of any problems found with the computers. All persons using the lab are expected to clean up their area before leaving.

14.5 Contact Information

Keys: Katy Sanderson, Latrobe 223, x6-6782
Computer Access: Lab Administrator Mike Johnson, x6-6752

15 Laser Engraving and Cutting System

15.1 Services and Equipment

Located in Krieger Hall room K-16, the Universal Laser Systems model X2-660 Laser engraving and cutting system is available for use by all persons assigned within the ME department who have been properly trained in its operation. A detailed operations manual is available online at http://www.me.jhu.edu/LaserCutter.pdf.

15.2 Technical Information

The CO2 class 1 laser with Red Diode Pointer (class 111a) is contained with a 32″x18″ work area. The Windows 2000/XP operating system on the computer driver makes the system user friendly. The system is air assisted and the air assist must be applied as described in the orientation class in order for the system to operate properly. A point of use filter with acrylic window is available to check the system for traces of water prior to laser operation. MSE cards are available for materials used with the system. A log is kept to indicate usage of the laser system. A small hourly rate is charged to the appropriate PI budget code for each use of the system.

15.3 Procedures for reserving time and space

An orientation class of about three hours in duration is required before access is granted to the machine. Training is done on a scheduled basis on a need basis. Schedule training through the lab administrator at x6-6752. Once training is

complete, the equipment is available on a seven-day / 24-hour first come – first serve basis. Conflicts in scheduling will be resolved by the lab administrator. Each user is responsible for signing in on the log with an appropriate budget code, cleaning up the area after use, reporting any problems immediately to the lab administrator, and for safely operating the equipment. Failure in any of these areas will result in the loss of the privilege of using the equipment.

*15.4 **Contact Information***

Lab Administrator Mike Johnson, x6-6752
Lab Technician Bob Blakely, x6-8660

16 NOTICE OF NONDISCRIMINATORY POLICY

The Johns Hopkins University admits students of any race, color, sex, religion, national or ethnic origin, handicap or veteran status to all of the rights, privileges, programs, benefits and activities generally accorded or made available to students at the University. It does not discriminate on the basis of race, color, sex, religion, sexual orientation, national or ethnic origin, handicap or veteran status in any program or activity, including the administration of its educational policies, admission policies, scholarship and loan programs, and athletic and other University-administered programs. Accordingly, the University does not take into consideration personal factors that are irrelevant to the program involved.

Questions regarding access to programs following Title VI, Title IX, and Section 504 should be referred to the Affirmative Action Officer, 205 Garland Hall, 410-516-8075.

17 Directory of Faculty, Staff, and Other Contacts

17.1 Faculty

Name	Telephone	E-mail	Office
Professor Shiyi Chen	410-516-7754	syc@jhu.edu	Latrobe 124
Professor Greg Chirikjian	410-516-7127	gregc@jhu.edu	CSEB 116
Assistant Professor Noah Cowan	410-516-5301	ncowan@jhu.edu	CSEB 126
Professor and Chair Kevin Hemker	410-516-6451	hemker@jhu.edu	Latrobe 223
Professor Cila Herman	410-516-4467	cherman@jhu.edu	Latrobe 102
Professor Joe Katz	410-516-5470	katz@jhu.edu	Latrobe 219
Professor Omar Knio	410-516-7736	knio@jhu.edu	Latrobe 103
Professor Charles Meneveau	410-516-7802	meneveau@jhu.edu	Latrobe 127
Assistant Professor Vicky Nguyen	410-516-4538	vicky.nguyen@jhu.edu	Latrobe 125
Associate Professor Allison Okamura	410-516-7266	aokamura@jhu.edu	CSEB 125
Professor Andrea Prosperetti	410-516-8534	prosperetti@jhu.edu	Latrobe 119
Professor K. T. Ramesh	410-516-7735	ramesh@jhu.edu	Latrobe 122
Professor William Sharpe (Retired)	410-516-7101	sharpe@jhu.edu	Latrobe 126
Assistant Professor Lester Su	410-516-8537	lsu@jhu.edu	Latrobe 229
Associate Professor Sean Sun	410-516-4003	ssun@jhu.edu	Latrobe 105
Associate Professor Jeff Wang	410-516-7086	thwang@jhu.edu	Latrobe 108
Professor Louis Whitcomb	410-516-6724	llw@jhu.edu	CSEB 115

17.2 Administrative Staff

Name	Telephone	E-mail	Office
Mike Bernard, Senior Academic Program Coordinator	410-516-7154	mike.bernard@jhu.edu	Latrobe 223-G
Bob Blakely, Mechanical Computing Technician	410-516-8660	bob@poseidon.me.jhu.edu	Krieger B-2
Lorrie Dodd, Senior Budget Analyst	410-516-4175	ldodd@jhu.edu	Latrobe 223-F
Debbi Donhauser, Administrator	410-516-8542	debbi@jhu.edu	Latrobe 223-E
Margie Gier, Senior Budget Analyst	410-516-3834	mgier1@jhu.edu	Latrobe 223-F
Megan Gorhan, Accounting Specialist	410-516-7132	mgorhan1@jhu.edu	Latrobe 223-G
Mike Johnson, Laboratory Administrator	410-516-8660	rjohns94@jhu.edu	Latrobe 113
Rich Middlestadt, Machinist	410-516-7710	rmiddle4@jhu.edu	Latrobe 3
Laurel Murphy, Editorial Coordinator, JFE	410-516-7286	laurel.murphy@jhu.edu	Latrobe 123
Katy Sanderson, Administrative Coordinator	410-516-6782	ksanderson@jhu.edu	Latrobe 223-D
Deana Santoni, Administrative Coordinator	410-516-6451	dsantoni@jhu.edu	Latrobe 223-B
Libby Starnes, Administrative Assistant	410-516-7257	lstarnes@jhu.edu	Latrobe 122
Kelly Ware, Publications Assistant	410-516-0463	kware1@jhu.edu	Latrobe 128

17.3 Other Contacts

Department	Telephone	Office
Applied Mathematics and Statistics	410-516-7459	Whitehead 304
Applied Physics Laboratory (http://www.jhuapl.edu/)	443-778-5000	Laurel, Maryland
Biomedical Engineering	410-516-8120	Clark 316
Civil Engineering	410-516-7473	Latrobe 207-A
Computer Science	410-516-6134	NEB 224
Electrical and Computer Engineering	410-516-5566	Barton 105
Geographical and Environmental Engineering	410-516-7092	Ames 323
Machine Shop, Latrobe Hall	410-516-7710	Latrobe 3
Materials Science and Engineering	410-516-5293	Maryland 102
Physics	410-516-7346	Bloomberg 366
Whiting School of Engineering Academic Affairs	410-516-7395	NEB 126
Office of the Registrar	410-516-8600	Garland 75

17.4 Centers

A complete list of centers is at http://engineering.jhu.edu/centers/.

Center	Telephone	Office
CAMCS – Center for Advanced Metals and Ceramic Systems	410-516-7735	Latrobe 122
CEAFM – Center for Environmental and Applied Fluid Mechanics	410-516-0463	Latrobe 128
CIS – Center for Imaging Science	410-516-3826	Clark 301
CLSP – Center for Language and Speech Processing	410-516-4237	Barton 320
CMFA – Center for Multifunctional Appliqué	410-516-8706	Stieff G010
CPIA – Chemical Propulsion Information Agency	410-992-7300	Columbia, Maryland
Information Security Institute	410-516-4250	Wyman 407