Princeton University

Mechanical and Aerospace Engineering

Undergraduate Handbook

Effective with the Class of 2017

DEPARTMENT OF
MECHANICAL AND AEROSPACE ENGINEERING
UNDERGRADUATE PROGRAMS
HANDBOOK

Effective Academic Year 2014-2015
Version 7

This booklet supersedes all others and applies to the Classes of 2017 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.

Mechanical and Aerospace Engineering Department Web Site:
http://www.princeton.edu/mae/

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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 upper class 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.

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 V. Plans after graduation for the last five classes are summarized in Section VI and a brief description of the faculty research interests is found in Section VII. Section VIII lists "Who to See" among the faculty and students to obtain additional information.

The undergraduate programs in Aerospace and Mechanical Engineering are accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org .

Program(s) Educational Objectives

Aerospace Engineering:

Objective No. 1
Our graduates will think critically and creatively and excel in applying the fundamentals of aerospace engineering.

Objective No. 2
Our graduates will pursue a life of curiosity with a desire for learning and have the ability and self-confidence to adapt to rapid and major changes.

Objective No. 3
Our graduates will advance toward leadership in shaping the social, intellectual, business and technical worlds and by excelling in diverse careers.

Mechanical Engineering:

Objective No. 1

Our graduates will think critically and creatively and excel in applying the fundamentals of mechanical engineering.

Objective No. 2

Our graduates will pursue a life of curiosity with a desire for learning, and have the ability and self-confidence to adapt to rapid and major changes.

Objective No. 3

Our graduates will advance toward leadership in shaping the social, intellectual, business and technical worlds and by excelling in diverse careers.

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

Some of the requirements may be satisfied 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 upper class 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 Mechanics[1]
   MAE 224 Integrated Laboratory

The Sophomore Laboratory provides experiments associated with Thermodynamics (MAE 221), Mechanics of Fluids (MAE 222) and Electronics. (Some of these courses may be satisfied by Advanced Placement Credit).

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

The following course is required for both Mechanical and Aerospace Engineers.

MAE 305 (MAT 301) Mathematics in Engineering I

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

- MAE 306 (MAT 392) 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 380/ELE 380)
- COS 340 Reasoning About Computation
- MAT 330 Complex Analysis with Applications
- MAT 393 Mathematical Programming
- PHY 403 Mathematical Methods of Physics

(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 Dynamics[1]
MAE 341 Space Flight[1]
MAE 345 Robotics and Intelligent Systems
MAE 433 Automatic Control Systems[2]
MAE 434 Modern Control

(b) **Fluid Mechanics/Thermal Sciences**

MAE 328 Energy for a Greenhouse-Constrained World
MAE 335 Fluid Dynamics [3]
MAE 336 Viscous Flows or MAE 552 Viscous Flows and Boundary Layers
MAE 423 Heat Transfer[3]
MAE 426 Rocket and Air-Breathing Propulsion Technology[4]
MAE 427 Energy Conversion and the Environment: Transportation Applications[4]
CBE 341 Mass, Momentum, and Energy Transport[5]

(c) **Materials/Structures**

MAE 324 Structure and Properties of Materials[6]
MSE 301 Materials Science and Engineering[6]
CEE 312 Statics of Structures[7]
CEE 361/MAE 325 Structural Analysis and Intro to Finite Element Methods[7]
CEE 362 Structural Dynamics and Earthquake Engineering[8]
CEE 364 Materials in Civil Engineering[8]

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[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 (may be used as additional engineering science elective (technical elective) in the Mechanical Program.
[5] CBE 341 is an acceptable substitute for MAE 423 for Mechanical Engineers.
[6] MAE 324 or MSE 301 required for Mechanical and Aerospace Engineers.

[7]CEE 312 or 361 required for Mechanical and Aerospace Engineers
[7] CEE 361/MAE 325 or 312 required for Mechanical Engineers.
[8] CEE 362 or CEE 364 may be considered as substitutes for the materials requirement. Requires the approval of the Department Representative.

2. **Engineering Design Courses** – There are three design requirements in each program. Two are satisfied by completing courses appropriate to the program (core course requirements for each program are footnoted below). The third is satisfied by completing Senior Independent Work, Senior Thesis, or Senior Project (see Section C.3).

   MAE 321 Engineering Design[1]
   MAE 322 Mechanical Design[2]
   MAE 332 Aircraft Design[3]
   MAE 342 Space System Design[3]
   MAE 412 Microprocessors for Measurement and Control[2]
   CEE 477 Engineering Design for Sustainable Development[4]

3. **Senior Independent work** - is the culminating experience for the mechanical and aerospace engineering programs. All seniors are required to participate in a research or engineering project. All projects must include elements of engineering design *(engineering design is the process of devising a system, component, or process to meet desired needs).* The following courses satisfy this requirement: MAE 439 Senior Independent Work (one semester, fall); MAE 440 Senior Independent Work (one semester, spring); MAE 442 Senior Thesis (year-long); MAE 444 Senior Project (year-long). **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 439/440 (Fall/Spring)
   MAE 442 Senior Thesis (Spring)[5]
   MAE 444 Senior Project (Spring)[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] CEE 477 is an acceptable substitute only for Mechanical Engineers who are pursuing the Sustainable Energy Certificate Program
[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 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/about-asme/governance/asme-society-policies)
Scroll to Policy 15.7 Ethics (available in PDF or Word format)

AIAA (https://www.aiaa.org/Secondary.aspx?id=4324&terms=code%20of%20ethics)
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. ***Please note that senior independent work, senior thesis, and senior project requirements have changed and are in effect for the Class of 2017. Course restructuring and renumbering will occur for senior independent work, senior thesis, and senior project as indicated below.***

228 Energy Solutions for the Next Century (Fall) – MAE 228 is an optional core requirement in the Sustainable Energy Certificate Program recommended for AB students. This course is open to Engineering and Liberal Arts Majors. Course will not serve as a Technical Elective.

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 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). **Either CEE 361 or CEE 312 is 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.)**

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 Junior Independent Work - Students may wish to complete a one term independent work project during their junior year. 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. *These courses do not satisfy the senior independent work requirement of the department.*

339D/340D Junior Independent Work with Design - Independent work with design is intended for juniors who wish to complete 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. *These courses do not satisfy the senior independent work requirement of the department.*

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**.

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 Energy Conversion and the Environment: Transportation Applications (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.

439/440 Senior Independent Work (Fall/Spring) – Senior independent work is intended for seniors who choose to complete a one term project. The independent work must incorporate aspects and principles of design, whether for a system, product, vehicle, device, software, or apparatus. 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. ***Either of these courses will satisfy the department's senior independent work requirement.***

442 Senior Thesis (Spring) - The senior thesis is an independent study for individual students. The thesis must incorporate aspects and principles of design, whether for a system, product, vehicle, device, software, or apparatus. 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 for their work. ***This course will satisfy the department's senior independent work requirement.***

444 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. The team or group project must incorporate aspects and principles of design, whether for a system, product, vehicle, device, software, or apparatus. 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 for their work. ***This course will satisfy the department's senior independent work requirement.***

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
- CEE 361/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 Independent Work or Senior Thesis or Senior Project
- MAE 345 Robotics and Intelligent Systems*
- MAE 412 Microprocessors for Measurement and Control
- N.T.E.

SPRING
- Senior Independent Work or Senior Thesis or Senior Project
- 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

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 Energy Conversion and the Environment: Transportation Applications
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
- CEE 361/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 Energy Conversion and the Environment: Transportation Applications
- N.T.E.

SENIOR YEAR

FALL
- MAE 335 Fluid Dynamics
- MAE 439 Senior Independent Work
- 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
- CEE 361/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 – Aircraft or Space Flight must be completed in their respective sequence for credit. If MAE 331 is elected MAE 335 should be taken concurrently and prior to MAE 426.)

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 - Aircraft or Space Flight must be completed in their respective sequence for credit)

SENIOR YEAR

FALL
- Senior Independent Work or Senior Thesis or Senior Project
- 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 Energy Conversion and the Environment: Transportation Applications or MAE 426 Rocket and Air-Breathing Propulsion Technology
- N.T.E.
- Senior Independent Work or Senior Thesis or Senior Project

SUGGESTED TECHNICAL ELECTIVES

MSE 302 Laboratory Techniques in Materials Science and Engineering
ELE 201 Information and Signals
ELE 203 Electronic Circuit Analysis, Design and Implementation
COS 217 Introduction to Programming Systems
MAE 412 Microprocessors for Measurement and Control
MAE 434 Modern Controls
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 upperclass 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
- CEE 361/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

SPRING
- PHY 408 Modern Classical Dynamics
- MAE 442 Senior Thesis
- 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		SPRING	
MAE 511	Experimental Methods	MAE 328	Energy for a Greenhouse Constrained World
MAE 521	Optics and Lasers		
MAE 523	Electric Propulsion	MAE 555	Nonequilibrium Gas Dynamics
MAE 527	Physics of Gases	PHY 405	Modern Physics I
PHY 406	Modern Physics II	MAE 434	Modern Control
PHY 312	Experimental Physics	MAE 427	Energy Conversion and the Environment: Transportation Applications

Note: This sample Engineering Physics program is in coordination with the Mechanical Engineering program. The Aerospace program may also be followed. The Undergraduate Office can provide Requirement Forms, such as those located in the back of this booklet, for students pursuing Engineering Physics and the Mechanical Engineering Program or Engineering Physics and the Aerospace Engineering Program.

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 Senior Thesis
- CBE 415 Polymers
- CEE 361/MAE 325 Structural Analysis & Intro to Finite Element Methods
- MAE 423 Heat Transfer
- N.T.E.

SPRING
- MAE 442 Senior Thesis
- 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 Energy Conversion and the Environment: Transportation Applications 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
CBE 415 Polymers
CBE 421 Catalytic Chemistry
ELE 341 Solid-State Devices
ELE 342 Principles of Quantum Engineering
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

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 551Theory and Application of Photonic Materials and Devices
MSE 512/MAE 518 Structural Materials
MSE 513/CHM 511 Chemistry and Physics of Nanomaterials
MSE 514/CBE 544 Solid-State Properties of Polymers
MSE 515/APC 515 Random Heterogeneous Materials
MSE 516, 517/PHY 525, 526 Condensed-Matter Physics
MSE 530/CBE 531 Introduction to Nano- and Microfabrication
MSE 532/CBE 541 Polymer Synthesis
CBE 522 Colloidal Dispersions
CBE 543 Solution Properties of Polymers
CBE 553 Topics in Interfacial Chemistry
CBE 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 Applications of Computing

Students with interests in computer science may use upper class electives to satisfy the requirements of this program. Students should contact the PAC program Director for specific details, see Section VIII.

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 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.

5. Program in Engineering Physics

Students interested in engineering physics may use upper class electives to satisfy the requirements of this program. There are also pre-approved substitutions in the sophomore level MAE requirements for students participating in this program (see page 18). Students should contact the EP Program Director for specific details of the program, see Section VIII.

6. 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.

7. 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.

8. 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 PSE 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.

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 a senior(s) 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.

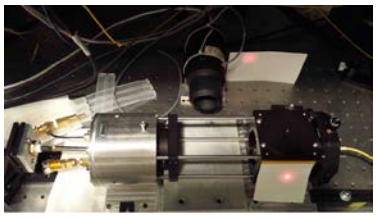
V. INDEPENDENT WORK AND STUDENT PUBLISHED PAPERS

A good indication of the interest of students in the MAE Department is the independent work they have chosen. Topics for the Class of 2014 are given below:

Aero/Astro Engineering

The Guardian: Unmanned Seaplane for Coastal Search and Rescue - S. Bonar, E. Carlson, E. Jung, P. Na, K. Skinner (Advisor – Martinelli)

Analysis and Development of a Low-Order Wavefront Sensor for Exoplanet Detection Applications - K. Cavanagh (Advisor – Kasdin)



The Ferrofluid Deformable Mirror Concept D. Chen (Advisor – Kasdin)

(a) The unfolded prototype

(b) The folded prototype

Conceptual Design of a Mobile Platform for Venus Atmospheric Study – J. Davis (Advisor – Martinelli)

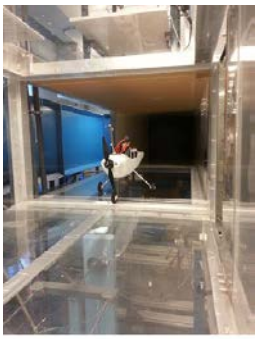
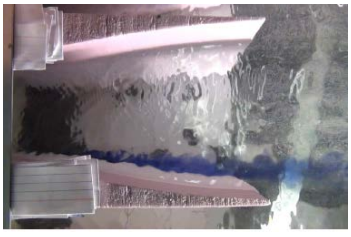


Figure 5.12: *Sensei* Wind Tunnel Test

Stability Augmentation of an Oblique Wing RC Aircraft - R. Johnson, D. Santillan (Advisor – Rowley)

Design of a Shape Memory Alloy Actuated Morphing Wing - T. DeVoe (Advisor – Martinelli)

Fluid Mechanics & Computational Fluid Dynamics



Harnessing Tidal Energy: Experimental Analysis of Optimal Contraction Ratios for Velocity Augmentation Through a Vertical Axis Tidal Turbine in a Stratford Construction – S. Gupta, E. Materniak, R. Waguespack (Advisor – Smits)

Towards Turbulent Drag Reduction on a Superhydrophobic Aluminum SLIPS Surface – K. Wang (Advisor – Hultmark)

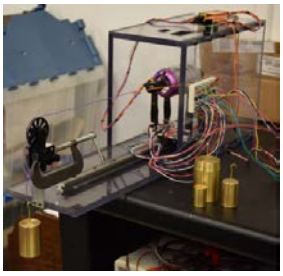
Energy and Environment

Soot Evolution in Turbulent Reacting Flows: Refining the Mesh for Bluff Body Ethylene Flames – L. Baldwin (Advisor – Mueller)

Acoustic Tuning of the Intake and Exhaust Systems of a 4-Stroke Motorcycle Engine – N. Brauser (Advisor – Littman)

The Design and Development of Three Low Cost Devices to Analyze the Characteristics of Batteries – D. Davies (Advisor – Steingart)

Design of a Low-Cost Frequency Response Analyzer for Electrochemical Impedance Spectroscopy – G. Grossman (Advisor – Steingart)



Measurement of the Thrust-Specific Fuel Consumption of a Small-Scale Jet Engine – K. Jones (Advisor – Martinelli)

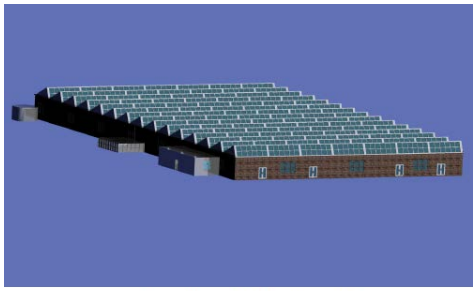


Figure 3.9: Final CAD Model of Building Design.

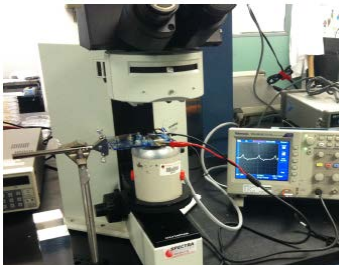
Overcoming Barriers for International Development and Poverty Reduction/ Engineering an Environmentally-Sustainable, Economic-Development Project in Sub-Saharan Africa – K. Oneil (Advisor – Van der Vink)

Weakly Buoyant Spherical Diffusion Flames: Properties of Hydrogen-CO/Ethylene Flames – L. Paxton (Advisor – Law)

(a) 5% C_2H_4 at 6 psi (b) 33% CO at 5 psi

Figure 5.5: Flame Comparison for Pressure Effect

Materials and Biomaterials

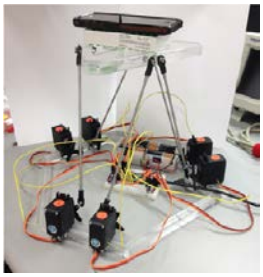


Ultrasonic Transducers for Peripheral Nerve Regeneration Studies – S. Alberti (Advisor McAlpine)

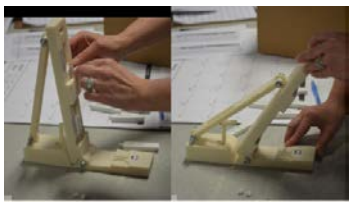
Mechanical Properties of Lithium-Ion Battery Separators – C. Leng (Advisor – Arnold)

3D Printed Biocapacitors for Sensing and Actuation – I. Trase (Advisor – McAlpine)

Humans, Machines, Components, and Controls

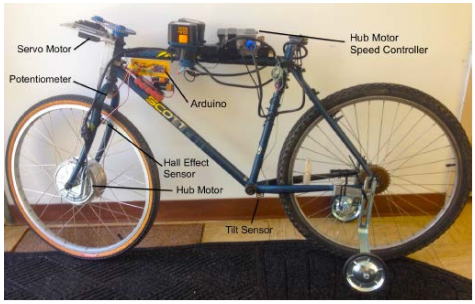


The Magic of Motion Simulation: The Design and Fabrication of a Model Stewart Platform Capable of Replicating Real-World Applications - J. Adelson (Advisor – Kasdin)



Workplace Design for the Disabled: Modifying an Assembly Sequence - B. Aktas (Advisor – Stone)

Asteroid Exploratory Robot (AER) – A. Boohene, D. Newill-Smith, T. Trieu (Advisor – Stengel)

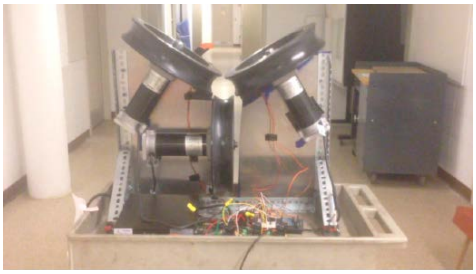


Active Control for a Riderless Bicycle – D. Chin (Advisor – Rowley)

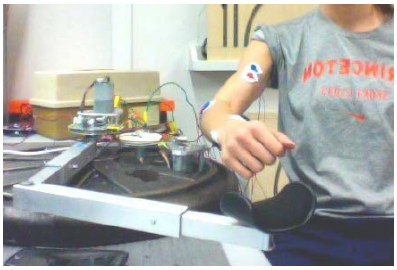
Design of a Jigsaw-Puzzle Solving Robot – B. Fisher (Advisor – Stengel)

The Hyperloop: A Top-Down Systems Engineering Evaluation of the Technical and Economic Feasibility – B. Hallin (Advisor – Nosenchuck)

L'Arrivee D'un Train en gare de Princeton Junction: Multiple Sweet Spot Binaural 3D Audio for Active Stereoscopic 3D Video – K. Hochgraf (Advisor – Choueiri)



Surpassing the Age of the Pitcher: Design for a Higher-Precision baseball Pitching Machine – M. Kelley (Advisor – Nosenchuck)

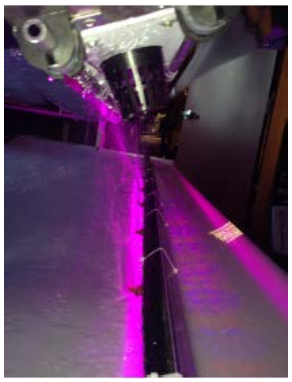


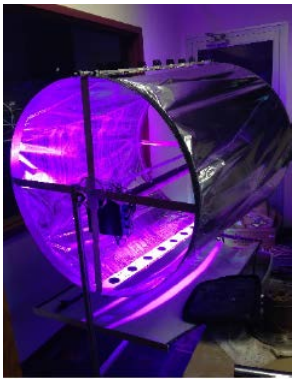
Moving an Immovable Limb: Prototyping a Low Cost Simplified Robotic Exoskeletal Arm Mobility Aid – C. Odabashian (Advisor – Littman)

No Force Necessary: Turning on the Targeting Computer with Polynomial Trajectory Estimation and Quadcopter Control – T. Matchen (Advisor – Holmes)

An Introduction to Electronics for Advanced High School Students – S. Modi (Advisor – Littman)

The Effect of a Flywheel on the Stability of a Riderless Bicycle – K. O'Neil (Advisor – Arnold)

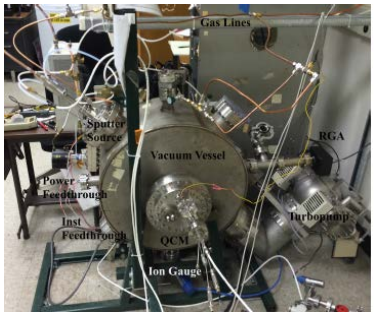




Growing Closer Aeroponic System – W. Tinsman (Advisor – Nosenchuck)

Bicycle Shimmy: An Analytical and Experimental Inquiry – N. Tyrell (Advisor – Rowley)

Applied Physics/Plasma Physics



Characterization of Thermal Desorption from Hydrogen-Carbon Co-Deposition Layers for Fusion Applications via Crystal Microbalance Measurements with Gallium Orthophosphate Crystals – A. Creely (Advisor – Jaworski)

Generation of the Magnetic Null Field Topography in a Novel Electric Propulsion Proof-of-Concept – C. Kelly (Advisor – Choueiri)

Computational Investigation of the Magnetic Nozzle – A. Macdonagh (Advisor – Choueiri)

An Approach to Cell Characterization for Filtered Rayleight Scattering Used in High Speed Flow Diagnostics – J. Shim (Advisor – Miles)

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:

- Development of a Mars Ascent Vehicle Using In-Situ Propellant Production, 2014 AIAA Space Ops Conference, May 2014, Pasadena, CA (L. Paxton, D. Vaughan)

- Propagation of Orbital-Angular-Momentum Carrying Beams Through a Pertubing Medium, Journal of Optics, September 13 (A. Chaibi, C. Mafusire, A. Forbes)

- In The Dance Studio: Analysis of Human Flocking, 2012 American Control Conference, Montreal (N. Leonard, G. Young, K. Hockgraf, D. Swain, A. Trippe, W. Chen, and S. Marshall)

- Experimental Characterization of Three-Dimensional Corner Flows at Low Reynolds Numbers, J. Fluid Mechanics, Vol. 707, September 2012, pp 37-52 (J. Sznitman, L. Guglielmini, D. Clifton, D. Scobee, H.A. Stone, and A.J. Smits)

- Localized Microwave Plasma Grid by Laser-Designation, AIAA-2011-4000, 42nd Plasmadynamics and Lasers Conference in conjunction with the 18th International Conference on MHD Energy Conversion (ICMHD), Honolulu, Hawaii (M.R. Edwards et al.)

- 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, 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 Interfermometer, 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)

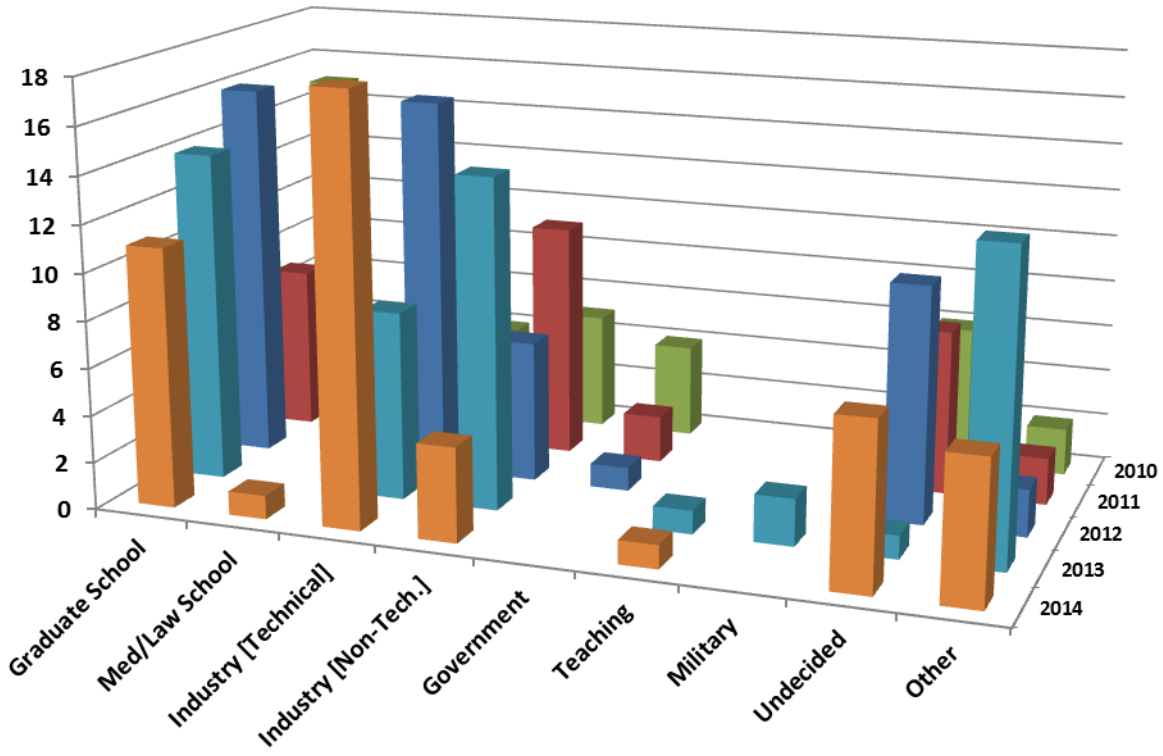
- A Knowledge-Based System For Controlling Automobile Traffic, Proceedings of the Third Conference on CLIPS, Houston, Sept 1994 (R. Stengel, A. Maravas).

- 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 2010 through 2014 are charted below.



VII. FACULTY RESEARCH INTERESTS

Craig B. Arnold	Research in the general area of materials synthesis and processing with interests in light-matter interactions, advanced optics, and energy storage and conversion. Current projects include laser-induced microfluidic jetting, high-speed adaptive optics for novel imaging and materials processing, photoresponsive materials for photonic applications, mechanics of batteries, and non-traditional chemistries for energy storage systems. Research includes a mix of both experimental and theoretical projects ranging from fundamental science through product commercialization.
Emily Carter	Development of efficient and accurate quantum mechanics techniques to characterize metal alloys for lightweight vehicles, materials for solar energy conversion (photovoltaics for electricity and photoelectrocatalysts for fuels) and liquid metal walls for plasma facing components of fusion reactors.
Edgar Y. Choueiri	Spacecraft propulsion, plasma dynamics, astronautics, space plasma physics, acoustics, 3D audio, sound perception and localization.
Frederick L. Dryer *(Emeritus)*	Environmental/energy/propulsion areas. Conventional and alternative fuels, engine emissions, microgravity research, experimental and numerical study of combustion and chemical kinetics. Developing methods to emulate real fuel property effects on applied combustion design. Research involvement on several levels of experimental work Including autoignition properties of alternative fuels, and sooting studies.
Alexander Glaser	Research focuses on the technical aspects of nuclear-energy use and related fuel-cycle technologies, and specifically on questions related to the proliferation of nuclear weapons. Analyses are supported by computer simulations of reactors. Additional projects on nuclear nonproliferation and disarmament, including nuclear forensics and nuclear archaeology. Web: http://nuclearfutures.princeton.edu
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, dislocation dynamics, mechanics of bulk metallic glasses, and evolving microstructures in biology.
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.

Marcus Hultmark	Research interests are in experimental and theoretical fluid mechanics, mainly focusing on the turbulent regime. Problems involving turbulent heat, mass and momentum transfer are being studied, including atmospheric flows, renewable energy and drag reduction. A unique laboratory setup to test wind turbines at conditions experienced by full size turbines is being developed.
Yiguang Ju	Energy conversion by using alternative fuels. Non-equilibrium plasma assisted combustion for propulsion systems. Advanced laser diagnostics and imaging of combustion processes. Multi-scale modeling of combustion in propulsion systems. Synthesis of functional nanomaterials for energy and biological applications.
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.
Egemon Koleman	Research focuses on the application of dynamics and control theory to experimental plasma physics, primarily to address the challenges of fusion reactor design. I analyze the dynamics of complex plasma phenomena using applied mathematics and control theory with the aim of designing and implementing novel control techniques, which I then use to build real-time control systems from the ground up. Current research includes reduction of the heat flux to the fusion reactor vessel using advanced magnetic divertor configuration, detachment, and radiation control; and disruption avoidance against instabilities such as Neoclassical Tearing Modes and Resistive Wall Modes.
Sau Hai Lam *(Emeritus)*	Theoretical reacting gas dynamics, Langrangian 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	Study of Joseph Henry's scientific instruments and Terrestrial Planet Finder (TPF). The history of engineering effort is centered on understanding the technical details of Joseph Henry's scientific experiments and instruments. Joseph Henry was a Professor of Natural Philosophy at Princeton College in the period, 1832-1846. 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. Prof. Littman also supervises student projects for improving teaching materials associated with his courses on microcomputer control, the history of engineering, and motorcycle design.
Luigi Martinelli	Computational Fluid Dynamics for high Reynolds number flow on complex shapes: theory, software implementation and utilization. Aerodynamic shape optimization for aeronautical and marine applications. Applied Aerodynamics for aircraft, ships, cars and wind/tidal turbines.
Michael McAlpine	Research activities in the McAlpine Group have focused on nanotechnology-enabled approaches to interfacing materials with vastly distinct mechanical properties, for fundamental investigations in the biomedical and energy sciences. Current work in particular focuses on two broad research themes: Nanoscale Piezoelectrics and Biomimetic Nanosensing. The development of a method for interfacing high performance inorganics with flexible, stretchable, and biocompatible polymers could yield breakthroughs in implantable or wearable systems. Yet, most high quality materials are hard or rigid in nature, and the crystallization of these materials generally requires high temperatures for maximally efficient performance. These properties render the corresponding devices incompatible with temperature-sensitive soft materials such as plastic, rubber, and tissue. Nanotechnology provides a route for overcoming these dichotomies, by altering the mechanics of materials while improving their performance.
Julia Mikhailova	Attosecond science, generation of attosecond pulses, light-matter interaction; ultrafast optics, generation and applications of ultrashort light pulses with the controlled carrier-envelope phase; optical parametric chirped pulse amplification; high-field physics, relativistic laser-plasma interaction, relativistic high-harmonic generation, laser-driven particle acceleration, quantum optics, entanglement of quantum states, biphoton states in spontaneous parametric scattering of light, fllamentation of light packets in air and solids; waveguides, nonlinear fiber optics, photonic-crystal fibers; nanowaveguide sensors.

Richard B. Miles *(Emeritus)*	Prof. Miles' research focuses on the use of lasers, electron beams, microwaves and magnetic devices to observe, control, accelerate, extract power and precondition gas flows for supersonic and hypersonic fluid dynamics, diagnostics and propulsion applications. He is currently examining microwave control of flame propagation, laser designated microwave driven ignition processes, the stand-off detection of molecules by laser/microwave techniques, the optimization of dielectric barrier discharge control of flows, the role of high-power microwaves, electron beams and lasers in driving and controlling aerodynamic phenomena, MHD and thermionic power extraction, magnetic interactions with high speed materials, and plasma flow control and drag reduction of hypersonic vehicles.
Michael E. Mueller	High-fidelity numerical modeling of turbulent combustion. Specific interests include modeling of soot and NOx emissions, radiation, mixed-mode combustion, turbulent mixing, spray combustion, and thermo-acoustic instabilities. Uncertainty quantification for turbulent combustion simulations. Numerical methods for complex geometries and algorithms for high-performance parallel computing. Applications to reciprocating engines, aircraft engines, and stationary gas turbines.
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.
Alexander J. Smits	The study of turbulent flows, new surfaces for drag reduction, fish-like propulsion systems, wind turbines, and the development of new experimental techniques.
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.
Dan Steingart	The relationship between energy and materials, particularly in the electrochemical domain, with an emphasis on novel electrochemical energy storage systems. His energy research focuses on printed microstructured electrodes as well as large-scale electrochemical energy storage.
Robert F. Stengel	Aerospace dynamics and control, robotics and intelligent systems, optimal control and estimation, systems biology.
Howard A. Stone	Research interests are in fluid dynamics, widely interpreted, and include a combination of experiment, theory, simulation and modeling. The studies are oriented towards flow problems where viscous effects are significant. The Stone group has active projects involving multiphase flows in microfluidic devices, thin film flows, high-speed imaging of flow phenomena, investigations in bioengineering such as cellular-scale hydrodynamics, formation of biofilms, etc. Many projects occur at the boundaries of traditional disciplines.
Szymon Suckewer	Prof. Suckewer and his group's interest and research revolve around ultra-short pulse lasers and their applications. Especially exciting are the medical applications of fsec-type lasers (in 100 fsec light travels a distance equal to1/3 the diameter of a strand of human hair), which due to their very short pulses they act like very sharp scalpels. Prof. Suckewer's group is using such lasers for a new type of eye surgery and for dermatology treatments. They are also using these types of lasers, but with extremely high intensity, for the development of X-ray lasers for applications in X-ray microscopy of biological cells. Besides applications and development of a new type of lasers they are also involved in improving the performance of internal combustion and jet engines by means of development of high volume plasma traveling spark ignition (TSI).

FACULTY AVAILABLE FOR CONSULTATION:

Barrie S. H. Royce *(Emeritus)*	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.

VIII. WHO TO SEE FOR MORE INFORMATION

Normally, Freshmen who choose to pursue Engineering in this Department have their course selections for the Sophomore year approved by the Departmental Representative. Sophomore Class Advisors for course selections are: Prof. Michael G. Littman (A – M); Prof. Luigi Martinelli (N - Z).

Upperclass students are assigned an academic advisor in the Department according to their area of interest (Aerospace Engineering, Mechanical Engineering, Interdepartmental Certificate Programs). 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 jolove@princeton.edu

Upperclass Advisors:

Class of 2015:

Professor Craig Arnold, D410, E-Quad, Ext. 8-0250, cbarnold@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 Richard Miles, D414, E-Quad, Ext. 8-5131, miles@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 Daniel Steingart, D438, E-Quad, Ext. 8-1257, steingart@princeton.edu

Class of 2016:

Professor Craig Arnold, D410, E-Quad, Ext. 8-0250, cbarnold@princeton.edu

Professor Marcus Hultmark, D222, E-Quad, Ext. 8-0314, hultmark@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 Julia Mikhailova, D302-D, E-Quad, Ext. 8-7154, jm41@princeton.edu

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

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

Engineering Biology:

Professor Michael Littman, D202-A, E-Quad., Ext. 8-5198

Engineering Physics:

Professor Edgar Choueiri, EP Lab E-Quad. or D432, E-Quad., Ext. 8-5220

Robotics and Intelligent Systems:

Professor Robert Stengel, D202-C, E-Quad., Ext. 8-5103

Sustainable Energy:

Professor Yiguang Ju, D330, E-Quad, Ext. 8-5644

Student Departmental Committee and Other Student Committees:

MAE Undergraduate Student Council:

President: *Nicole Schiavone '15 nschiavo@princeton.edu*

ASME (American Society of Mechanical Engineers) and
AIAA (American Institute of Aeronautics and Astronautics)* (Current Officers)*:

Faculty Advisor AIAA: *Richard Miles, miles@princeton.edu*

Faculty Advisor ASME: *Mikko Haataja, mhaataja@princeton.edu*

President: *Karena Cai '15, kcai@princeton.edu*

Treasurer: *Eric Principato '16, erictp@princeton.edu*

Student Outreach Coordinators: *Daniel Zirkel '16, dzirkel@princeton.edu*

Rosa Ciummo '16, rciummo@princeton.edu

Webmaster: *Hafeez Sulaimon '15, sulaimon@princeton.edu*

Student Outreach Chair: *Francois Charpentier '16, fcharpen@princeton.edu*

SAE and Formula SAE (Society of Automotive Engineering):

Faculty Advisor: *Yiguang Ju, yju@princeton.edu*

Princeton Racing Electric: *Hafeez Sulaimon '15, sulaimon@princeton.edu*

Interdepartmental Programs (For Academic Year 2014-2015):

Program in Applied & Computational Mathematics
Director: Peter Constantin – const@math.princeton.edu
206 Fine Hall, Phone: 8-6303

Program in Applications of Computer
Director: Jaswinder P. Singh – jps@princeton.edu
423 Computer Science, Phone: 8-5329

Program in Engineering Biology
Director: Celeste Nelson – celesten@princeton.edu
303 Hoyt Chemical Laboratory, Phone 8-8851

Program in Engineering and Management Systems
Director: Warren Powell – powell@princeton.edu
Sherrerd Hall 230, Phone: 8-5373

Program in Engineering Physics
Director: Edgar Choueiri – choueiri@princeton.edu
EP Lab E-Quad or D-432 E-Quad, Phone: 8-5220

Program in Materials Science & Engineering
Director: Craig Arnold – cbarnold@princeton.edu
D422 E-Quad, Phone 8-0250
Education Coordinator: Sandra Lam – sclam@princeton.edu
Bowen Hall 321, Phone: 8-6704

Program in Robotics and Intelligent Systems
Director: Robert Stengel – stengel@princeton.edu
D-202C E-Quad, Phone: 8-5103

Program in Sustainable Energy
Director: Yiguang Ju – yju@princeton.edu
D-330 E-Quad, Phone: 8-5644

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, Office of International Programs. 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, the University of Sydney/Australia, Indian Institute of Technology/India, the University of Edinburgh/Scotland, University of Manchester, and the University of Cantabria/Spain.

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
D202-A, E-Quad
8-5198,
mlittman@princeton.edu

Dean Nancy Kanach
355 - 36 University Place
8-5524
nkanach@princeton.edu

Dean Peter Bogucki
C205, E-Quad
8-4554
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Study Abroad Home Page:
http://www.princeton.edu/oip/sap/

NOTES

APPENDIX I
REQUIREMENT FORMS

Aerospace Engineering Program

Name:	*Year:*	*Advisor:*

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 (15 courses required)

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**			
Required Technical	**MAE 331 or 341**		**CEE 361 or 312**		**MAE 335**	
Electives (5)	**MAE 433**		**MAE 426 or 427**			
Senior IW -or-	**MAE 439**		**MAE 440**		**One Semester of independent**	
Senior Thesis -or-	**MAE 442**				**work is required. More than**	
Senior Project	**MAE 444**				**one suggested.**	
Aero Requirements: *Checklist*	**MAE 321, MAE 331/341 or MAE 332/342, MAE 335, MAE 427/426, MAE 433, Materials, CEE361(MAE325)/CEE312, Sr. IW or Sr. Thesis or Sr. Project - satisfies 3rd Design Requirement**					

	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

****Third Design requirement will be satisfied by either Senior Independent Work, Senior Thesis, or Senior Project***

Revised for AY 14/15

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 103/104, 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
CEE 477 Engineering Design for Sustainable Development (for students participating in the Sustainable Energy Program)

Mechanical Engineering Program

Name:	*Year:*	*Advisor:*

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*		

DEPARTMENT REQUIREMENTS (15 courses required)

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***			
Math Elective (1)						
Required Technical	**MAE 335 or 423**		**CEE 361 or 312**		**Tech Elective**	
Electives (4)	**MAE 433**					
Senior IW -or-	**MAE 439**		**MAE 440**		**One Semester of independent**	
Senior Thesis -or-	**MAE 442**				**work is required. More than**	
Senior Project	**MAE 444**				**one suggested.**	
Mech Requirements:	**MAE 321, MAE 322/412, MAE 335/423, Math Elective, TE, MAE 433, Materials**					
Checklist	**CEE361(MAE325)/CEE312, Sr. IW or Sr. Thesis or Sr. Project - satisfies 3rd Design Requirement**					

	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***

*****Third Design requirement will be satisfied by either Senior Independent Work, Senior Thesis, or Senior Project***

Revised for AY 14-15

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 103/104, CHM 201 and COS 126

Suggested Second Math Course:
MAE 306 (MAT 392) 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 380/ELE 380)
COS 340 Reasoning About Computation
MAT 330 Complex Analysis with Applications
MAT 393 Mathematical Programming
PHY 403 Mathematical Methods of Physics

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
CEE 477 Engineering Design for Sustainable Development (pre-approved as Mech Design for those students enrolled in the Sustainable Energy Program)

Technical Electives:
CB3 341 Mass, Momentum, and Energy Transport (may replace MAE 423 Heat Transfer)

Mechanical and Aerospace Engineering Programs

Name:	***Year:***	***Advisor:***

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 (total of 17 courses required)

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 (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	**MAE 331/341 (AE)**		**MAE 335 (AE/ME)**		**MAE 427/426 (AE)**	
Electives (5)	**MAE 433 (AE/ME)**		**CEE361/312 (AE/ME)**			
Senior IW -or-	**MAE 439**		**MAE 440**		**One Semester of independent**	
Senior Thesis -or-	**MAE 442**				**work is required. More than**	
Senior Project	**MAE 444**				**one suggested.**	

Aero Requirements:	**MAE 321, MAE 331/341 or MAE 332/342, MAE 335, MAE 427/426, MAE 433, Materials,**
Checklist	**CEE361(MAE325)/CEE312, Sr. IW or Sr. Thesis or Sr. Project - satisfies 3rd Design Requirement**
Mech Requirements:	**MAE 321, MAE 322/412, MAE 335/423, Math Elective, TE, MAE 433B, Materials**
Checklist	**CEE361(MAE325)/CEE312, Sr. IW or Sr. Thesis or Sr. Project - satisfies 3rd Design Requirement**

	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***

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

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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

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ORF 245 Fundamentals of Engineering Statistics
ORF 307 Optimization
ORF 309 Probability and Stochastic Systems (MAT 380/ELE 380)
COS 340 Reasoning About Computation
MAT 330 Complex Analysis with Applications
MAT 393 Mathematical Programming
PHY 403 Mathematical Methods of Physics

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MAE 322 Mechanical Design
MAE 332 Aircraft Design
MAE 342 Space System Design
MAE 412 Microprocessors for Measurement and Control
CEE 477 Engineering Design for Sustainable Development (pre-approved as Mech Design for those students enrolled in the Sustainable Energy Program)