

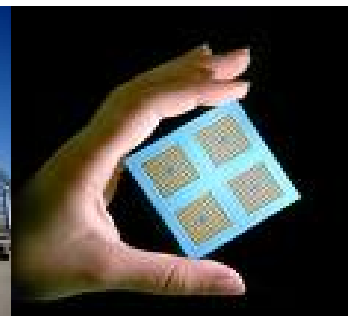


Undergraduate Handbook



2009-2010

Mechanical and Aerospace Engineering *at Princeton University*



DEPARTMENT OF
MECHANICAL AND AEROSPACE ENGINEERING
UNDERGRADUATE PROGRAMS
HANDBOOK

Spring 2009 Edition

This booklet supersedes all others and applies to the Classes of 2012 and beyond.

This booklet describes the undergraduate academic program of the MAE Department in more detail than that available in the Undergraduate Announcement. It provides information both to prospective concentrators and to undergraduates already enrolled in the Department. For specific course descriptions see the Undergraduate Announcement or the Graduate School Announcement as appropriate.

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THE DEPARTMENT OF MECHANICAL AND AEROSPACE ENGINEERING

I. OVERVIEW

The Department of Mechanical and Aerospace Engineering is concerned with the engineering science and technologies associated with ground, air, water, and space transportation, including control and dynamics of vehicles and systems, energy conversion and use, environmental effects, fluids, materials, and applied physics. To accommodate this breadth of interest, the Department offers two programs of study: **Mechanical Engineering** and **Aerospace Engineering**. Either program may be completed individually or, through careful planning and selection of technical electives, the requirements of both the **Mechanical and Aerospace Engineering programs** may be satisfied simultaneously. (See the Department Representative for further information). Departmental students may also participate in the **SEAS Engineering Physics Program**, or other SEAS certificate programs such as **Engineering and Management Systems, Engineering Biology, Applied and Computational Mathematics, Robotics and Intelligent Systems, Materials Science in Engineering, Sustainable Energy, and the Program in Applications of Computing**.

Both the Mechanical and Aerospace Engineering programs draw on courses in the underlying fundamental sciences and mathematics during the first year and introductory engineering science courses during the second year. Students are shown the creative application of knowledge for the solution of technical problems. Various aspects of engineering design, the process of devising a system to meet a need, are introduced to the student through the laboratories in the second year and continue through the upperclass years. Normally, during the third year all students take a two semester design sequence and additional engineering science courses, performing analyses and studying applications in the areas of energy, power systems, structures, and the dynamics of machines and their control. The courses in design offered during the third year, combined with further depth in engineering science, enable students to undertake realistic design projects during their senior year. The programs are designed to prepare the graduate for an engineering career and the ability to grow professionally.

The Department recognizes that students have a wide variety of career objectives. Some may intend to enter industry directly in an engineering capacity, or to continue studies in the graduate school in engineering or applied science. Others may wish to take an engineering program in preparation for careers in business, law, or medicine. Sufficient flexibility is provided within the undergraduate program in the Department to permit meeting these and other varied objectives while acquiring a foundation in the engineering disciplines and associated problem solving skills.

The undergraduate programs in Aerospace and Mechanical Engineering are accredited by the Engineering Accreditation Commission of ABET, Inc. (111 Market Place, Suite 1050, Baltimore, MD 21202, Telephone: (410) 347-7000, Fax: (410) 625-2238, Web: <http://www.abet.org>).

All Departmental students engage in independent projects, some as early as the sophomore year but, most commonly, during the senior year. Independent work is an important complement to formal course work, and affords students the opportunity to collaborate closely with faculty and graduate students while working on real engineering problems. Support for student projects is available through the **John Marshall II Memorial Prize**, awarded annually to one or more seniors to support their experimental projects, with preference given to projects in aeronautics. Additionally, the **Morgan W. McKinzie '93 Senior Thesis Fund** provides financial support for independent work or senior thesis with preference given to projects in aircraft design and propulsion. The selection is based on proposals submitted by students in the fall of the senior year for both awards. Excellence in independent work is recognized by the Department through the **Donald Janssen Dike Award for Excellence in Undergraduate Research**, and outstanding senior thesis is recognized through the **Morgan W. McKinzie '93 Senior Thesis Prize**, both prizes are awarded on Class Day.

Departmental requirements are described in Section II. Sample curricula are presented in Section III. Titles of recent independent projects undertaken by undergraduates in the Department appear in Section IV. Plans after graduation for the last five classes are summarized in Section V and a brief description of the faculty research interests is found in Section VI. Section VII lists "Who to See" among the faculty and students to obtain additional information.

II. REQUIREMENTS (See Individual Forms, Appendix I.)

Some of the requirements may be satisfied by advanced placement or by equivalent courses. No courses taken to satisfy these requirements may be taken on a pass/fail or audit basis. Students entering the Department are expected to meet the requirements for the freshman year established by the School of Engineering and Applied Science.

A. Introductory Courses (Sophomore Year)

The required introductory courses that are prerequisites for the Departmental upperclass courses, **normally completed by the end of the sophomore year**, are:

1. Mechanical and Aerospace Engineering
 - MAE 206 Introduction to Engineering Dynamics
 - MAE 221 Thermodynamics
 - MAE 222 Mechanics of Fluids
 - MAE 223 Modern Solid Mechanics¹
 - MAE 224 Integrated Laboratory

The Sophomore Laboratory provides experiments associated with Thermodynamics (MAE 221), Mechanics of Fluids (MAE 222) and Electronics.

2. Mathematics
 - MAT 201/202 Multivariable Calculus and Linear Algebra
 - or-**
 - MAT 203/204 Advanced Multivariable Calculus and Linear Algebra
3. Computer Programming (School of Engineering & Applied Science requirement)
 - All BSE students must take COS 126 to satisfy the BSE computing requirement.

¹ CEE205 is an acceptable substitute for MAE 223 for those students interested in structures

B. Upperclass Courses (Junior and Senior Year).

To graduate, **all** Departmental students must satisfactorily complete the following requirements:

1. Applications of Mathematics

Two courses are required for both Mechanical and Aerospace Engineers.

a. One of these must be a course in differential equations:

MAE 305 (MAT 301) Mathematics in Engineering I

b. The other course must be a course in matrix analysis and finite element methods:

CEE 361 (MAE 325) Structural Analysis and Introduction to Finite Element Methods

In addition, all Mechanical Engineers must take a mathematics elective usually selected from the following list:

- MAE 306 (MAT 302) Mathematics in Engineering II (strongly recommended for those planning graduate work in engineering or applied science)
- ORF 245 Fundamentals of Engineering Statistics
- ORF 307 Optimization
- ORF 309 Probability and Stochastic Systems (MAT 309/ELE 380)
- COS 309 Fundamentals of Scientific Computing
- COS 340 Reasoning About Computation
- MAT 304 Introduction to Partial Differential Equations
- MAT 305 Mathematical Programming
- MAT 306 Introduction to Discrete Mathematics
- MAT 317 Complex Analysis with Applications

(Alternatives not on this list must be approved by the Departmental Representative in advance).

C. Departmental Courses

A minimum of eight upper level Departmental courses are required. These eight courses must be distributed in the following manner:

1. Engineering Science Courses - Five courses are required from Sections (a) (b) and (c). Core requirements for both programs are footnoted.

(a) Dynamics and Control

MAE 331 Aircraft Flight Dynamics¹

MAE 341 Space Flight¹

MAE 344 Introduction to Bioengineering and Medical Devices

MAE 345 Robotics and Intelligent Systems

MAE 433 Automatic Control Systems²

MAE 434 Modern Control

(b) Fluid Mechanics/Thermal Sciences

MAE 328 Energy for a Greenhouse-Constrained World

MAE 335 Fluid Dynamics³

MAE 336 Viscous Flows or MAE 552 Viscous Flows and
Boundary Layers

MAE 423 Heat Transfer³

MAE 426 Rocket and Air-Breathing Propulsion Technology⁴

MAE 427 Mobile Power Plants⁴

(c) Materials/Structures

MAE 324 Structure and Properties of Materials⁵

MAE 325 Structural Analysis and Intro to Finite Element Methods⁶

MAE 334 Materials Selection and Design⁵

MSE 301 Materials Science and Engineering⁵

CEE 362 Structural Dynamics and Earthquake Engineering

¹ MAE 331 or 341 required for Aerospace Engineers.

² MAE 433 required for Mechanical and Aerospace Engineers.

³ MAE 335 or 423 required for Mechanical Engineers. MAE 335 required for Aerospace Engineers.

⁴ MAE 427 or 426 required for Aerospace Engineers.

⁵ MAE 324 or 334 or MSE 301 required for Mechanical and Aerospace Engineers.

⁶ MAE 325 required for Mechanical and Aerospace Engineers.

2. **Engineering Design Courses** - Three courses are required.

MAE 321 Engineering Design¹

MAE 322 Mechanical Design²

MAE 332 Aircraft Design³

MAE 342 Space System Design³

MAE 412 Microprocessors for Measurement and Control²

*Note: Independent Work, Senior Project or Senior Thesis **with design** may satisfy one of the three design requirements. These courses are: MAE 339D, MAE 340D, MAE 440D and MAE 442D*

3. **Independent Work** - All students are required to participate in a self-directed research or engineering project. At least one semester of independent work as applied science research or an engineering project is required. This may be satisfied by a semester of independent work (339 or 340). If approved by the Departmental representative, an independent work project may satisfy a portion of the design requirement (339D, 340D). 339 and 339D are offered in the fall, and 340 and 340D are offered in the spring. A year-long senior project (440) or senior thesis (442) or senior project with design (440D) or senior thesis with design (442D) also meets this requirement. **Students are strongly encouraged to select the year-long project or thesis option.** Senior projects are intended for teams or groups while senior thesis is intended for individuals. For senior project or thesis, work begins in the fall but enrollment is only in spring term when a double grade is awarded. *Please note: If a student has selected to participate in a year-long project or thesis and is enrolled in only three courses during the fall semester, it is required that they will enroll in Senior Project or Thesis during the spring semester. For these students, it will NOT be possible to drop-down to a one-semester course of Independent Work without incurring a failure for Independent Work in the fall term.*

MAE 339/340 Independent Work (Fall/Spring)

MAE 339D/340D Independent Work with Design (Fall/Spring)⁴

MAE 440 Senior Project (Spring)⁵

MAE 440D Senior Project with Design (Spring)^{4,5}

MAE 442 Senior Thesis (Spring)⁵

MAE 442D Senior Thesis with Design (Spring)^{4,5}

None of the Department requirements can be taken on a pass/fail or audit basis. All requests for substitution, other than those listed under the Engineering Physics Program (Section E), must be approved by the Departmental Representative in advance.

¹ Required for Mechanical Engineers and Aerospace Engineers.

² MAE 322 or MAE 412 required for Mechanical Engineers.

³ MAE 332 or MAE 342 required for Aerospace Engineers.

⁴ May also satisfy one Engineering Design requirement.

⁵ Year-long project with enrollment in spring semester only

4. The Engineering School requirements in the **humanities and social sciences** must also be met (a minimum of seven courses covering four distinct areas from the six areas offered). See the Undergraduate Announcement for full description and distribution areas. In addition a one semester writing course is required. This course is typically completed in the freshman year.

D. General Information

Students are encouraged to elect more than the one required semester of independent work (with or without design) as part of their plan of study, and to participate in the extensive research programs of the Department.

Additional technical courses (which may include both undergraduate and graduate courses) can be used to pursue a specialty within the Department in greater depth.

It is also possible to participate in a variety of interdepartmental programs or expand one's studies in the humanities or social sciences beyond the seven courses required by the School of Engineering and Applied Science.

Professional Ethics

Professional ethics is an important topic for all engineers. Honor code, adherence to University Regulations and adherence to rules in individual courses and laboratories are all part of our student's exposure to professional ethical matters. In addition, aspects of engineering ethics are considered in engineering courses through examples and case studies. Given that mechanical and aerospace engineering works have impact on society, the concepts of economical and safe design are foundations of ethical conduct of practitioners in the field. Students are urged to understand ethical guidelines further in the mechanical and aerospace fields as defined by the engineering societies:

ASME (http://www.asme.org/Governance/Society_Policies.cfm)
Scroll to Policy 15.7 Ethics (available in PDF or Word format)

AIAA (<http://www.aiaa.org/content.cfm?pageid=198>)
Code of Ethics

Honors

The determination of honors upon graduation is made by the faculty of the Department based primarily on the grade average achieved during junior and senior year in both required and elective technical courses. The student's overall academic record and performance in independent work is also considered.

The completion of all the Departmental requirements, together with an average of 2.0* or better in the Departmental courses will lead to a Departmental recommendation that the student graduate. The decision to deny a recommendation for graduation, to any student failing to meet the criteria above, will be made by the Departmental faculty on the basis of a full review of the student's record.

*The grade average will be computed on the basis of equal weighing of the grades in the Departmental courses within the following numerical equivalents: A+ = 4.0, A = 4.0, A- = 3.7, B+ = 3.3, B = 3.0, B- = 2.7, C+ = 2.3, C = 2.0, C- = 1.7, D = 1.0, F = 0.0

III. RECOMMENDED SAMPLE CURRICULA

Each student's program is planned individually in consultation with their advisor or the Departmental Representative. Sample curricula for the major options within the Department are presented later in this booklet. These sample curricula should be used as recommendations only. Individual variations are possible (and encouraged) as long as the Departmental requirements are satisfied.

A. Course Descriptions

Descriptions of the courses offered appear in the Undergraduate Announcement or the Graduate School Announcement, as appropriate. Additional information can be obtained by contacting the instructor in charge. The list below summarizes information on prerequisites and other background for each of the **undergraduate upper level courses** in the Department. The following information is intended to assist the student in the selection of courses in the upper class years.

- 305 Mathematics in Engineering I (Fall/Spring) (Ordinary Differential Equations) - requires MAT 201 and MAT 202 as prerequisites with the possibility that MAT 202 may be taken concurrently. This course should be taken as early as possible in the student's program. **Required for all Mechanical and Aerospace Engineering majors.**
- 306 Mathematics in Engineering II (Spring) (Partial Differential Equations and Complex Variables) - requires MAE 305 as an absolute prerequisite. This course satisfies the second mathematics requirement in the department and in the Engineering Physics Program and is *recommended for those planning to go to graduate school in engineering or applied science.*
- 321/322 Engineering Design/Mechanical Design (Fall/Spring) - Requires only the sophomore curriculum. **MAE 321 is required for all Mechanical and Aerospace Engineering students. Either MAE 322 or MAE 412 is required for all Mechanical Engineering students.**
- 324 Structure and Properties of Materials (Fall). SEAS freshman requirements of chemistry, physics, and math are prerequisites. **Either MAE 324, MAE 334 or MSE 301 is required for all Mechanical and Aerospace Engineering majors.**
- 325
[CEE 361] Structural Analysis and Intro to Finite Element Methods (Fall) – requires only sophomore Modern Solid Mechanics (MAE 223). **Required of all Mechanical and Aerospace Engineering students.**
- 328 Energy for a Greenhouse-Constrained World (Spring) – Recommended for students interested in energy production and its influence on the environment. Requires MAE 221/222 as prerequisites.

- 331/332 Aircraft Flight Dynamics/Aircraft Design (Fall/Spring) - Requires the sophomore curriculum. Simultaneous enrollment in Fluid Dynamics (MAE 335) is desirable, although it is not required. **Required for Aerospace Engineering majors. Optionally, MAE 341/342 may be taken to satisfy this requirement. (MAE 331/332 and MAE 341/342 are offered in alternate years.)**
- 334 Materials Selection and Design [Fall] – Requires Modern Solid Mechanics [MAE 223]. **Either MAE 324, MAE 334 or MSE 301 is required for all Mechanical and Aerospace Engineering majors.**
- 335 Fluid Dynamics (Fall) - requires only the sophomore curriculum as a prerequisite and Mathematics in Engineering I (MAE 305) as a co-requisite. **Required for Aerospace Engineering majors. MAE 335 or MAE 423 is required for all Mechanical Engineering students.**
- 336 Viscous Flows (Spring) - requires only the sophomore curriculum and Mathematics in Engineering I (MAE 305) as a prerequisite.
- 339/340 Independent work is intended for juniors or seniors doing only a one term project. Students develop a topic of their own or select from a list of topics prepared by the faculty. They develop a work plan and select an adviser and a second reader. Registration for the course is accomplished at normal course selection time, while topic and advisor can be selected at any time prior to the end of the first two weeks of the appropriate semester.
- 339D/340D Independent work with design is intended for juniors or seniors doing only a one term project. Similar to 339/340, with the principal difference that the project must incorporate aspects and principles of design in a system, product, vehicle, device, apparatus, or other design element. Registration for the course is accomplished at normal course selection time, while topic and advisor can be selected at any time prior to the end of the first two weeks of the appropriate semester. **Appropriateness of the design aspects of the project is subject to approval by the Departmental Representative.**
- 341/342 Space Flight/Space System Design (Fall/Spring) – MAE 341 requires Calculus and MAE 305 or permission of instructor. MAE 342 requires MAE 305 and MAE 341 is recommended. **Required for Aerospace Engineering majors. Optionally, MAE 331/332 may be taken to satisfy this requirement. (MAE 331/332 and MAE 341/342 are offered in alternate years.)**
- 344 Introduction to Bioengineering and Medical Devices [Spring] – MAE 344 requires MAT 103, MAT 104, PHY 103 and PHY 104.
- 345 Robotics and Intelligent Systems [Fall] – MAE 345 is an optional core requirement of the Robotics and Intelligent Systems Certificate Program. This courses requires MAT 202 or MAT 204 and COS 111, or COS 126, or ORF 201.

- 412 Microprocessors for Measurement and Control (Fall) - requires satisfactory completion of the departmental electronics requirement. Often taken in junior year by those with potential interest in senior independent work in this area. **Either MAE 322 or MAE 412 is required for all Mechanical Engineering students.**
- 423 Heat Transfer (Fall) - requires the standard sophomore curriculum and MAE 305 as a co-requisite. **Either MAE 423 or MAE 335 is required for all Mechanical Engineering students.**
- 425 Introduction to Physical Oceanography (Fall) - requires MAT 202
[GEO 425] as a prerequisite.
- 426 Rocket and Air-Breathing Propulsion Technology (Spring) – Prerequisites: MAE 221 and MAE 222. **Either MAE 426 or MAE 427 is required for all Aerospace Engineering students.**
- 427 Fossil Fuel Energy Conversion: Mobile Power Plants (Spring) - requires only the sophomore prerequisites. **Either MAE 427 or MAE 426 is required for all Aerospace Engineering students.**
- 433 Automatic Control Systems (Spring) - Mathematics in Engineering I (MAE 305) in addition to sophomore curriculum is a prerequisite. **Required of all Mechanical and Aerospace Engineering students.**
- 434 Modern Control (Spring) - A useful complement to MAE 433, treating more advanced topics in control system design. MAE 433 is a prerequisite.
- 440 Senior Project (Spring) - The senior project is a year long independent study intended for students who choose to work in teams of two or more. Work begins in the fall, but enrollment is only in spring term when a double grade is awarded. Groups develop their own topic or select a topic from a list of topics prepared by the faculty. Groups develop a work plan and select an advisor and a second reader for their work.
- 440D Senior Project with Design (Spring) - Similar to 440 with the principal difference that the team or group project must incorporate aspects and principals of design, whether for a system, product, vehicle, device, software, or apparatus. The year-long senior project with design may be used satisfy a portion of the department's design requirement. **Appropriateness of the design aspects of the project is subject to approval by the Departmental Representative.**
- 442 Senior Thesis (Spring) - The senior thesis is an independent study for individual students. Work begins in the fall, but enrollment is only in spring term when a double grade is awarded. Students develop their own topic or select a topic from a list of topics prepared by the faculty. Students develop a work plan and select an advisor and a second reader for their work.

- 442D Senior Thesis with Design (Spring) – Similar to 442 with the principal difference that the thesis must incorporate aspects and principals of design, whether for a system, product, vehicle, device, software, or apparatus. The year-long senior thesis with design may be used to satisfy a portion of the department's design requirement. **Appropriateness of the design aspects of the project is subject to approval by the Departmental Representative.**
- 445 Entrepreneurial Engineering (Spring) – Open to Engineering and Liberal Arts Majors. Course will not serve as a Technical Elective.

B. Standard Sophomore Curriculum

The recommended sophomore curriculum is common to all Departmental students, except Engineering Physics students who are allowed certain substitutions (see Section E).

(T.E. = Technical Elective)

(N.T.E. = Non Technical Elective)

SOPHOMORE YEAR

FALL*

- Mathematics
- MAE 223 Modern Solids Mechanics
- MAE 221 Thermodynamics
- N.T.E. or Materials
- N.T.E.

SPRING

- Mathematics
- MAE 206 Introduction to Engineering Dynamics
- MAE 222 Mechanics of Fluids
- MAE 224 Laboratory
- N.T.E.

The School of Engineering and Applied Science computer programming requirement must be satisfied by the end of the Sophomore Year.

Some sample programs are presented to indicate the major options within the Department

*Note that the course load for this recommended curriculum is heavier in the fall than in the spring. MAE 221 has a laboratory whereas MAE 222 does not. Instead, the laboratory in the spring is listed as a separate course, MAE 224. The time commitment for MAE 224 is about one-half of a regular course. Therefore, the course load in the fall is about 5 ½ courses whereas the course load in the spring is about 4 ½ courses. The course grade in MAE 224 is determined from the laboratory course work from both the fall and spring terms.

C. Mechanical Engineering

Students desiring an emphasis on design and analysis of the dynamics and control of engineering devices can follow the **Dynamics Systems and Design Option**. Students desiring an emphasis on power generation and conversion can elect to follow the **Energy Sciences Option**. It is however not necessary to rigidly follow either of these options as long as the requirements in Section II are satisfied.

1. Dynamic Systems and Design (Typical program)

JUNIOR YEAR

FALL

- MAE 325 Structural Analysis & Intro to Finite Element Methods
- MAE 321 Engineering Design
- MAE 324 Structure and Properties of Materials or MAE 423 Heat Transfer
- N.T.E.
- N.T.E.

SPRING

- Mathematics Elective
- T.E. or MSE 301 Materials Science and Engineering
- MAE 433 Automatic Control Systems
- T.E./N.T.E.
- T.E./N.T.E.

SENIOR YEAR

FALL

- Senior Thesis with or without Design
- MAE 345 Robotics and Intelligent Systems*
- MAE 412 Microprocessors for Measurement and Control
- N.T.E.

SPRING

- Senior Thesis with or without Design
- MAE 322 Mechanical Design
- T.E./N.T.E.
- N.T.E.

* Normally MAE 345 is offered in alternate years – plan accordingly.

SUGGESTED TECHNICAL ELECTIVES

FALL

- MAE 331 Aircraft Flight Dynamics
- MAE 341 Space Flight
- MAE 335 Fluid Dynamics
- MAE 345 Robotics and Intelligent Systems
- MAE 412 Microprocessors for Measurement & Control
- CEE 361 Structural Analysis and Introduction to Finite-Element Methods

SPRING

- MAE 328 Energy for a Greenhouse-Constrained World
- MAE 332 Aircraft Design
- MAE 342 Space System Design
- MAE 344 Introduction to Bioengineering and Medical Devices
- MAE 427 Mobile Power Plants
- MAE 434 Modern Control
- CEE 461 Design of Large Scale Structures
- MAE 546 Optimal Control and Estimation

2. Energy Sciences (Typical Program)

JUNIOR YEAR

FALL

- MAE 325 Structural Analysis & Intro to Finite Element Methods
- MAE 321 Engineering Design
- MAE 335 Fluid Dynamics
- T.E./N.T.E.
- N.T.E.

SPRING

- Mathematics Elective
- MAE 322 Mechanical Design
- MSE 301 Materials Science and Engineering
- MAE 427 Mobile Power Plants
- N.T.E.

SENIOR YEAR

FALL

- MAE 335 Fluid Dynamics
- MAE 339 Independent Work with Design
- MAE 423 Heat Transfer
- N.T.E.
- N.T.E.

SPRING

- MAE 328 Energy for a Greenhouse-Constrained World
- MAE 433 Automatic Control Systems
- T.E./N.T.E.
- N.T.E.

SUGGESTED TECHNICAL ELECTIVES

FALL

MAE 527 Physics of Gases I
MAE 331 Aircraft Flight Dynamics
MAE 341 Space Flight
MAE 412 Microprocessors for Measurement and Control

SPRING

MAE 426 Rockets and Air-Breathing Propulsion Technology
MAE 531 Combustion
MAE 332 Aircraft Design
MAE 342 Space System Design

SUGGESTED NON-TECHNICAL ELECTIVES

FALL

ECO 100 Introduction to Microeconomics

SPRING

ECO 101 Introduction to Macroeconomics

3. General Mechanical Engineering

Students not wishing to specialize in either one of the areas above (1 or 2) can select any mix of the two sample curricula, provided they meet the requirements stated in Section II.

D. Aerospace Engineering

Students wishing to concentrate their study on vehicles in air and space follow the curriculum in Aerospace Engineering (see Section II for required courses). A typical program is listed below:

JUNIOR YEAR

FALL

- MAE 325 Structural Analysis and Intro to Finite Element Methods
- MAE 3X1 Flight Dynamics*
- MAE 321 Engineering Design
- N.T.E.
- N.T.E.

*(Note: Either MAE 331 Aircraft Flight Dynamics -or- MAE 341 Space Flight

SPRING

- MAE 3X2 Design*
- MSE 301 Materials Science and Engineering
- MAE 433 Automatic Control Systems
- N.T.E.
- N.T.E.

*(Note: Either MAE 332 Aircraft Design -or- MAE 342 Space System Design

SENIOR YEAR

FALL

- Senior Independent Work with Design
- MAE 335 Fluid Dynamics
- MAE 412 Microprocessors for Measurement and Control
- T.E./N.T.E.
- N.T.E.

SPRING

- MAE 434 (or see list of technical electives below)
- MAE 427 Mobile Power Plants or MAE 426 Rocket and Air-Breathing Propulsion Technology
- N.T.E.
- Continuation of Independent Work or Senior Thesis

SUGGESTED TECHNICAL ELECTIVES

FALL

- MSE 302 Laboratory Techniques in Materials Science and Engineering
- ELE 201 Intro to Electrical Signals and Systems
- ELE 203 Electronic Circuits
- COS 217 Introduction to Programming Systems
- MAE 412 Microprocessors for Measurement & Control

SPRING

- MAE 434 Modern Control
- MAE 546 Optimal Control and Estimation

E. Engineering Physics Program

Students with a strong interest in applied science and plans for graduate study may wish to participate in the Engineering Physics Program. Students should contact the Engineering Physics Program Director when they join the Department. The program requirements include six Physics courses beyond the freshman level (the sequence Physics 208, 305 is required), and two upper class mathematics courses (300 and 400 level).

SOPHOMORE YEAR

FALL

- Mathematics
- PHY 205 Classical Mechanics B
or
PHY 207 Mechanics and Waves
- MAE 221 Thermodynamics
- N.T.E.

SPRING

- Mathematics
- PHY 208 Principles of Quantum
Mechanics
- MAE 222 Mechanics of Fluids
- MAE 224 Integrated Engineering Science
Laboratory
- N.T.E.

Physics 205/207 usually substitutes for **MAE 206**. The Departmental requirement of MAE 223 is normally met by taking MAE 325 (CEE 361), or MAE 332 or MAE 342 during the Junior Year (see below).

JUNIOR

FALL

- Mathematics
- PHY 301 Thermal Physics
- MAE 321 Engineering Design
- MAE 325 Structural Analysis and Intro to
Finite Element Methods
- N.T.E.

SPRING

- Mathematics
- PHY 304 Advanced Electro-magnetism
- MSE 301 Materials Science and
Engineering
- MAE 433 Automatic Controls
- N.T.E.

SENIOR

FALL

- PHY 305 Introduction to the Quantum
Theory
- MAE 335 Fluid Dynamics
- MAE 412 Microprocessors for
Measurement and Control
- *Begin Senior Thesis with Design*

SPRING

- PHY 408 Modern Classical Dynamics
- MAE 442D Senior Thesis with Design
- N.T.E.
- T.E.

If **PHY 301** is completed, this course can be used to satisfy one of the engineering science requirements.

SUGGESTED TECHNICAL ELECTIVES

FALL

MAE 511 Experimental Methods
MAE 521 Optics and Lasers
MAE 523 Electric Propulsion
MAE 527 Physics of Gases
PHY 405 Modern Physics I
PHY 311, 312 Experimental Physics

SPRING

MAE 328 Energy for a Greenhouse
Constrained World
MAE 555 Nonequilibrium Gas Dynamics
PHY 406 Modern Physics II
MAE 434 Modern Control
MAE 427 Mobile Power Plants

Note: This sample Engineering Physics program is in coordination with the Mechanical Engineering program. The Aerospace program may also be followed.

F. Materials Science in Engineering Program

Students wishing to concentrate in materials engineering may choose courses that satisfy both the Departmental course requirements for mechanical or aerospace engineering, and the Certificate in Materials Science and Engineering. **The certificate program requires:**

1. One core course in materials (MAE 324 or MSE 301);
2. One materials experimental methods course (MSE 302 or CHM 372); note CHM 371 may be taken if CHM 372 not offered;
3. Three additional courses from the materials elective list, and;
4. A two semester senior thesis on a materials topic approved by the certificate committee.

The Departmental program(s) require:

One materials course, four engineering science courses, three design courses and one semester of independent work or two semesters of senior thesis. Specified materials science technical electives will qualify as engineering science technical electives in the Mechanical program. See list of engineering science courses on page 5 of this booklet.

A typical course sequence following the Mechanical Engineering Program and Materials Certificate Program is as follows:

SOPHOMORE

FALL

- MAE 221 Thermodynamics
- Mathematics
- MAE 324 Structure and Properties of Materials
- MAE 223 Modern Solid Mechanics
- N.T.E.

SPRING

- MAE 206 Intro to Engineering Dynamics
- MAE 222 Fluid Mechanics
- MAE 224 Integrated Engineering Science Laboratory
- N.T.E.
- T.E.

JUNIOR

FALL

- Mathematics Elective
- MAE 321 Engineering Design
- MSE 302 Materials Lab
- MAE 412 Microprocessors for Measurement and Control
- N.T.E.

SPRING

- MAE 322 Mechanical Design
- MAE 433 Automatic Controls
- Materials T.E.
- N.T.E.

SENIOR

FALL

- *Begin Materials Senior Thesis with Design*
- CHE 415 Polymers
- MAE 325 Structural Analysis & Intro to Finite Element Methods
- MAE 423 Heat Transfer
- N.T.E.

SPRING

- MAE 442D Materials Senior Thesis with Design
- Materials T.E.
- N.T.E.
- N.T.E.

NOTE: Those students wishing to follow the Aerospace Engineering Program should consult with their Academic Advisor or Departmental Representative for careful selection of technical electives. For the Aerospace Program MAE 331/332 Flight Dynamics and Aircraft Design –or– MAE 341/342 Space Flight and Space Craft Design are required as well as MAE 427 Mobile Power Plants or MAE 426 Rocket and Air-Breathing Propulsion Technology. MAE 335 Fluid Dynamics must be taken in a fall semester in lieu of MAE 423 Heat Transfer.

SUGGESTED TECHNICAL ELECTIVES:

One of the attractive features of the program is the opportunity to choose a focus in a particular area of materials science and engineering that is of special interest to the student. For example, students may choose electives in the areas of: micro- and nano-scale materials science and engineering; biomedical materials and bioengineering; materials modeling, or structural materials.

Other areas of concentration may also be developed, depending on student interest. The technical electives may be selected from the list of courses shown below. Note that they include both undergraduate and graduate courses. Students are encouraged to take selected graduate courses, especially in their senior year.

Approved Undergraduate Courses in Materials Science and Engineering:

CHM 303/304 Organic Chemistry
CHM 305/306 Physical Chemistry
CHM 406 Advanced Physical Chemistry
CHM 407/408 Inorganic Chemistry
CHE 410 Molecular Structure and Property: Product Engineering
CHE 415 Polymers
CHE 421 Catalytic Chemistry
ELE 341 Solid-State Devices
ELE 342 Physical Principles of Electronic Devices
ELE 351 Electromagnetic Field Theory and Optics
ELE 352 Physical Optics
ELE 441/442 Solid-State Physics I, II
ELE 453 Optical Electronics
MAE 324 Structure and Properties of Materials
MAE 344 Introduction to Biomedical Engineering
MOL 350 Laboratory in Molecular Biology

PHY 304 Advanced Electromagnetism
PHY 305 Introduction to Quantum Theory
PHY 405 Modern Physics I: Condensed Matter Physics

Note: Additional materials science courses have been proposed and are pending approval.

Graduate Courses Suitable for the Certificate Program:

MSE 501/CHM 525/MAE 515 Introduction to Materials
MSE 502 Thermodynamics and Kinetics of Materials
MSE 503 Structure of Materials
MSE 504 Modeling and Simulation in Materials Science
MSE 510/EE 541 Electronic Materials
MSE 511/EE 551 Theory and Application of Photonic Materials and Devices
MSE 512/MAE 518 Structural Materials
MSE 513/CHM 511 Chemistry and Physics of Nanomaterials
MSE 514/CHE 544 Solid-State Properties of Polymers
MSE 515/APC 515 Random Heterogeneous Materials
MSE 516, 517/PHY 525, 526 Condensed-Matter Physics
MSE 530/CHE 531 Introduction to Nano- and Microfabrication
MSE 532/CHE 541 Polymer Synthesis
CHE 522 Colloidal Dispersions
CHE 543 Solution Properties of Polymers
CHE 553 Topics in Interfacial Chemistry
CHE 555 Topics in Polymer Materials: Molecular Structure and Properties
MSE 534/EE 549 Physics and Technology of VLSI
MSE 540/MAE 516 Fracture Mechanics
CHM 501 Introduction to Quantum Chemistry
CHM 503 Introduction to Statistical Mechanics
CHM 507 Solid-State Chemistry

G. Interdepartmental Programs

1. [Program in Engineering and Management Systems](#)

Students with a strong interest in the systems and management aspect of an engineering career may combine Departmental courses with the requirements of the Program in **Engineering and Management Systems**. Those wishing to pursue this program should see the EMS Program Director (see Section VIII) early in their academic career. A number of the program requirements satisfy Departmental requirements as well.

2. [Program in Applied and Computational Mathematics](#)

Students with interests in applied mathematics may use upper class electives to satisfy program requirements in Applied and Computational Mathematics. Students should contact PACM Program Director for further details, see Section VIII.

3. [Program in Engineering Biology](#)

Students interested in engineering biology may use upper class electives to satisfy the requirements of this program. Students should contact the EB Program Director for specific details, see Section VIII.

4. [Program in Robotics and Intelligent Systems](#)

Students interested in robotics and intelligent systems may use upper class electives to satisfy the requirements of this program. Students should contact the RIS Program Director for specific details, see Section VIII.

5. [Program in Materials Science and Engineering](#)

Students interested in materials science and engineering may use upper class electives to satisfy the requirements of this program. Students should contact the MSE Program Director for specific details, see Section VIII.

Sufficient flexibility is present in the Department Program to permit students to participate in other certificate programs such as the one offered by the Woodrow Wilson School.

6. [Program in Sustainable Energy](#)

Students interested in sustainable energy may use upper class electives to satisfy the requirements of this program. Students should contact the SE Program Director for specific details, see Section VVIII.

IV. DEPARTMENTAL PRIZES

Six Departmental prizes are awarded each year at Class Day.

THE GEORGE BIENKOWSKI PRIZE: This is a financial award given in honor of George Bienkowski, former Professor and Undergraduate Representative. This award is given to a senior student(s) of sound academic standing and who has contributed to the department and engineering through their service during their career at Princeton.

THE JOHN MARSHALL II MEMORIAL PRIZE: This prize provides financial support for undergraduate independent work with preference given to projects in aerospace engineering. The prize is given in memory John Marshall II, '72. Prize winners are selected by the Undergraduate Faculty Committee based on written proposals submitted early in the fall. Additionally, a prize will be awarded in spring.

DONALD JANSSEN DIKE AWARD FOR EXCELLENCE IN UNDERGRADUATE RESEARCH: In memory of Donald Janssen (D.J.) Dike, '51. This financial award is presented to senior or seniors who in the opinion of the faculty have excelled in independent work.

SAU-HAI LAM *58 PRIZE IN MECHANICAL AND AEROSPACE ENGINEERING
Established by a donation from Professor Sau-Hai Lam, an emeritus faculty member, to the Mechanical and Aerospace Engineering Department, this prize was established to recognize graduating seniors and possibly juniors for their outstanding academic achievement.

MORGAN W. MCKINZIE '93 SENIOR THESIS FUND AND PRIZE
In memory of Morgan W. McKinzie '93. The Senior Thesis fund provides financial support for independent work with preference given to projects in aircraft design and propulsion. The Senior Thesis prize is a financial award for the best Senior Thesis in the MAE Department as determined by the faculty.

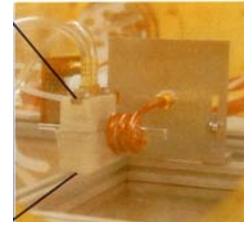
ENOCH J. DURBIN PRIZE FOR ENGINEERING INNOVATION
This prize, established in memory of faculty emeritus Enoch J. Durbin, is awarded to a senior in the Department where independent work or thesis has shown special interest and aptitude in engineering innovation.

V. INDEPENDENT WORK AND STUDENT PUBLISHED PAPERS

A good indication of the interest of students in the MAE Department is the independent work they have chosen. Recent topics are given below:

Aero/Astro Engineering

Open-Ended RF-Sustained Discharge (OERSTED): A Novel Plasma-Based Technique for Sample Ablation and Ionization on Mars – F. Bellemare '08 & D.K. Johnson '08 (Advisor – Choueiri)



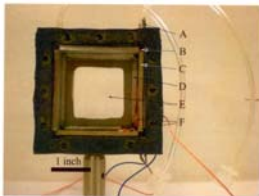
Using RADAR REMPI for Remote Trace Species Detection – C. Brennan '08 (Advisor – Miles)



Thermal Analysis and Physical Work on Lithium Lorentz Force Accelerator – G. Lace '08 & D. Lau '08 (Advisor – Choueiri)

A Numerical and Experimental Investigation of Stochastic Differential Equations – L. Stankievich '08 (Advisor – Kasdin)

Materials and Biomaterials



Design and Fabrication of Tunable Acoustic Gradient Index of Refraction Lenses – T. Lipp '08 (Advisor – Arnold)



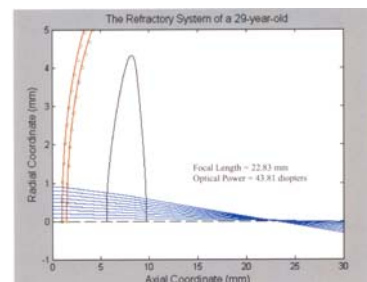
A Novel Laser Transfer Technique for Cellular Manipulation – D. Cohen '08 (Advisors – Arnold & Weiss)



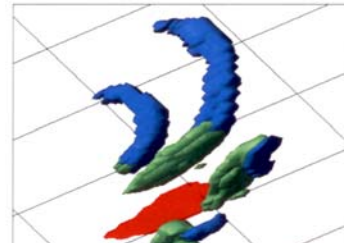
Design of an Implantable Biomedical Device for Localized Drug Delivery – A. Van Hoek '08 (Advisor – Soboyejo)

Computational Fluid Dynamics and Fluid Mechanics

Mechanical and Optical Modeling of the Human Eye with Applications to the Development of Predictive Software for Corneal Reshaping Procedures – Z. Kherani '08 (Advisor – Smits)



A Spline-Based Approach to Solving Coupled Aeroelastic Problems Using Higher-Order Panel Methods – E. Conbeer '08 (Advisor – Martinelli)



Chasing Eddies and Their Wall Signature in Turbulent Boundary Layers – C. O'Farrell '08 (Advisor – Martin)

Energy and the Environment (Combustion)



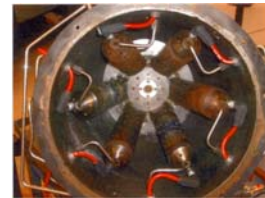
Alternative Wind Power Generator – E. Hammar '08, R. Simnick '08 & L. Tracey '08 (Advisor – Martinelli)

Investigating the Efficiencies of Photosynthesis in Plants – S. Plucinski '08 (Advisors – Carter & Wagner)

A Study of Fischer-Tropsch Liquid Fuel Production for Coal and Biomass with Carbon Capture Sequestration – J. Vogel '08 (Advisors – Ju & Larsen)

Humans and Machines, Components and Controls

Design and Build a Turbine Engine as a Standalone Power Plant for Deployment in Developing Countries – R. Brenner '08 & D. Cummins '08 (Advisor – Nosenchuck)

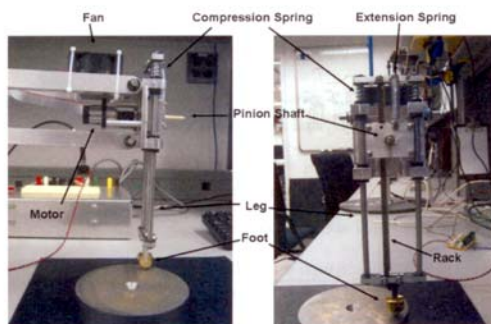


Design of an Autonomous Lamprey-Based Robot with 3D Mobility and Object Avoidance Capabilities – Y. Dai '08 (Advisor – Smits)

Camera Stabilization with a Stewart Platform – T. Kolade '08 & M. Wood '08 (Advisor – Littman)



Hands Free Crutches – A. Rogers '08 & J. Odeyemi '09 (Advisor – Soboyejo)



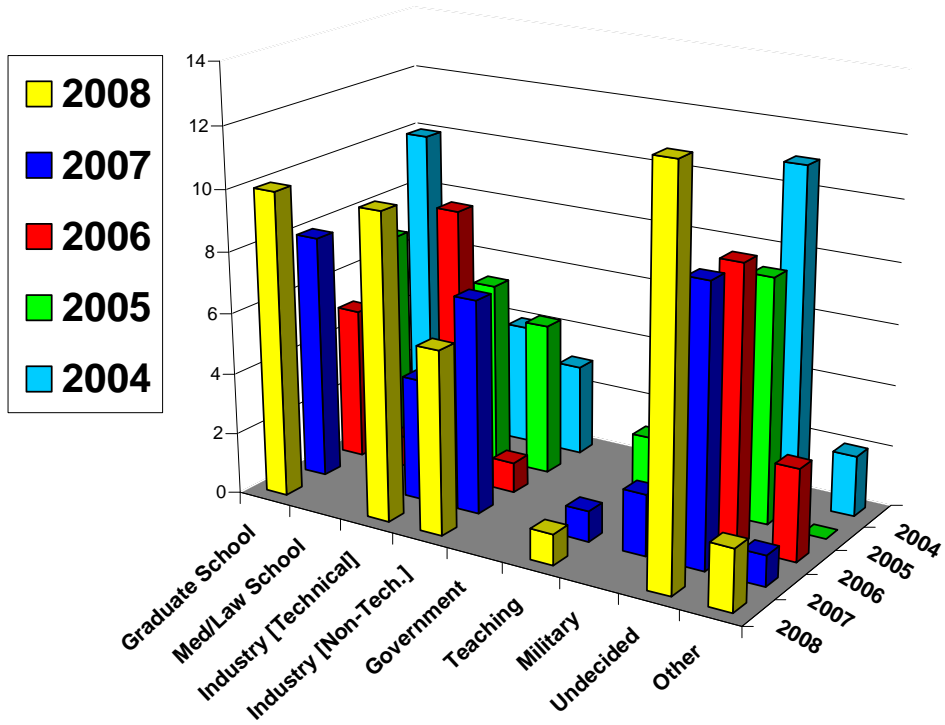
Open-Loop Stability in Legged Robots – E. Whitman '08 (Advisors – Holmes & Littman)

Independent Work Projects or Senior Thesis research may result in a published paper with the student's advisor. Here are some examples of student published papers:

- Design and Analysis of a Single-Stage Hypersonic Concept for Ultra-Rapid Global Travel, 15th AIAA International Space Planes and Hypersonic Systems and Technologies Conference, April 2008, Dayton, Ohio, Paper No. AIAA 2008-2521, (J.B. Glass, Z.S. Glass, A. Mackowski, S. Plucinski, S. Sherman, C.A. Teichner and A. Van Hoek, D. Cummins, T. Conbeer, R. Mellish, B. Vigil, J. Vogel, Z. Xia, and K. Bowcutt)
- Eddy Hunting in Compressible Boundary Layers using DNS Data, 59th APS Division of Fluid Dynamics Meeting, November 2006, Tampa, Richdale, (G.C. Richdale, M.P. Martin, and D. Silver)
- Leo Constellation Design Using the Lunar L1 Point, 14th AAS/AIAA Space Flight Mechanics Conference, February 2004, Maui, Hawaii, Paper No. AAS 04-248, (J. Chase, N. Chow, E. Gralla, N.J. Kasdin)
- Hovercraft Satellite Simulation Test-Bed, 14th AAS/AIAA Space Flight Mechanics Conference, February 2004, Maui, Hawaii, Paper No. AAS 04-300, (B. Essenberg, J. Sarokhan, N.J. Kasdin)
- Integrated Robotic Team for Martian Water Collection, 2002 RASC-AL Student Design Competition, Cocoa Beach, FL, November 2002, (K. Alemany, K. Bethke, N. Bhatt, B. Bollman, J. Viventi, D. Nosenchuck, S. Lyon, M. Littman)
- Control of Optical Phase and Amplitude in a Coronagraph using a Michelson Interferometer, August 2002, SPIE Conference on Future EUV-UV and Visible Space Astrophysics Missions and Instrumentation, Proceedings (Vol. 4854), (M. Littman, M. Carr, J. Leighton, E. Burke, D. Spergel, N.J. Kasdin)
- Design and Analysis of an Underwater Vehicle for Controlled Gliding, Proceedings of the 1998 Conference on Information Sciences and Systems, Princeton, NJ, March 1998, p. 801-806 (J. Graver, J. Liu, C. Woolsey, N. E. Leonard).
- Radiatively-Driven Hypersonic Wind Tunnel, AIAA Journal 33, No. 8, August 1995, pp. 1463-1470 (R.B. Miles, G. L. Brown, W. R. Lempert, R. Yetter, G. J. Williams, Jr., S. M. Bogdonoff, D. Natelson, J. R. Guest)
- A Knowledge-Based System For Controlling Automobile Traffic, Proceedings of the Third Conference on CLIPS, Houston, Sept 1994 (R. Stengel, A. Maravas).
- A Taxonomy of Agents for an Intelligent Vehicle Highway System, Proceedings of the 1993 IEEE Regional Conference on Control Systems, Newark, NJ, Aug 1993, pp. 166-169. (R. Stengel, T. Chao).
- Simulator of Optimally Controlled Molecular Motion, Am. J. Phys. 62 (9), September 1994, pp. 817-821 (D. Morris, C. Schwieters, M. Littman, H. Rabitz).

VI. POST-GRADUATION PLANS

An indication of the career plans of the graduates of the Department obtained from the immediate post graduation plans of the Classes of 2004 through 2008 are charted below.



VII. FACULTY RESEARCH INTERESTS

Craig B. Arnold	Research focuses on laser processing and transport in materials. Current experimental work includes laser direct-write and non-traditional patterning of small-scale devices and structures, lightweight and flexible energy storage systems, adaptive optics and optical trapping, and materials processing for mid-infrared technologies.
Frediano V. Bracco <i>Emeritus</i>	Experimental and computational studies of combustion in reciprocating engines to understand their controlling combustion processes.
Garry L. Brown	Fluid mechanics; a radiatively driven hypersonic wind-tunnel, turbulence, shear flow structure and mixing, multi-hole cooling and heat transfer, compressible flows with real gas effects on heat transfer, supersonic receptivity, instability and transition.
Emily Carter	Ab initio quantum mechanics-based predictions of materials behavior followed by optimal design, combustion thermochemistry, and catalysis. Materials considered include semiconductors, metals, and ceramics, with and without defects and impurities. Phenomena include hydrogen embrittlement of metals, high temperature evolution of jet engine thermal barrier coatings, carburization of metals, corrosion and wear of metals and metal oxides, dislocation formation and motion in metal alloys during plastic deformation, photovoltaics, and photocatalysis. Development of quantum mechanics based simulation methods to treat all of the above.
Edgar Y. Choueiri	Spacecraft propulsion, plasma dynamics, astronautics, and space plasma physics.
Howard C. Curtiss, Jr. <i>(Emeritus)</i>	Dynamics and control characteristics of helicopters, VTOL aircraft. Sailing craft aerodynamics and control.
Frederick L. Dryer	Environmental/energy/propulsion areas. Conventional and alternative fuels, engine emissions, microgravity research, experimental and numerical study of combustion and chemical kinetics. Microchemical reaction and propulsion applications. Fire safety.
Irvin Glassman <i>(Emeritus)</i>	Combustion related problems. Department history.

Mikko Haataja	Research focuses on theoretical and computational materials science and physical biology. Current work includes studies of microstructure formation during solid-solid phase transformations and solidification, growth of quantum heterostructures, recrystallization kinetics, and signaling pathways in cells.
Philip Holmes	Nonlinear dynamical systems, fundamental problems in the mechanics of solids, fluids and biological systems, and related mathematical methods. Current interests include neuro-mechanical models of insect locomotion and lamprey swimming; neural networks and brain modelling, including cognitive control and attention.
Robert G. Jahn (<i>Emeritus</i>)	Physics and engineering of high power plasma discharges for space propulsion and other applications. Experiments in anomalous human/machine interactions and human information processing. Theoretical modeling of the interaction of human consciousness with physical systems and processes.
Yiguang Ju	Energy conversion by using alternative fuels. Flame dynamics and multiscale kinetic modeling. Micro scale-combustion for power and chemical reactors. Non-equilibrium plasma assisted combustion for supersonic propulsion. Upconversion nano-particle synthesis for biological and homeland security applications. CO ₂ and NO _x emission control. Near limit combustion and fire safety.
N. Jeremy Kasdin	Space systems design, space telescopes, extrasolar planet finding, astrodynamics, autonomous operation and navigation of space vehicles, spacecraft formation flying, optimal estimation and control, stochastic systems, nonlinear control, systems engineering.
Sau Hai Lam (<i>Emeritus</i>)	Theoretical reacting gas dynamics, Lagrangian dynamics and nonlinear control theories, applied mathematics.
Chung King Law	Research interests include droplet and spray combustion, formulation of synthetic and high-energy fuels, flame structure studies, ignition and extinction phenomena, soot formation in flames, climatic issues including hydrogen combustion and safety, combustion synthesis of materials, laser diagnostics and numerical simulation of flames.

- Naomi E. Leonard Nonlinear control theory and application to mechanical systems including autonomous underwater vehicles and robotic systems. Biology-inspired, coordinated control of multi-vehicle networks. Mobile sensor networks and adaptive ocean sampling. Modeling and analysis of collective motion and collective decision-making in animal groups such as fish schools. Decision dynamics of mixed teams of humans and robots.
- Michael G. Littman Terrestrial Planet Finder (TPF) project and the study of historic engineering devices. The TPF effort involves the use of adaptive optics to correct for errors in telescope mirror shape and reflectivity. The objective is to minimize the effect of diffraction to improve visibility of faint astronomical objects including earth-like planets around nearby stars. The history of engineering effort involves recreating important technological devices to illustrate their scientific foundations and their importance to society. Objects of interest are in the area of structures, machines, networks and processes.
- Pino Martin The study of fundamental physical phenomena in transitional and turbulent flows with particular interest in the interaction between non-equilibrium chemical reactions and unsteady fluid motion and shockwave/ turbulence interaction. The research efforts include theory, numerical simulation, data analysis, and validation against experiments. The aim of this research is to develop new computational tools that capture the real flow physics via a better understanding of the fundamental physical phenomena, and bridging these new tools and production codes that are used for practical engineering applications.
- Luigi Martinelli Computational Fluid Dynamics for complex flow on complex geometry: Algorithms development and parallel computing. Aerodynamic shape optimization for aeronautical and marine applications: Development of adjoint based methods and their implementation.
- Michael McAlpine The focus of our research is in exploring nanotechnology-enabled approaches to address fundamental problems in medicine, energy, and flexible electronics. Current experimental work is focused on 1) the synthesis, assembly, and characterization of new nanoscale materials, 2) the fabrication of portable energy sources which derive their power from biomechanical motion, and 3) strategies for developing miniaturized sensing platforms which can mimic nature's amazing sensory capabilities.

Richard B. Miles	New laser diagnostics for non intrusive detection with applications to combustion (for the detection of radical species and temperature), hypersonic flows (for the detection of temperature, vibrational nonequilibrium, air chemistry, and velocity), weakly ionized plasmas (for temperature, electron number density, and vibrational nonequilibrium), and for homeland defense (for detection of hazardous species in gas clouds); high speed imaging of flow structure; advanced technologies for the development of hypersonic vehicles including electron beam driven hypersonic wind tunnels; plasma aerodynamics for power extraction, drag reduction, performance enhancement and control of hypersonic air breathing vehicles and reentry vehicles; the study of molecular dynamics and energy transfer in small molecules; nonlinear optical processes in high fields; laser and plasma-driven aerodynamics; development of laser systems.
Daniel M. Nosenchuck	Experimental/computational fluid mechanics and instrumentation. Active control of boundary layer instabilities and turbulence. Product design and manufacture, rapid prototyping; entrepreneurship.
Clarence Rowley	Dynamical systems modeling of fluids, both to better understand the physics of complex flows, and to control these flows. Model reduction and symmetry reduction for bifurcation analysis and control. Numerical methods, and applications of geometric methods in fluid mechanics.
Barrie S. H. Royce (<i>Emeritus</i>)	Present research is concerned with the mechanical properties of materials on the nanometer length scale. Of particular interest is study of materials in a biological environment and MEMS structures. Mechanical testing techniques are being developed to look at elastic and plastic properties of nano- or micro-structured materials, their resistance to fatigue environments, and the effects of surface morphology on cell-material interactions.
Alexander J. Smits	The study of turbulent flows at subsonic, supersonic and hypersonic speeds, fluid/structure interactions, fish-like propulsion systems, heat transfer, and environmental fluid mechanics.
Winston O. Soboyejo	Research interests focus on engineered materials for applications in medicine/dentistry, alternative energy systems, transportation and infrastructure systems. Functionalized nanoparticles and BioMEMS structures are being developed for the targeting and treatment of cancer and cardiovascular disease, while novel concepts are being developed for future alternative energy systems. Eco-friendly materials are being explored for human transportation and infrastructure, while porous materials are being explored for water filtration.

- Robert H. Socolow Carbon management: Reconciling a world dominated by fossil fuels for another century with the constraints of the atmospheric greenhouse. Engineering studies of carbon capture during the production of electricity, hydrogen, and synthetic hydrocarbon fuels from coal and biomass. Opportunities for carbon dioxide storage. Energy efficiency, renewable energy, and nuclear power.
- Robert F. Stengel Systems biology, aerospace dynamics and control.
- Howard A. Stone Research interests include a variety of fundamental problems in fluid motions dominated by viscosity, so-called low Reynolds number flows, and a combination of theory, computer simulation and modeling, and experimentation to provide a quantitative understanding of the flow phenomenon under investigation. Studies have also been directed toward heat transfer and mass transfer problems involving convection, diffusion and surface reactions. Contributions to a wide range of problems involving effects of surface tension, buoyancy, fluid rotation, and surfactants. Also the study of problems concerning the flow of lipid bilayers and monolayers, and investigation of the motions of particles suspended in such interfacial layers.
- Szymon Suckewer Recent interests are related primarily to the development and applications of X-ray lasers, X-ray microscopy, powerful picosecond and femtosecond lasers, laser interactions with matter, the application of lasers to gas and plasma diagnostics, spectroscopy, and atomic processes in plasmas and gases. Professor Suckewer is also Head of the X-ray Laser Project at the Princeton University Plasma Physics Laboratory.

VIII. WHO TO SEE FOR MORE INFORMATION

Normally, Freshman who choose to pursue Engineering in this Department have their course selections for the Sophomore year approved by the Departmental Representative. Sophomore Class Advisors are currently: Prof. Michael G. Littman (A – M) and Prof. Craig Arnold (N – Z).

Upperclass students are assigned an academic advisor in the Department according to their area of interest (Aerospace Engineering, Mechanical Engineering, Engineering Physics). The advisor is available throughout the academic year to 1) discuss and advise students on course selections etc., 2) approve course selection score worksheets and course change forms. Students should feel free to discuss any questions related to their academic program with the Departmental Representative.

Departmental Representative:	M.G. Littman Ext. 8-5198	D-202A E-Quad. mlittman@princeton.edu
Undergraduate Administrator:	Jo Ann Love Ext. 8-5169	D-230 E-Quad jlove@princeton.edu

Upperclass Advisors:

Class of 2010:

Professor Edgar Choueiri, D432, E-Quad, Ext. 8-5220, choueiri@princeton.edu

Professor Yiguang Ju, D330, E-Quad, Ext. 8-5644, yju@princeton.edu

Professor Michael Littman, D202-A, E-Quad, Ext. 8-5169, mlittman@princeton.edu

Professor Gigi Martinelli, D302-C, E-Quad, Ext. 8-6652, gigi@phantom2.princeton.edu

Professor Dan Nosenchuck, D302-B, E-Quad, Ext. 8-5136, dan@princeton.edu

Professor Clarence Rowley, D234, E-Quad, Ext. 8-7321, cwrowley@princeton.edu

Professor Wole Soboyejo, D404, E-Quad, Ext. 8-5609, soboyejo@princeton.edu

Professor Robert Stengel, D202-C, E-Quad, Ext. 8-5103, stengel@princeton.edu

Class of 2011:

Professor Mikko Haataja, D404-C, E-Quad, Ext. 8-9126, mhaataja@princeton.edu

Professor Yiguang Ju, D330, E-Quad, Ext. 8-5644, yju@princeton.edu

Professor Michael Littman, D202-A, E-Quad, Ext. 8-5169, mlittman@princeton.edu

Professor Michael McAlpine, D414, E-Quad, Ext. 8-8613, mcm@princeton.edu

Professor Richard Miles, D414, E-Quad, Ext. 8-5131, miles@princeton.edu

Professor Clarence Rowley, D234, E-Quad, Ext. 8-7321, cwrowley@princeton.edu

Engineering Physics:

Professor Edgar Choueiri, EP Lab E-Quad. or D-432 E-Quad., Ext. 8-5220

Engineering Biology:

Professor Michael Littman, D-202A E-Quad., Ext. 8-5198

**Student Departmental Committee and Other Student Committees
(2008-2009):**

MAE Undergraduate Student Council:

Co-Presidents: *Jessica Odeyemi '09, jodeyemi@princeton.edu
Victor Pinedo '10, vpinedo@princeton.edu*

AIAA (American Institute of Aeronautics and Astronautics):

Faculty Advisors: Richard Miles, miles@princeton.edu

*Co-Presidents: Ephraim Chen '09, ejchen@princeton.edu
Matt Isakowitz '09, misakowi@princeton.edu*

Treasurer: Dan Maass '09, dwmaass@princeton.edu

Social Chair: Dave Hegermiller '10, dhegermi@princeton.edu

Tech/Web Chair: Trevor O'Neill '10, tmoneill@princeton.edu

ASME (American Society of Mechanical Engineers):

Faculty Advisor: Clarence Rowley, cwrowley@princeton.edu

SAE and Formula SAE (Society of Automotive Engineering):

Faculty Advisor: Yiguang Ju, yju@princeton.edu

Interdepartmental Programs (For Academic Year 2008 - 2009):

Program in Sustainable Energy

Director: Yiguang Ju
D-330 E-Quad. Phone: 8-5644

Program in Engineering and Management Systems

Director: Warren Powell
E-222 E-Quad. Phone: 8-5373

Program in Engineering Physics

Director: Edgar Choueiri
EP Lab E-Quad. or D-432 E-Quad. Phone: 8-5220

Program in Engineering Biology

Director: Robert Prud'homme
A-301 E-Quad. Phone: 8-4577

Program in Applied & Computational Mathematics

Director of: Weinan E
Undergraduate 207 Fine Hall Phone: 8-3683
Studies:

Program in Materials Science & Engineering

Director of: Winston O. Soboyejo
Undergraduate D-404 E-Quad. Phone: 8-5609
Studies:

Program in Robotics and Intelligent Systems

Director: Robert Stengel
D-202C E-Quad. Phone: 8-5103

Program in Energy and the Environment

Director: Robert Socolow
139 Guyot Phone: 8-5446

Program in Applications of Computer

Director: Kenneth Steiglitz
421 Computer Science Phone: 8-4629

Study Abroad and Foreign Exchange:

Engineering is an international enterprise and American companies undertake projects on all continents. In addition, the globalization of enterprises frequently distributes the manufacturing and research activities of a company to several countries. Well-prepared engineers should, therefore, be familiar with the different cultures in which their expertise may be used. The Study Abroad program of the University provides an excellent opportunity to begin this process while obtaining credits from a foreign university that will count towards your degree program. Because the academic year follows different schedules in different countries and hemispheres, you will need to explore the most suitable time to enter such a program. It may be possible to combine a summer program in a country with at least one term of study in your discipline. In this context, some students with advanced standing have used the spring term of the sophomore year followed by summer study whereas others have used the fall term of the junior year. Several foreign universities prefer visiting students to attend for a full academic year as their courses run through the year and the examinations occur at the end of this period.

The Department encourages students who are interested in this educational opportunity to discuss it with their advisor; the Department Undergraduate Representative, Professor Michael G. Littman; Dean Peter Bogucki of the School of Engineering and Applied Science; and Dean Nancy Kanach, Office of the Dean of the College. You may also access the Study Abroad home page. Planning should start as early in the academic process as possible so that your degree program can be designed to accommodate this period of foreign study.

In the past few years, MAE students have studied at the University of Cape Town/South Africa, the University of Auckland/New Zealand, the University of Melbourne/Australia.

Foreign Exchange:

The School of Engineering and Princeton University have established two Foreign Exchange programs. MAE students have recently participated in the Oxford University Exchange Program in the United Kingdom spending their Junior year abroad. A program has also been established with Ecole Centrale in Paris which may focus on energy studies followed by a summer internship in an energy related industry. A strong background in French is encouraged. Students interested in the Ecole program may contact MAE Professor Richard Miles, 8-5131, miles@princeton.edu.

Contact Information:

Professor Michael G. Littman
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8-5198,
mlittman@princeton.edu

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APPENDIX I
REQUIREMENT FORMS

Aerospace Engineering Program

Name:	Year:	Advisor:
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HUMANITIES AND SOCIAL SCIENCE REQUIREMENTS: (total of 7 required in four distinct areas)

Distribution Area	Course #	Sem/Yr	Ck	Course #	Sem/Yr	Ck	Course #	Sem/Yr	Ck
(EC) Epist & Cogn									
(EM) Ethic & Moral									
(SA) Social Analysis									
(HA) Historical Analysis									
(LA) Literature & Arts									
(FL) Foreign Language									

ENGINEERING SCHOOL REQUIREMENTS (total of 8 courses required or AP credit)

Course	Check	Semester/Yr	Course	Check	Semester/Yr
MAT 103			PHY 103 or 105*		
MAT 104			PHY104 or 106*		
MAT 201 or 203*			CHM 201 or 203*		
MAT 202 or 204			COS 126*		

DEPARTMENTAL REQUIREMENTS (16 courses required - or 15 required if completing IW w/Design as 3rd Design)

Course	Check	Semester/Yr	Course	Check	Semester/Yr
MAE 223			MAE 221		
MAE 206			MAE 222		
MAE 305			MAE 224 Lab		

Upper Level Departmental Requirements:

() = Number of Courses Required

	Course	Semester/Yr	Course	Semester/Yr	Course	Semester/Yr
Materials (1)	MAE 324 or MSE 301					
Design (3)	MAE 321		MAE 332 or 342		3rd Design Course**	
Required Technical	MAE 331 or 341		CEE 361 (MAE 325)		MAE 335	
Electives (5)	MAE 433		MAE 426 or 427			
Independent Work (1) or IW w/Design Senior Project Senior Project w/Design Senior Thesis Senior Thesis w/Design	MAE 339		MAE 340		One Semester of independent work is required. More than one suggested. Senior Thesis or Project two consecutive semesters enrolling in Spring only.	
	MAE 339D		MAE 340D			
			MAE 440			
			MAE 440D			
			MAE 442			
		MAE 442D				

Aero Requirements Checklist MAE 321, MAE 331/341 or MAE 332/342, 3rd Design, MAE 335, MAE 427/426, MAE 433, Materials, CEE361(MAE325), IW -or- Sr. Thesis -or- Sr. Project

	Course	Semester/Yr	Course	Semester/Yr	Course	Semester/Yr
Free Electives/ Additional Courses (Non-Tech Electives)						
Writing Requirement (1)						

Total # of Courses Must Equal 36

Certificate Program(s):

*See back page for approved alternate courses

**May be satisfied by completing Ind. Work or Thesis w/Design

OUTSIDE COURSES (If Applicable)			
Princeton Equivalent Course #	Name of University	Semester & Year	Comments

Notes:

Substitutions not requiring Departmental Representative's Approval:

Math:

EGR 192 replaces MAT 201 or MAT 203

Physics:

PHY 107/108/109 sequence "General Physics" may replace the PHY103/105 or PHY 105/106 sequence

EGR 191 replaces PHY 103 or PHY 105

EGR 193 replaces PHY 104 or PHY 106

Chemistry:

CHM 207 Advanced General Chemistry: Materials Chemistry

NOTE: ISC 231, 232 (Fall) and ISC 233, 234 (Spring) replaces PHY 105/106, CHM 201 and COS 126

All other courses substitutions must be approved *in writing* by the Departmental Representative.

Design Courses:

MAE 321 Engineering Design

MAE 322 Mechanical Design

MAE 332 Aircraft Design

MAE 342 Space System Design

MAE 412 Microprocessors for Measurement and Control

Mechanical Engineering Program

Name:	Year:	Advisor:
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HUMANITIES AND SOCIAL SCIENCE REQUIREMENTS: (total of 7 required in four distinct areas)

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(EC) Epist & Cogn									
(EM) Ethic & Moral									
(SA) Social Analysis									
(HA) Historical Analysis									
(LA) Literature & Arts									
(FL) Foreign Language									

ENGINEERING SCHOOL REQUIREMENTS (total of 8 courses required or AP credit)

Course	Check	Semester/Yr	Course	Check	Semester/Yr
MAT 103			PHY 103 or 105*		
MAT 104			PHY104 or 106*		
MAT 201 or 203*			CHM 201 or 203*		
MAT 202 or 204			COS 126*		

DEPARTMENTAL REQUIREMENTS (16 courses required - or 15 required if completing IW w/Design as 3rd Design)

Course	Check	Semester/Yr	Course	Check	Semester/yr
MAE 223			MAE 221		
MAE 206			MAE 222		
MAE 305			MAE 224 Lab		

Upper Level Departmental Requirements:

() = Number of Courses Required

	Course	Semester/Yr	Course	Semester/Yr	Course	Semester/Yr	
Materials (1)	MAE 324 or MSE 301						
Design (3)	MAE 321		MAE 322 or 412		3rd Design Course**		
Math Elective (1)							
Required Technical Electives (4)	MAE 335 or 423		CEE 361 (MAE325)		Tech Elective		
	MAE 433						
Independent Work (1) or IW w/Design	MAE 339		MAE 340		One Semester of independent work is required. More than one suggested.		
Senior Project	MAE 339D		MAE 340D				
Senior Project w/Design			MAE 440			Senior Thesis or Project two consecutive semesters enrolling in Spring only.	
Senior Thesis			MAE 440D				
Senior Thesis w/Design			MAE 442				
			MAE 442D				

Mech Requirements: MAE 321, MAE 322/412, 3rd Design, MAE 335/423, Math Elective, TE, MAE 433, Materials

Checklist CEE361(MAE325), IW -or- Sr. Thesis -or- Sr. Project

	Course	Semester/Yr	Course	Semester/Yr	Course	Semester/Yr
Free Electives/ Additional Courses (Non-Tech Electives)						
Writing Requirement (1)						

Total # of Courses Must Equal 36

Certificate Program(s):

*See back page for approved alternate courses

**May be satisfied by completing Ind. Work or Thesis w/Design

OUTSIDE COURSES (If Applicable)			
Princeton Equivalent Course #	Name of University	Semester & Year	Comments

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EGR 192 replaces MAT 201 or MAT 203

Physics:

PHY 107/108/109 sequence "General Physics" may replace the PHY103/105 or PHY 105/106 sequence

EGR 191 replaces PHY 103 or PHY 105

EGR 193 replaces PHY 104 or PHY 106

Chemistry:

CHM 207 Advanced General Chemistry: Materials Chemistry

NOTE: ISC 231, 232 (Fall) and ISC 233, 234 (Spring) replaces PHY 105/106, CHM 201 and COS 126

Suggested Second Math Course:

MAE 306 [MAT 302] Mathematics in Engineering II (recommended for those planning graduate work in engineering or applied science)

ORF 245 Fundamentals of Engineering Statistics

ORF 307 Optimization

ORF 309 Probability and Stochastic Systems (MAT 309/ELE 380)

COS 309 Fundamentals of Scientific Computing

COS 340 Reasoning About Computation

MAT 304 Introduction to Partial Differential Equations

MAT 305 Mathematical Programming

MAT 306 Introduction to Discrete Mathematics

MAT 317 Complex Analysis with Applications

All other courses substitutions must be approved *in writing* by the Departmental Representative.

Design Courses:

MAE 321 Engineering Design

MAE 322 Mechanical Design

MAE 332 Aircraft Design

MAE 342 Space System Design

MAE 412 Microprocessors for Measurement and Control

Mechanical and Aerospace Engineering Programs

Name:	Year:	Advisor:
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DEPARTMENTAL REQUIREMENTS (total of 16 courses required)

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MAE 223			MAE 221		
MAE 206			MAE 222		
MAE 305			MAE 224 Lab		

Upper Level Departmental Requirements:

() = Number of Courses Required

	Course	Semester/Yr	Course	Semester/Yr	Course	Semester/Yr
Materials (1)	MAE 324 (AE/ME)		MSE 301 (AE/ME)			
Design (3)	MAE 321 (AE/ME)		MAE 332/342 (AE)		MAE 322/412 (ME)	
Math Elective (ME) (1)						
Required Technical Electives (5)	MAE 331/341 (AE)		MAE 335 (AE/ME)		MAE 427/426 (AE)	
Independent Work (1) or IW w/Design Senior Project Senior Project w/Design Senior Thesis Senior Thesis w/Design	MAE 339		MAE 340		One Semester of independent work is required. More than one suggested. Senior Thesis or Project two consecutive semesters enrolling in Spring only.	
	MAE 339D		MAE 340D			
			MAE 440			
			MAE 440D			
			MAE 442			
		MAE 442D				

Aero Requirements: Checklist MAE 321, MAE 331/341 or MAE 332/342, 3rd Design, MAE 335, MAE 427/426, MAE 433, Materials, CEE361(MAE325), IW -or- Sr. Thesis -or- Sr. Project

Mech Requirements: Checklist MAE 321, MAE 322/412, 3rd Design, MAE 335/423, Math Elective, TE, MAE 433, Materials CEE361(MAE325), IW -or- Sr. Thesis -or- Sr. Project

	Course	Semester/Yr	Course	Semester/Yr	Course	Semester/Yr
Free Electives/ Additional Courses (Non-Tech Electives)						
Writing Requirement (1)						

Total # of Courses Must Equal 36

Certificate Program(s):

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EGR 191 replaces PHY 103 or PHY 105

EGR 193 replaces PHY 104 or PHY 106

Chemistry:

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