Civil engineers apply sophisticated analysis and design techniques to advance the needs of society for shelter, infrastructure, and a safe environment. Graduates are employed in the fields of structural analysis and design, soil mechanics and foundation design, environmental engineering and policy, materials engineering, and coastal and ocean engineering, and increasingly are taking on far-reaching management roles in infrastructure, hazard mitigation, sustainability, and technical roles in the planning, design, and construction of large-scale engineered systems. In addition, a civil engineering degree provides exposure to broad societal challenges and the logical thinking necessary for pursuing careers in other professional fields, such as law, business, and medicine.

The Department of Civil Engineering offers programs at the undergraduate, graduate, and postdoctoral levels. Civil Engineering at Johns Hopkins offers a unique balance centered in mechanics fundamentals, and enriched by state-of-the-art tools in modeling, simulation, and physical experimentation. The small size of the CE Department fosters a collegial, close-knit relationship between the students, staff, and faculty, while our partnerships with other Johns Hopkins departments provide a wide range of collaborative opportunities that span the larger disciplines of systems, structures, and materials. A wide range of research opportunities distinguishes the program. Students have participated in projects on structural reliability, earthquake resistance of structures, testing and analysis of historic bridges, computational design of materials, failure of brittle materials, cold-formed steel members and their connections, and structural fire to name a few. A five-year bachelor's/master's degree program is also offered. Graduates of Johns Hopkins University have traditionally risen to leadership roles in education, research, industry, and government.

The Department sponsors an undergraduate and graduate seminar series, as well as the Richard J. Carroll endowed lectureship; all of which are designed to bring prominent civil engineers to campus to speak with students and faculty.

Facilities
The Department’s teaching and research labs are located in Latrobe Hall. Teaching laboratories include a modern multi-use facility for exploring experiments in statics, mechanics of materials, dynamics and other courses, and a dedicated soil mechanics laboratory. Research laboratories include the Thin-walled Structures Laboratory, Structural Testing Laboratory, a Structural Materials Laboratory at High Temperature Laboratory. The Department also possesses its own 3-D printer, fabrication facilities for the purposes of building and maintaining equipment and experiments. The Civil Engineering High Performance Cluster (CE-HPC) is a medium scale high performance computing cluster used primarily for undergraduate research. We are also pleased to provide an undergraduate Design Studio and computer lab, as well as office space for doctoral students and a graduate student lounge.

Undergraduate Programs
The Department of Civil Engineering offers an undergraduate program that strives to educate intellectual leaders of the profession by instilling in them a fundamental understanding of the mathematical and physical principles that underlie civil engineering science, an appreciation for the challenges of creative engineering design, and a sense of responsibility for professional service. Civil Engineering is a broad field with many subdisciplines. The Civil Engineering curriculum exposes students to the fields of structural engineering, engineering mechanics, systems engineering, environmental engineering, water resources, and geotechnical engineering.

The program has the following as its objectives:

1. That within a few years of graduation, our graduates will attain:
   a. an advanced degree in engineering or
   b. required experience toward professional licensure as an engineer, or
   c. an advanced degree in a field other than engineering, or
   d. a position within an organization that broadly supports the goals of civil engineering;

2. a position or degree that values adaptability and innovation in their work.

Students graduating with a B.S. in civil engineering will have demonstrated:

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. an ability to communicate effectively with a range of audiences
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

The program has been accredited by the Engineering Accreditation Commission of ABET since 1936.

Requirements for the B.S. Degree
The B.S. degree in civil engineering requires 128 credits. A brief summary of the requirements are listed below. For more detailed information students should look at the Department of Civil Engineering website (http://engineering.jhu.edu/civil/undergraduate-studies). Each student is assigned a faculty advisor who provides the guidance needed to meet these requirements.

Note that no course listed as a requirement may be taken as Satisfactory/Unsatisfactory (S/U) and a maximum of 3 credits from the Humanities and Social Science (H/S) requirements may be taken S/U. Technical electives may be taken S/U only with the approval of the
advisor. No more than two grades of D in the required engineering and technical electives may be counted.

**Basic Sciences (20 credits)**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS.171.101</td>
<td>General Physics: Physical Science Major I</td>
<td>4</td>
</tr>
<tr>
<td>or AS.171.107</td>
<td>General Physics for Physical Majors (AL)</td>
<td></td>
</tr>
<tr>
<td>AS.173.111</td>
<td>General Physics Laboratory I</td>
<td>1</td>
</tr>
<tr>
<td>AS.171.102</td>
<td>General Physics: Physical Science Major II</td>
<td>4</td>
</tr>
<tr>
<td>or AS.171.108</td>
<td>General Physics for Physical Majors (AL)</td>
<td></td>
</tr>
<tr>
<td>AS.173.112</td>
<td>General Physics Laboratory II</td>
<td>1</td>
</tr>
<tr>
<td>AS.030.101</td>
<td>Introductory Chemistry I</td>
<td>3</td>
</tr>
<tr>
<td>AS.030.105</td>
<td>Introductory Chemistry Laboratory I</td>
<td>1</td>
</tr>
<tr>
<td>EN.510.106</td>
<td>Foundations of Materials Science &amp; Engineering</td>
<td>3</td>
</tr>
</tbody>
</table>

One additional Basic Science elective

**Mathematics (16 credits)**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS.110.108</td>
<td>Calculus I</td>
<td>4</td>
</tr>
<tr>
<td>AS.110.109</td>
<td>Calculus II (For Physical Sciences and Engineering)</td>
<td>4</td>
</tr>
<tr>
<td>AS.110.202</td>
<td>Calculus III</td>
<td>4</td>
</tr>
<tr>
<td>or AS.110.211</td>
<td>Honors Multivariable Calculus</td>
<td></td>
</tr>
<tr>
<td>EN.553.291</td>
<td>Linear Algebra &amp; Differential Equations</td>
<td>4</td>
</tr>
</tbody>
</table>

**Humanities and Social Sciences (18 credits)**

Students are encouraged to create a program of study that is supplemented by meaningful classes outside of engineering.

**Free Electives**

Select 7 credits of free electives

**Civil Engineering Fundamentals (34 credits)**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN.560.141</td>
<td>Perspectives on the Evolution of Structures</td>
<td>3</td>
</tr>
<tr>
<td>EN.560.201</td>
<td>Statics &amp; Mechanics of Materials</td>
<td>3</td>
</tr>
<tr>
<td>EN.560.211</td>
<td>Statics and Mechanics of Materials Laboratory</td>
<td>1</td>
</tr>
<tr>
<td>EN.560.202</td>
<td>Dynamics</td>
<td>4</td>
</tr>
<tr>
<td>EN.560.206</td>
<td>Solid Mechanics &amp; Theory of Structures</td>
<td>3</td>
</tr>
<tr>
<td>EN.560.207</td>
<td>Civil Engineering Undergraduate Research Labor</td>
<td>1</td>
</tr>
<tr>
<td>EN.500.113</td>
<td>Gateway Computing: Python</td>
<td>3</td>
</tr>
<tr>
<td>EN.560.305</td>
<td>Soil Mechanics</td>
<td>4</td>
</tr>
<tr>
<td>EN.560.320</td>
<td>Structural Design I</td>
<td>3</td>
</tr>
<tr>
<td>EN.560.325</td>
<td>Structural Design II</td>
<td>3</td>
</tr>
<tr>
<td>EN.560.348</td>
<td>Probability &amp; Statistics in Civil Engineering</td>
<td>3</td>
</tr>
<tr>
<td>EN.570.351</td>
<td>Introduction to Fluid Mechanics</td>
<td>3</td>
</tr>
</tbody>
</table>

**Professional Practice (12 credits)**

In preparation for Professional Practice, students must also take the Fundamentals of Engineering (FE) exam in the spring of their senior year.

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN.661.110</td>
<td>Professional Writing and Communication</td>
<td>3</td>
</tr>
<tr>
<td>EN.660.361</td>
<td>Engineering Business and Management</td>
<td>3</td>
</tr>
<tr>
<td>EN.560.451</td>
<td>Civil Engineering Design I</td>
<td>2</td>
</tr>
<tr>
<td>EN.560.452</td>
<td>Civil Engineering Design II</td>
<td>3</td>
</tr>
<tr>
<td>EN.560.491</td>
<td>Civil Engineering Seminar I</td>
<td>.5</td>
</tr>
<tr>
<td>EN.560.492</td>
<td>Civil Engineering Seminar II</td>
<td>.5</td>
</tr>
</tbody>
</table>

**Technical Areas, select 4 (12 credits)**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN.560.404</td>
<td>Engineering Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>EN.570.303</td>
<td>Environmental Engineering Principles and Applications</td>
<td>3</td>
</tr>
</tbody>
</table>

**Technical Electives (9 credits)**

Students have the opportunity to explore one or more of the civil engineering technical areas (engineering mechanics, environmental engineering, geotechnical engineering, structural engineering, systems engineering and water resources) in greater depth through technical electives.

**Total Credits = 128**

* ABET defines a basic science as consisting of "chemistry and physics, and other biological, chemical and physical sciences, including astronomy, biology, climatology, ecology, geology, meteorology, or oceanography"; there are several courses offered by the Department of Earth and Planetary Sciences that may be used here, including 270.220 Dynamic Earth. Faculty advisors can provide more guidance when needed.

** Classes in the Humanities and Social Behavioral Sciences provide students with an appreciation for societal concerns and humanistic issues, tools that are essential for a professional who serves the public good. A minimum of 18 credits from six 3-credit H or S courses is required. One of the H/S electives must be used to fulfill a writing intensive requirement. This can either be done through AS.060.113/AS.060.114 Expository Writing or a 300-level, Writing-Intensive, H or S elective course. See the Distribution tab in the Requirements for a Bachelor's Degree (http://e-catalog.jhu.edu/undergrad-students/academic-policies/requirements-for-a-bachelors-degree) section for two exceptions to the rule that each H/S distribution course be at least 3 credits.

*** Technical electives (all required to be at or above the 300-level) are designed to provide students with greater depth in one or more of the civil engineering technical areas above. To that end, a minimum of one 3-credit technical elective must be in a civil engineering technical area. One 3-credit technical elective must have an E distribution credit, but may be a course offered outside of the traditional civil engineering areas, and one 3-credit technical elective may come from any (Q), (N), or (E) course. While the Department of Civil Engineering allows some flexibility in students’ choice of technical electives, we advise that to the extent possible, students select their technical electives from within the department’s offerings.

**Sample B.S. Program**

To view a sample civil engineering program, visit the Civil Engineering website and click on Undergraduate Studies, Academic Advising or click here. (https://engineering.jhu.edu/civil/undergraduate-studies/sample-curriculum)This sample illustrates the general sequence of courses; individual programs may vary as a result of AP credits, study abroad, or pursuit of a minor in another department.

**Minor in Civil Engineering**

This program is available to nondepartmental majors only who would like an overview of the principles of civil engineering. In addition to the prerequisite courses of AS.171.101 General Physics: Physical Science Major I for Physical Science Majors, AS.110.108 Calculus I, and AS.110.109 Calculus II (For Physical Sciences and Engineering), 18 credits are required for the minor, including 11 credits from fundamental civil engineering courses and 6 credits from a two-course sequence in
one of three civil technical areas (geotechnical engineering, structural engineering, or systems engineering). No D grades can be counted toward the minor.

EN.560.141 Perspectives on the Evolution of Structures 3
EN.560.201 Statics & Mechanics of Materials 3
EN.560.211 Statics and Mechanics of Materials Laboratory 1
EN.560.206 Solid Mechanics & Theory of Structures 3
EN.560.491 Civil Engineering Seminar I .5
EN.560.492 Civil Engineering Seminar II .5

Students must choose to focus in one of the following three technical areas, completing two courses in one area of their choice.

Structural Engineering
EN.560.320 Structural Design I 3
EN.560.325 Structural Design II 3
EN.560.421 Architectural Engineering - Form, Function and Technology 3
EN.560.445 Advanced Structural Analysis 3

Geotechnical Engineering
EN.560.305 Soil Mechanics 4
EN.560.330 Foundation Design 3

Systems Engineering
EN.560.348 Probability & Statistics in Civil Engineering 3
EN.560.442 Equilibrium Models in Systems Engineering 3
EN.560.458 Natural Disaster Risk Modeling 3
EN.560.450 Operations Research 3

Total Credits = 18(19)

Financial Aid
Scholarships and other forms of financial assistance for undergraduates are described under Admissions and Finances (http://e-catalog.jhu.edu/undergrad-students/admissions-and-finances). In addition, some undergraduate students are employed by departmental faculty to provide assistance on research projects.

Combined Bachelor’s/Master’s Programs
The Department of Civil Engineering offers combined bachelor’s/master’s degrees. One program combines a B.S. in Civil Engineering with a Master of Science in Engineering (M.S.E.) in Civil Engineering. For students who are admitted to this program, the two degrees typically require five years total to complete. The other option combines a B.S. in Civil Engineering with a Master of Science in Engineering Management (M.S.E.M.) (http://mse.msem.engineering.jhu.edu). Formal application through the M.S.E.M. Department (http://mse.msem.engineering.jhu.edu) is required. Students enrolled in a Combined B.S./M.S.E. program are awarded a Dean’s Master’s Fellowship, covering half their tuition, after they have completed eight semesters of undergraduate study. More information about these programs can be found at http://engineering.jhu.edu/academics/combined-bachelors-masters/.

Graduate Programs
Civil engineering today is a dynamic, complex, and technologically sophisticated field. Powerful computational methods and high-strength materials offer new opportunities and new challenges. The Department of Civil Engineering offers a graduate program that is based primarily in mechanics of materials, systems, and structures. Fundamental to these areas is research in solid, structural, and stochastic mechanics. The graduate program is designed to instill in the student the fundamental theoretical concepts of mechanics as well as practical knowledge of modern materials, systems, and structural engineering. To be admitted to the program, students are expected to have graduated with an outstanding record in an appropriate undergraduate program.

Master’s Program
Our Master of Science and Engineering (M.S.E.) Program develops a sound understanding of the scientific principles upon which engineering research and practice are based. Different aspects of learning are integrated through classroom, laboratory instruction, and independent study experiences. Graduates of the program possess critical thinking skills, the ability for both independent and team problem-solving, and a sense of the excitement of engineering creativity and design. The program also develops communication skills necessary for its graduates to function in teams and to deal with other professions in public and private arenas. Its progressive education furthers student understanding of the context in which engineering is practiced in modern society. Thus, the program educates leaders for tomorrow, providing the tools and perspectives for a lifetime of learning, opportunities, and professional advancement.

Requirements for the M.S.E. Degree
After admission to the M.S.E. program, students must successfully complete one of two requirements in order to obtain the M.S.E. degree:

Course-Only MSE Requirements
The most common path for JHU Civil Engineering MSE graduates is to complete the degree through coursework alone. The MSE degree requirements are as follows:

- 8 courses, 7 of which must be technical.
- All courses must be completed at the 600-level or above.
- 4 of the 8 courses must be from Civil Engineering (EN.560.XXX or EN.565.XXX).
- First three semesters must be full-time. The fourth semester can be part-time if student satisfies all eligibility requirements.
- No more than one course with a grade lower than a B- may be counted toward the course requirements. No course with a grade lower than a C- may be counted toward the degree requirements.
- Transfer credits are not permitted.
- Enrollment in Civil Engineering Graduate Seminar (Fall – EN.560.691, Spring – EN.560.692) is required for two semesters.
- Completion of the Academic Ethics short course EN.500.603.
- Completion of Responsible Conduct of Research short course (if required) AS.360.624 or AS.360.625.

Academic advisors, in consultation with the faculty in the Department of Civil Engineering, will determine whether the 8 courses leading to this degree are appropriate and if they have been completed satisfactorily.

- Students must comply with all requirements stipulated by the Whiting School of Engineering Academic Policies and Procedures as outlined at https://engineering.jhu.edu/graduate-studies/academic-policies-procedures-graduate/.

Notes:
1. Seminars, Academic Ethics (EN.500.603) and Responsible Conduct of Research (AS.360.624/625) courses are less than 3 credits each and do not count towards minimum course requirements.
2. It is expected that the degree will be completed in one year with the student enrolling in 4 courses per semester, although in select cases students may require a third semester of study.

3. Typically limited financial support is available for M.S.E. students. Funding decisions will be made on an individual basis by the Department of Civil Engineering and will be communicated during the admissions process.

4. Students are expected to maintain a GPA of 2.6 each semester or be placed on probation. See the Probation Policy for master’s students (https://engineering.jhu.edu/civil/graduate-programs/masters-program/policies-and-procedures) for more details.

MSE with Thesis Requirements
The MSE with thesis option is primarily intended for students interested in pursuing a Ph.D. The requirements are as follows:

- 7 courses (6 of which must be technical).
- Enroll in a two-semester research sequence with research advisor.
- All courses must be completed at the 600-level or above.
- 4 of the 7 courses must be from Civil Engineering (EN.560.XXX or EN.565.XXX).
- First three semesters must be full-time. The fourth semester can be part-time if student satisfies all eligibility requirements.¹
- No more than one course with a grade lower than a B- may be counted toward the course requirements. No course with a grade lower than a C- may be counted toward the degree requirements.
- Transfer credits are not permitted.
- Enrollment in Civil Engineering Graduate Seminar (Fall — EN.560.691, Spring — EN.560.692) is required for two semesters.
- Completion of the Academic Ethics short course EN.500.603.
- Completion of the Responsible Conduct of Research short course (required) AS.360.624 or AS.360.625.
- The student must write a final thesis that is approved by the research advisor and one additional reader who will typically be a full-time Johns Hopkins Civil Engineering faculty member. Any external reader must be approved by the Chair of the Department of Civil Engineering.
- The student must present their research in a public forum attended by two members of the WSE faculty or other faculty approved by the Chair of the Department of Civil Engineering.
- Academic advisors, in consultation with the faculty in the Department of Civil Engineering, will determine whether the courses leading to this degree are appropriate and if they have been completed satisfactorily.
- Students must comply with all requirements stipulated by the Whiting School of Engineering Academic Policies and Procedures as outlined at https://engineering.jhu.edu/graduate-studies/academic-policies-procedures-graduate/.

The MSE with thesis program is expected to be completed in 3-4 semesters with the student enrolled in 2-3 courses per semester in addition to research. Summer research is typical but not necessary and is left to the discretion of the student and advisor.

Notes:
1. Seminars, Academic Ethics (EN.500.603) and Responsible Conduct of Research (AS.360.624/625) courses are less than 3 credits each and do not count towards minimum course requirements.
2. Typically limited financial support is available for M.S.E. students. Funding decisions will be made on an individual basis by the Department of Civil Engineering and will be communicated during the admissions process.

3. Students are expected to maintain a GPA of 2.6 each semester or be placed on probation. See the Probation Policy for master’s students (https://engineering.jhu.edu/civil/graduate-programs/masters-program/policies-and-procedures) for more details.

Combined Bachelor’s/Master’s Program
All Combined Bachelor’s/Master’s students must meet the requirements stipulated above for the respective MSE program (course-only or thesis program) with the following exception:

- The Department of Civil Engineering will accept one course from JHU undergraduate studies at the 400-level or above toward the course requirements listed above.

Notes:
1. See the Department Academic Program Coordinator, or Director of Graduate Studies to determine if you are eligible for part-time status.

Ph.D. Program
The PhD program at the Johns Hopkins University Department of Civil Engineering aims to inspire the leaders of tomorrow to take on the challenge of creating and sustaining the built environment that underpins our society. Focal research areas in the Department include structural engineering, structural mechanics, probabilistic methods, hazards management, and systems engineering.

The small size of the CE Department fosters a collegial, close-knit relationship between the students, staff, and faculty, while our partnerships with the Mechanical Engineering, Biomedical Engineering, Materials Science & Engineering, Applied Mathematics & Statistics, Departments of Environmental Health and Engineering, Emergency Medicine, Public Health, and other John Hopkins groups provide a wide range of opportunities that surpasses those of much larger programs.

Students graduate from the program with a sense of the responsibility that the civil engineering profession accepts for applying the principles of engineering sciences for the betterment of the built environment and society. Its graduates have an appreciation of professional ethics and the value of service to their profession and society through participation in technical activities, and in community, state and national organizations.

Requirements for the Ph.D. Degree
There are a number of Whiting School of Engineering policies related to Ph.D. students, which are listed at http://engineering.jhu.edu/graduate-policies. Ph.D. student requirements for the Civil Engineering Department include:

- 8 Courses, at the 600- or 700-level, completed with a grade of B or better
- Department Qualifying Examination (DQE)
- Graduate Board Oral Examination (GBO)
• Responsible Conduct of Research short course (AS.360.625) and Academic Ethics (EN.500.603) short course
• Final Ph.D. Thesis Defense

**Typical Timeline for Ph.D. Students**

**Year 1 Fall:**
- Arrival prior to start of classes
- Selection of first semester courses (typically 4) with Director of Graduate Studies or research advisor
- Language/communication testing and placement for International Students
- Responsible Conduct of Research (AS.360.625) short course (https://engineering.jhu.edu/wse-research/resources-policies-forms/responsible-conduct-of-research)
- Academic Ethics (EN.500.603) short course
- First semester coursework and research
- Determination of permanent advisor in first semester

**Year 1 Interim:**
- Interim session research
- Department Qualifying Exam (DQE) (completed in early January)
- Annual review completed by January 31

**Year 1 Spring:**
- Second semester coursework and research

**Year 1 Summer:**
- Research

**Year 2 Fall:**
- Research
- Coursework (typically finishing up this semester)
- Ph.D. Thesis Committee Meeting required prior to end of Fall semester

**Year 2 Interim:**
- Research
- Annual review completed by January 31

**Year 2 Spring:**
- Research
- Coursework (if necessary)

**Year 2 Summer:**
- Research

**Year 3:**
- Research (Year-round)
- Ph.D. Thesis Committee Meeting
- Annual review completed by January 31
- GBO: Exact timing determined by advisor in consultation with the student

**Year 4 and Beyond:**
- Research (Year-round)
- Ph.D. Thesis Committee Meeting every Fall prior to the end of the semester
- Annual review completed by January 31

**Final semester:**
- Thesis Defense

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**Note:** Teaching assistant duties may also be assigned during one or more semesters.

**Language/Communication Testing and Placement**

All Ph.D. students who do not have a prior degree from an English speaking university must take an English Language Assessment. If it is determined at the assessment that the student needs further English language instruction, he/she will be required to take 370.602 or equivalent.

**Determination of Permanent Advisor**

In some cases students are admitted to work with a specific advisor, in which case the permanent advisor is the faculty member listed in the offer letter. In other cases students are not assigned a specific advisor at the time of the admission letter. During September and October of the first semester, these students should meet with the faculty, discuss their research interests, and learn more about the research being conducted by the faculty. By the beginning of November the student must state his/her preference(s) for a permanent advisor. The faculty will meet and determine the final advisor placements prior to the end of the semester. Every effort will be made to match students with their requested advisors, but financial constraints may not always make this possible.

A PhD student will not be able to remain in good standing with their academic and research progress if they do not have a research advisor. A student who is without a research/dissertation advisor for a period of 3 months may be placed on probation or terminated from the PhD program.

Note that it is typically not the role of a department to find an advisor for a student.

**Interim**

Interim (the period between Fall and Spring terms) is an important time for research. Interim is not a vacation. Any leave taken during interim is subject to the policies outlined in the Graduate Student Assistant Leave Guidelines (http://engineering.jhu.edu/include/content/pdf/RA_TA%20leave%20guidelines%20(FINAL).pdf). Release time (if any) granted in that period must be approved by the advisor.

**Department Qualifying Examination (DQE)**

The DQE is a comprehensive oral exam designed to determine whether or not the student is properly prepared to continue in the Ph.D. program. All first-year students studying for a Ph.D. take the DQE after their first semester of enrollment, typically in early January of the first year. This exam tests whether the student is prepared to continue in their Ph.D. studies based on their grasp of basic undergraduate-level and introductory graduate-level Civil Engineering knowledge. Possible outcomes of the exam are Pass or Fail. Only an outcome of Pass will allow the student to continue in the Ph.D. program. If the outcome of the exam is Fail, the student may pursue, with approval from the chair, a M.S.E. degree. Financial support beyond the first academic year is not typical.

**Annual Reviews**

Reviews of all Ph.D. students in Civil Engineering must be performed annually prior to January 31, and are consistent with the WSE policy found in the Graduate Student Academic Review Policy (https://engineering.jhu.edu/include/content/pdf/Acad%20Review%20Policy%20(FINAL).pdf). The review process follows the format given in the annual review form. The completed form must be submitted to the Academic Program Coordinator by January 31. If this annual review is not completed by this date, the student’s funding may be jeopardized.

**Ph.D. Thesis Committee**
Every Ph.D. student must have a Thesis Committee of at least 3 faculty members. The advisor, in consultation with his/her student, selects the makeup of the committee, and this information is recorded in the student’s file. The student is encouraged to meet with this committee a minimum of once per year. The thesis committee also typically serves as a subset of the actual GBO examination committee and forms the final Ph.D. defense committee. This committee must consist of a minimum of 2 full-time faculty of the Civil Engineering Department.

**Responsible Conduct of Research**
Every Ph.D. student of the Whiting School of Engineering is required to take the Responsible Conduct of Research course (details on the requirement can be found on the WSE Policy on the Responsible Conduct of Research Training [here](http://engineering.jhu.edu/wse-research/resources-policies-forms/responsible-conduct-of-research) webpage. For Civil Engineering students, this should be completed in the Fall or Spring of the first year of studies. Students who do not complete this requirement prior to Fall of their third year of studies may put their funding in jeopardy.

**GBO Examination**
The University maintains complete guidelines for the Graduate Board Orals here. ([here](http://homewoodgrad.jhu.edu/academics/graduate-board/degree-candidacy) The GBO committee consists of 5 members, (3 in Department, 2 outside) with 2 alternates (1 in Department, 1 outside) and is selected by the Chair of the Department and the Director of Graduate Studies, who will consult with the student’s advisor. When a Ph.D. student and advisor feel that the student is ready to take the GBO, the advisor should consult with the Director of Graduate Studies and the Civil Engineering Academic Program Coordinator to initiate the process of scheduling the exam. Both students and advisors should be aware that 4-6 weeks advance notice is needed in order to allow for scheduling the exam with the faculty and with the Graduate Board.

The exact format of each GBO examination is specified by the individual Chair of the GBO committee. The student may be requested to provide to the GBO committee prior to the examination some written document describing his or her research. In such cases, the latest annual Thesis Committee report and/or a recent conference or journal publication may suffice. It is typical that the student would be asked to provide a brief presentation of research at the beginning of the examination (no more than 10 slides, no longer than 10 minutes). The examination questions may be on any topic of the committee members’ choosing, but many of the questions relate to the student’s coursework and research. At the conclusion of the examination, the GBO committee may recommend pass, conditional pass, fail with re-examination, fail (final) as detailed here ([here](http://homewoodgrad.jhu.edu/academics/graduate-board/graduate-board-oral-exams)).

**M.S.E. Degree for Ph.D. Students**
Ph.D. students may petition for a M.S.E. degree following their GBO Examination. If the student passes the GBO, he/she may file for a non-terminal M.S.E. degree. If the student fails (final) the GBO, he/she may petition for a terminal M.S.E. degree. In all instances the students must have satisfied the M.S.E. degree course requirements as detailed here ([here](http://engineering.jhu.edu/civil/graduate-studies/mse-requirements)).

In instances where the research is highly interdepartmental, the student, with permission of the advisor, may request that the M.S.E. degree be awarded by another department in the Whiting School of Engineering. In such cases, the student must have satisfied M.S.E. degree requirements and receive the approval of, and an accepted application to, the awarding Department, as well as satisfied M.S.E. degree requirements of the Civil Engineering Department and receive approval from the Civil Engineering Chair. In all cases, the awarding of any JHU M.S.E. degree to a Civil Engineering Ph.D. student may only occur after the student has completed the GBO exam.

**Thesis Defense**
The Thesis Defense is the final examination before conferral of the Ph.D. degree. The student defends his/her thesis in a seminar setting that is open to the public. The seminar is followed by a comprehensive examination of the student, focused on the thesis research.

**Ethics:** The Department of Civil Engineering is dedicated to upholding the highest standards of academic and research integrity. Plagiarism, and other forms of unethical conduct, are not tolerated. Students are referred to the JHU Graduate Board Policy ([here](http://homewoodgrad.jhu.edu/academics/policies) webpage and the Whiting School of Engineering’s Responsible Conduct of Research Policy ([here](https://engineering.jhu.edu/wp-content/uploads/2013/07/WSE_Research_Rules.pdf)) for a discussion of ethics and university policies.

**Defense Committee:** A committee of at least 3 members administers the exam (typically the Ph.D. Thesis Committee). The Advisor, in consultation with the Department, selects the committee members, at least 2 of whom must be full-time faculty of the Civil Engineering Department. This should be done at the beginning of the semester in which the student plans to graduate.

**Scheduling and Pre-Defense:** The defense should be scheduled at least 3 weeks in advance through the Department’s Academic Coordinator. A complete written dissertation should be given to the committee at least 14 days in advance of the defense. Failure to meet this 2 week deadline will result in rescheduling the Ph.D. defense. The date and place of the defense, along with the thesis abstract, should be circulated 5-7 days prior to the defense.

**Post-Defense:** Completion of the Ph.D. requirements typically takes 4-8 weeks after a successful defense examination. All data and source codes related to the thesis should be properly archived according to requirements set forth by the Advisor. Any changes or additions specifically requested by the reviewers before or during the defense seminar should be incorporated into the thesis in consultation with the Advisor. A final copy of the thesis must then be made available to the reviewers for inspection no less than 48 hours before the deadline date for filing set by the Graduate Board. A receipt of ETD [approval] email must be sent to the Academic Program Coordinator and the Graduate Board/WSE Office of Academic Affairs (for M.S.E. students).

**Additional Information:** It is the responsibility of the student to be aware of requirements and deadlines. It is suggested that this information be obtained before the start of the semester of intended graduation. All students should plan the timing of the final defense accordingly (making sure to account for the 4-8 week period following the defense) to satisfy any deadlines related to upcoming graduation or exhaustion of funding.

University requirements for the thesis can be obtained from the Sheridan Libraries ([here](https://www.library.jhu.edu/library-services/electronic-theses-dissertations) web site. Doctoral Theses must be submitted to the ETD (Library). The deadline date for filing is set by the Graduate Board Office ([here](https://homewoodgrad.jhu.edu/academics/graduate-board/deadlines)).

**Financial Aid**
A limited amount of financial assistance is available to Civil Engineering graduate students in the form of teaching assistantships, research assistantships, including fellowships from the Joseph...
Meyerhoff Scholarship Fund, the Richard D. Hickman Endowment, and the Hoones Rich Graduate Fellowship. Fellowships and Assistantships are awarded on a competitive basis and continued support is subject to the student's performance and future availability of research or teaching assistantship funds. In some cases, partial fellowships are offered to outstanding master's students.

For current faculty and contact information go to http://engineering.jhu.edu/civil/faculty/

**Faculty**

**Chair**
Lori Graham-Brady  
Professor

**Professors**
Somnath Ghosh  
Professor and Michael G. Callas Chair in Civil Engineering: computational mechanics - multi-scale multi-structure analysis and simulations, multi-physics modeling and simulation, materials characterization, integrated computational materials engineering.

Lori Graham-Brady  
Professor: stochastic finite element methods, probabilistic mechanics, stochastic simulation of material properties, micromechanics.

Takeru Igusa  
Professor: systems dynamic modeling, agent-based modeling, community resilience, structural dynamics, acoustics.

Benjamin Schafer  
Professor and Swirnow Family Faculty Scholar: thin-walled structures, structural stability, structural optimization, stochastic mechanics, steel structures, fracture mechanics, experimental methods, computational mechanics.

**Associate Professors**
Lauren Gardner  
Associate Professor: public health, bio-secure mobility, transport systems, infectious disease spread, network modeling.

James K. Guest  
Associate Professor: topology optimization, structural optimization, materials design, structural design, computational mechanics.

**Assistant Professors**
Stavros Gaitanaros  
Assistant Professor: mechanics of architected materials, large deformations and structural stability, shock formation and impact dynamics, structural DNA nanotechnology.

Thomas Gernay  
Assistant Professor: structural fire engineering, performance-based structural design, computational mechanics, community resilience assessment.

Kimia Ghobadi  
Assistant Professor: healthcare operations, medical decision making, mathematical modeling, real-time algorithms, mixed-integer programming, inverse optimization.

Michael D. Shields  
Assistant Professor: stochastic simulation, uncertainty quantification, computational stochastic mechanics.

Sauleh Siddiqui  
Assistant Professor: natural gas and crude oil infrastructure and markets, electricity markets, patient flow in hospitals, clinical trials system, global vaccination, bilevel optimization, multiobjective optimization, integer optimization and equilibrium.

**Sr. Lecturers**
Rachel H. Sangree  
Sr. Lecturer, Program Chair EP Civil Engineering: structural engineering, historic structures.

**Lecturers**
Lucas de Melo  
Lecturer (part-time): geotechnical engineering.

Matthew Farmer  
Lecturer (part-time): brick, stone, and cast stone masonry; facade assessment, repair & rehabilitation design, failure investigation, structural evaluation, testing & instrumentation, historic preservation.

John A. Matteo  
Lecturer (part-time): structural engineering and architecture, historic structures.

Edmund Meade  
Lecturer (part-time): restoration and renovation, historic preservation.

Christina Parker  
Lecturer (part-time): disaster risk modeling, natural hazard simulations, wind and structural engineering, quantitative decision making.

Joseph Rogers  
Lecturer (part-time): investigation and evaluation of building envelopes, development of building-enclosure designs, preparation of specifications and construction documents, and construction administration and monitoring.

**Associate Research Professor**
Cristopher Moen  
Associate Research Professor: mechanics and simulation of ductile and brittle materials, behavior and performance of thin-walled structures, system reliability quantification for civil infrastructure, analysis and design of steel building systems.

**Joint and Visiting Appointments**
William Ball  
Joint Appointment, Professor, Department of Environmental Health and Engineering: environmental engineering, physical and chemical processes, water quality.

Edward Bouwer  
Joint Appointment, Professor, Department of Environmental Health and Engineering: environmental microbiology, waste treatment.

J. Hugh Ellis  
Joint Appointment, Professor, Department of Environmental Health and Engineering: structural health engineering, environmental systems.
Scott Levin  
Joint Appointment, Professor, Department of Emergency Medicine: systems engineering in healthcare, optimization of hospital resources and patient outcomes.

Jonathan Links  
Joint Appointment, Director, Center for Public Health Preparedness: environmental health sciences, imaging, dosimetry, radiation, dirty bombs, OpenCourseWare, nuclear medicine, radiological terror, public health preparedness.

Alan Stone  
Joint Appointment, Professor, Department of Environmental Health and Engineering.

Adjunct Appointments  
Shahabeddin Torabian  
Adjunct Associate Research Scientist: thin-walled structures.

Professor Emeritus  
Robert A. Dalrymple  
Professor and Willard and Lillian Hackerman Chair in Civil Engineering: coastal engineering, water wave mechanics, fluid mechanics.

For current course information and registration go to https://sis.jhu.edu/classes/

Courses  
EN.560.101. Freshman Experiences in Civil Engineering. 1.0 Credit.  
An introduction to civil engineering for first-year students. This course welcomes freshmen to the major by exploring civil engineering design and the range of design projects in which professional civil engineers engage. Students will have the opportunity to practice the design process using hands-on team-based projects, with emphasis on creative design, graphical communication, and teamwork.  
Prerequisites: Students must have completed Lab Safety training prior to registering for this class. To access the tutorial, login to myLearning and enter 458083 in the Search box to locate the appropriate module.  
Corequisites: NA  
Instructor(s): R. Sangree  
Area: Engineering  
NA.

EN.560.201. Statics & Mechanics of Materials. 3.0 Credits.  
Basic principles of classical mechanics applied to the equilibrium of particles and rigid bodies at rest, under the influence of various force systems. In addition, the following topics are studied: free body concept, analysis of simple structures, friction, centroids and centers of gravity, and moments of inertia. Includes laboratory experience.  
Prerequisites: Students must have completed Lab Safety training prior to registering for this class. To access the tutorial, login to myLearning and enter 458083 in the Search box to locate the appropriate module, AS.171.101 OR AS.171.107 OR (EN.530.123 AND EN.530.124) or instructor permission.  
Corequisites: NA  
Instructor(s): R. Sangree  
Area: Engineering  
NA.

EN.560.202. Dynamics. 4.0 Credits.  
Basic principles of classical mechanics applied to the motion of particles, system of particles and rigid bodies. Kinematics: analytical description of motion; rectilinear and curvilinear motions of particles, rigid body motion. Kinetics: force, mass, and acceleration; energy and momentum principles. Introduction to vibration. Includes laboratory experience.  
Prerequisites: Students must have completed Lab Safety training prior to registering for this class. To access the tutorial, login to myLearning and enter 458083 in the Search box to locate the appropriate module.; (EN.560.201 OR EN.530.201 ) AND AS.110.109  
Corequisites: NA  
Instructor(s): L. Graham-Brady  
Area: Engineering  
NA.

EN.560.206. Solid Mechanics & Theory of Structures. 3.0 Credits.  
Application of the principles of structural analysis for statically determinant and indeterminant structures (trusses, cables, beams, arches, and frames). Calculation of internal forces and stresses in members and structures. Determination of deflections by equilibrium and energy methods. Analysis of indeterminate structures by flexibility and stiffness methods.  
Prerequisites: EN.560.201 OR EN.530.201  
Corequisites: NA  
Instructor(s): M. Shields  
Area: Engineering  
NA.

EN.560.207. Civil Engineering Undergraduate Research Laboratory. 1.0 Credit.  
Laboratory course to be taken by Civil Engineering students concurrently with EN.560.206 (Solid Mechanics & Theory of Structures).  
Prerequisites: To be taken concurrently with EN.560.206.; Students must have completed Lab Safety training prior to registering for this class. To access the tutorial, login to myLearning and enter 458083 in the Search box to locate the appropriate module.  
Corequisites: NA  
Instructor(s): M. Shields  
Area: Engineering  
NA.
EN.560.211. Statics and Mechanics of Materials Laboratory. 1.0 Credit.
The complementary laboratory course for and required corequisite to
EN.560.201 Statics and Mechanics of Materials.
Prerequisites: Students must have completed Lab Safety training prior to
registering for this class. To access the tutorial, login to myLearning and
enter 458083 in the Search box to locate the appropriate module.
Corequisites: EN.560.201
Instructor(s): R. Sangree
Area: Engineering
NA.

EN.560.220. Civil Engineering Programming. 3.0 Credits.
Civil engineering problems are formulated and then solved by numerical
methods. Matrix inversion, data fitting and interpolation, root-finding,
and solutions of ordinary and partial differential equations are
presented. Matlab programming will be introduced to facilitate the
solutions. Recommended Course Background: AS.110.106/AS.110.108,
AS.110.107/AS.110.109
Prerequisites: NA
Corequisites: NA
Instructor(s): B. Schafer
Area: Engineering
NA.

EN.560.305. Soil Mechanics. 4.0 Credits.
Basic principles of soil mechanics. Classification of soils. Compaction
theory. Consolidation seepage and settlement analysis. Stress-strain and
shear strength of soils. Introduction to earth pressure theories and slope
stability analysis.
Prerequisites: Students must have completed Lab Safety training prior to
registering for this class. To access the tutorial, login to myLearning and enter 458083 in the Search box to locate the appropriate module.
Corequisites: EN.560.206 OR EN.570.351
Instructor(s): L. de Melo
Area: Engineering
NA.

EN.560.330. Foundation Design. 3.0 Credits.
Application of soil mechanics theory and soil test results to the analysis
and design of foundations for structures; retaining walls; embankments;
design of pile and shallow footing foundations; slope stability.
Prerequisites: EN.560.305
Corequisites: NA
Instructor(s): L. de Melo
Area: Engineering
NA.

EN.560.348. Probability & Statistics in Civil Engineering. 3.0 Credits.
Application and development of the analysis of uncertainty, including
basic probability, statistics and decision theory, in civil engineering
systems. Recommended Course Background: AS.110.109
Prerequisites: Statistics Sequence restriction: Students who have completed any of these courses may not register: EN.550.310 OR
EN.550.311 OR EN.560.435 OR EN.550.420 OR EN.550.430.
Corequisites: NA
Instructor(s): S. Siddiqui
Area: Engineering
NA.

EN.560.404. Engineering Mechanics. 3.0 Credits.
This course will build a strong foundation in engineering mechanics, from
fundamental theory to computational modeling. Constitutive relations
governing various physical systems will be discussed, with a particular
focus on constitutive symmetries and characteristic failure mechanisms
corresponding to specific materials. Examples include ductile yielding
and fracture in metals, shear banding in granular materials, fracture in
composites, nonlinear inelasticity in biomaterials, and micro-buckling
in architected materials. Finite element software will be used to model
equations of these mechanisms.
Prerequisites: EN.560.206 or permission of instructor
Corequisites: NA
Instructor(s): J. Guest; L. Graham-Brady
Area: Engineering
NA.

EN.560.421. Architectural Engineering - Form, Function and Technology.
3.0 Credits.
This course will cultivate broad knowledge of the use of engineering
principles in the art of architecture. Fundamental definitions of
architecture in the basic provision of shelter and social use are paired
with aesthetics and cultural heritage. The course emphasizes structural
frameworks and systems within the Civil Engineering curriculum,
while expanding upon their critical intersections with the highly varied
specialized components and systems of modern architecture, and the
responding community of specialists that represent them. Topics
include a historical view of the evolution of specialization in architecture,
a quantitative review of loads and resistance systems, architectural and
structural determinants of form, the function and aesthetics of building
surface, and an introduction to environmental systems and their role
in design sustainability. The class will include a trip to Fallingwater, the
house designed by Frank Lloyd Wright, in western Pennsylvania, which
stands as an iconic example of American architecture and a complex
example of architectural engineering. This course is co-listed with
EN.560.621 and EN.565.621.
Prerequisites: NA
Corequisites: NA
Instructor(s): J. Matteo
Area: Engineering
NA.
EN.560.423. Bridge Engineering. 3.0 Credits.
This course will explore bridge design and analysis by studying local bridges of various forms, materials, and load demands. Topics include an overview of the history of bridge engineering, an introduction to the AASHTO Standard Specifications for Highway Bridges, analysis techniques and load ratings, bridge details, and substructure design.
Prerequisites: EN.560.320 AND EN.560.325
Corequisites: NA
Instructor(s): R. Sangree
Area: Engineering
NA.

EN.560.429. Preservation Engineering: Theory and Practice. 3.0 Credits.
The renovation of existing buildings often holds many advantages over new construction, including greater economy, improved sustainability, and the maintenance of engineering heritage and architectural character in our built environment. Yet, the renovation of existing structures presents many challenges to structural engineers. These challenges include structural materials that are no longer in widespread use (e.g., unreinforced masonry arches and vaults, cast iron, and wrought iron) as well as structural materials for which analysis and design practices have changed significantly over the last half-century (e.g., wood, steel, and reinforced concrete). This course will examine structures made of a wide variety of materials and instruct the student how to evaluate their condition, determine their existing capacity, and design repairs and/or reinforcement. The investigation and analysis procedures learned from this course may then be applied to create economical and durable structural alterations that allow for the reuse of older buildings. Site visits near Homewood campus will supplement lectures.
Prerequisites: EN.560.320 AND EN.560.325 or equivalent for graduate students.
Corequisites: NA
Instructor(s): E. Meade; M. Farmer
Area: Engineering
NA.

EN.560.431. Preservation Engineering II: Theory and Practice. 3.0 Credits.
Building on the content in Preservation Engineering I: Theory and Practice, this course will begin with materials introduced at the start of the Industrial Revolution—namely with the beginning of the use of iron materials as major structural elements within buildings. The course will continue with the introduction of cast iron, wrought iron, and finally, structural steel members. After introducing iron materials the course will continue with the early use of reinforced concrete as a major structural material. The course will discuss the historic structural analysis methods associated with such materials and contrast such methods with more modern analytical approaches. It will also discuss concrete deterioration and repair methods. Concepts related to masonry facade investigation and repair will be presented along with the analytical methods associated with thin-shell masonry construction from the 19th and 20th centuries. The course will conclude with a review of the assessment and retrofit of historic foundations. Course is co-listed with EN.560.431 and EN.560.321.
Prerequisites: EN.560.429 OR Permission from the instructor.
Corequisites: NA
Instructor(s): E. Meade; M. Farmer
Area: Engineering
NA.

EN.560.434. Structural Fire Engineering. 3.0 Credits.
This course will discuss the analysis and design of structures exposed to fire. It will cover the fundamentals of fire behavior, heat transfer, the effects of fire loading on materials and structural systems, and the principles and design methods for fire resistance design. Particular emphasis will be placed on the advanced modeling and computational tools for performance-based design. Applications of innovative methods for fire resistance design in large structural engineering projects, such as stadiums and tall buildings, will also be presented. Course is co-listed with graduate-level EN.560.634.
Prerequisites: NA
Corequisites: NA
Instructor(s): T. Gernay
Area: Engineering
NA.

EN.560.442. Equilibrium Models in Systems Engineering. 3.0 Credits.
Provide an introduction to equilibrium problems involving systems. The course will start with an introduction to optimization theory followed by various equilibrium problems including market, spatial, and network models. Solution techniques to these types of problems will be discussed, along with applications to systems engineering. Recommended Course Background: AS.110.201 and AS.110.109 or equivalent.
Prerequisites: NA
Corequisites: NA
Instructor(s): S. Siddiqui
Area: Engineering
NA.

EN.560.445. Advanced Structural Analysis. 3.0 Credits.
Matrix methods for the analysis of statistically indeterminate structures such as beams, plane and space trusses, and plane and space frames. Stiffness and flexibility methods. Linear elastic analysis and introduction to nonlinear analysis.
Prerequisites: EN.560.206
Corequisites: NA
Instructor(s): J. Guest
Area: Engineering
NA.

EN.560.450. Operations Research. 3.0 Credits.
An introduction to operations research and its applications. The course will review the basics of mathematical modelling, linear programming, primal and dual Simplex methods, post-optimization analysis, decomposition methods, and heuristic methods along with sample applications. Recommended course background AS.110.201 and AS.110.109 or equivalent.
Prerequisites: NA
Corequisites: NA
Instructor(s): K. Ghobadi
Area: Engineering
NA.
EN.560.451. Civil Engineering Design I. 2.0 Credits.  
A study of the engineering design process from problem definition to the schematic or conceptual design. There are both individual and team projects which include written and oral presentations. The students’ understanding of and communication about the built environment is exercised with three languages – Speech (written and verbal), Graphics (drawings and diagrams) and Mathematics (engineering calculations). First principles of mechanics and design procedures are connected with real world constructions and design concepts.  
Prerequisites: NA  
Corequisites: NA  
Instructor(s): B. Schafer  
Area: Engineering

EN.560.452. Civil Engineering Design II. 3.0 Credits.  
A study of the engineering design process from conceptual to the final design. There are team projects which include written and oral presentations. A common project is defined for the class, however each group is allowed freedom to develop their designs independently, which typically demonstrates the great range of design solutions to a given problem. Work during the semester takes on a design studio approach, with team engineering and regular reviews and input from the instructor. In addition to engineering calculations, students produce a 3D digital model, engineering drawings, and presentation posters with written summary. The culmination of the semester is the final presentation of their design projects in an open forum of peers, professors, and representatives from the profession.  
Prerequisites: NA  
Corequisites: NA  
Instructor(s): J. Matteo  
Area: Engineering

EN.560.453. An Introduction to Network Modeling. 3.0 Credits.  
Many real-world problems can be modeled using network structures, and solved using tools from network theory. For this reason, network modeling plays a critical role in various disciplines ranging from physics and mathematics, to biology and computer science, and almost all areas of social science. This course will provide an introduction to network theory, network flow algorithms, modeling processes on networks and examples of empirical network applications spanning transport, health and energy systems.  
Prerequisites: EN.553.291  
Corequisites: NA  
Instructor(s): L. Gardner  
Area: Engineering, Quantitative and Mathematical Sciences

EN.560.458. Natural Disaster Risk Modeling. 3.0 Credits.  
This course will introduce the student to disaster risk modeling process, including: structure of catastrophe models and uses in loss estimation and mitigation, study and modeling of hazards (esp. hurricanes and earthquakes; also flood, landslide, and volcanic), vulnerability assessment including simulation of building damage, and estimation of post-disaster injuries and casualties. Additionally topics will include, exposure modeling (building typology distribution), introduction to disaster economic loss modeling, interpretation of risk metrics (return periods, PML, AAL, VaR, TVaR), their uncertainty, and applicability to management and financial decision making process and elements of present and future risk, such as, climate and exposure changes. Students will gain introductory experience in the use of GIS and simulation with Matlab.  
Prerequisites: NA  
Corequisites: NA  
Instructor(s): G. Pita  
Area: Engineering

EN.560.491. Civil Engineering Seminar I. NA Credit.  
Seminar series of speakers on various aspects of civil engineering. Juniors and Seniors in Civil Engineering are expected to enroll in this sequence; juniors and seniors receive one-half credit. Different speakers are invited each semester. Satisfactory/ Unsatisfactory only.  
Prerequisites: NA  
Corequisites: NA  
Instructor(s): R. Sangree  
Area: Engineering

EN.560.492. Civil Engineering Seminar II. NA Credit.  
Seminar series of speakers on various aspects of civil engineering. Juniors and Seniors in Civil Engineering are expected to enroll in this sequence; juniors and seniors receive one-half credit. Different speakers are invited each semester. Satisfactory/ Unsatisfactory only.  
Prerequisites: EN.560.491  
Corequisites: NA  
Instructor(s): R. Sangree  
Area: Engineering

EN.560.493. Civil Engineering Seminar III. NA Credit.  
Seminar series of speakers on various aspects of civil engineering. Juniors and Seniors in Civil Engineering are expected to enroll in this sequence; juniors and seniors receive one-half credit. Different speakers are invited each semester. Satisfactory/ Unsatisfactory only.  
Prerequisites: EN.560.492  
Corequisites: NA  
Instructor(s): R. Sangree  
Area: Engineering

EN.560.494. Civil Engineering Seminar IV. NA Credit.  
Seminar series of speakers on various aspects of civil engineering. Juniors and Seniors in Civil Engineering are expected to enroll in this sequence; juniors and seniors receive one-half credit. Different speakers are invited each semester. Satisfactory/ Unsatisfactory only.  
Prerequisites: EN.560.493  
Corequisites: NA  
Instructor(s): R. Sangree  
Area: Engineering
EN.560.501. Undergraduate Research. 0.0 - 3.0 Credits.
Research in Civil Engineering
Prerequisites: You must request Independent Academic Work using
the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.
Corequisites: NA
Instructor(s): B. Schafer; J. Guest; M. Shields; R. Sangree; S. Siddiqui
Area: NA
NA.

EN.560.511. Group Undergraduate Research. 0.0 - 3.0 Credits.
This section has a weekly research group meeting that students are expected to attend.
Prerequisites: You must request Independent Academic Work using
the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.
Corequisites: NA
Instructor(s): B. Schafer; J. Guest; R. Sangree; S. Siddiqui
Area: NA
NA.

EN.560.525. Independent Study. 1.0 - 3.0 Credits.
NA
Prerequisites: NA
Corequisites: NA
Instructor(s): J. Guest; R. Dalrymple; S. Siddiqui; T. Igusa
Area: NA
NA.

EN.560.526. Independent Study - Civil Engineering. 0.0 - 3.0 Credits.
NA
Prerequisites: You must request Independent Academic Work using
the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.
Corequisites: NA
Instructor(s): B. Schafer; J. Guest; M. Shields; S. Siddiqui; T. Igusa
Area: NA
NA.

EN.560.536. Research in Civil Engineering. 0.0 - 3.0 Credits.
NA
Prerequisites: NA
Corequisites: NA
Instructor(s): Staff
Area: NA
NA.

EN.560.590. Civil Engineering Internship. 1.0 Credit.
NA
Prerequisites: You must request Independent Academic Work using
the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.
Corequisites: NA
Instructor(s): B. Schafer; J. Guest
Area: NA
NA.

EN.560.597. Summer Research - Civil Engineering. 3.0 Credits.
Independent academic work conducted for credit for undergraduates working with an Civil Engineering instructor.
Prerequisites: You must request Independent Academic Work using
the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.
Corequisites: NA
Instructor(s): Staff
Area: NA
NA.

EN.560.601. Applied Math for Engineers. 3.0 Credits.
This course presents a broad survey of the basic mathematical methods used in the solution of ordinary and partial differential equations: linear algebra, power series, Fourier series, separation of variables, integral transforms.
Prerequisites: NA
Corequisites: NA
Instructor(s): X. Ye
Area: Engineering, Quantitative and Mathematical Sciences
NA.

EN.560.604. Introduction to Solid Mechanics. 3.0 Credits.
Basic solid mechanics for structural engineers. Stress, strain and constitutive laws. Linear elasticity and viscoelasticity. Introduction to nonlinear mechanics. Static, dynamic and thermal stresses. Specialization of theory to one- and two-dimensional cases: plane stress and plane strain, rods, and beams. Work and energy principles; variational formulations.
Prerequisites: NA
Corequisites: NA
Instructor(s): S. Gaitanaros
Area: NA
NA.

EN.560.608. Multilevel and Multiobjective Optimization in Systems. 3.0 Credits.
This course will introduce nonlinear optimization and convexity in higher dimensions to model large-scale systems. Graduate students only. Recommended Course Background: AS.110.201 or EN.553.291, AS.110.202.
Prerequisites: EN.560.442 OR EN.560.641
Corequisites: NA
Instructor(s): S. Siddiqui
Area: Engineering
NA.

EN.560.618. Probabilistic Methods in Civil Engineering and Mechanics. 3.0 Credits.
Covers probabilistic computational modeling in civil engineering and mechanics: Monte Carlo simulation, sampling methods and variance reduction techniques, simulation of stochastic processes and fields, and expansion methods. Applications to stochastic finite element, uncertainty quantification, reliability analysis, and model verification and validation.
Prerequisites: NA
Corequisites: NA
Instructor(s): M. Shields
Area: NA
NA.
EN.560.619. Advanced Structural Analysis. 3.0 Credits.
Matrix methods for the analysis of statistically indeterminate structures such as beams, plane and space trusses, and plane and space frames. Stiffness and flexibility methods. Linear elastic analysis and introduction to nonlinear analysis.
Prerequisites: NA
Corequisites: NA
Instructor(s): J. Guest
Area: Engineering
NA.

EN.560.621. Architectural Engineering - Form, Function and Technology. 3.0 Credits.
This course will cultivate broad knowledge of the use of engineering principles in the art of architecture. Fundamental definitions of architecture in the basic provision of shelter and social use are paired with aesthetics and cultural heritage. The course emphasizes structural frameworks and systems within the Civil Engineering curriculum, while expanding upon their critical intersections with the highly varied specialized components and systems of modern architecture, and the corresponding community of specialists that represent them. Topics include a historical view of the evolution of specialization in architecture, a quantitative review of loads and resistance systems, architectural and structural determinants of form, the function and aesthetics of building surface, and an introduction to environmental systems and their role in design sustainability. The class will include a trip to Fallingwater, the house designed by Frank Lloyd Wright, in western Pennsylvania, which stands as an iconic example of American architecture and a complex example of architectural engineering. This course is co-listed with EN.560.421 and EN.565.621.
Prerequisites: NA
Corequisites: NA
Instructor(s): J. Matteo
Area: Engineering
NA.

EN.560.623. Bridge Engineering. 3.0 Credits.
This course will explore bridge design and analysis by studying local bridges of various forms, materials, and load demands. Topics include an overview of the history of bridge engineering, an introduction to the AASHTO Standard Specifications for Highway Bridges, analysis techniques and load ratings, bridge details, and substructure design.
Prerequisites: NA
Corequisites: NA
Instructor(s): R. Sangree
Area: Engineering
NA.

EN.560.629. Preservation Engineering I: Theory and Practice. 3.0 Credits.
The renovation of existing buildings often holds many advantages over new construction, including greater economy, improved sustainability, and the maintenance of engineering heritage and architectural character in our built environment. Yet, the renovation of existing structures presents many challenges to structural engineers. These challenges include structural materials that are no longer in widespread use (e.g., unreinforced masonry arches and vaults, cast iron, and wrought iron) as well as structural materials for which analysis and design practices have changed significantly over the last half-century (e.g., wood, steel, and reinforced concrete). This course will examine structures made of a wide variety of materials and instruct the student how to evaluate their condition, determine their existing capacity, and design repairs and/or reinforcement. The investigation and analysis procedures learned from this course may then be applied to create economical and durable structural alterations that allow for the reuse of older buildings. Site visits near Homewood campus will supplement lectures. This course is co-listed with EN.565.628.
Prerequisites: NA
Corequisites: NA
Instructor(s): E. Meade; M. Farmer
Area: Engineering
NA.

EN.560.630. Structural Dynamics. 3.0 Credits.
Functional and computational examination of elastic and inelastic single degree of freedom systems with classical and non-classical damping subject to various input excitations including earthquakes with emphasis on the study of system response. Extension to multi-degree of freedom systems with emphasis on modal analysis and numerical methods. Use of the principles of structural dynamics in earthquake response.
Prerequisites: NA
Corequisites: NA
Instructor(s): C. Moen
Area: NA
NA.

EN.560.631. Preservation Engineering II: Theory and Practice. 3.0 Credits.
Building on the content in Preservation Engineering I: Theory and Practice, this course will begin with materials introduced at the start of the Industrial Revolution—namely with the beginning of the use of iron materials as major structural elements within buildings. The course will continue with the introduction of cast iron, wrought iron, and finally, structural steel members. After introducing iron materials the course will continue with the early use of reinforced concrete as a major structural material. The course will discuss the historic structural analysis methods associated with such materials and contrast such methods with more modern analytical approaches. It will also discuss concrete deterioration and repair methods. Concepts related to masonry facade investigation and repair will be presented along with the analytical methods associated with thin-shell masonry construction from the 19th and 20th centuries. The course will conclude with a review of the assessment and retrofit of historic foundations. This course is co-listed with EN.560.431 and EN.565.631
Prerequisites: NA
Corequisites: NA
Instructor(s): E. Meade
Area: Engineering
NA.
EN.560.633. Investigations, Diagnosis, and Rehabilitation. 3.0 Credits.
Why do buildings deteriorate, and how do we address this problem? This course examines the deterioration (by human and nature) of building materials and systems. Through lectures and a field trip, students will learn how to set up and execute an investigation, study the symptoms, diagnose the problems, determine what kinds of tests are needed, design the necessary repairs, and maintain existing systems. This course is co-listed with Engineering for Professionals EN.565.633.
Prerequisites: NA
Corequisites: NA
Instructor(s): C. Parker; J. Rogers
Area: Engineering
NA.

EN.560.634. Structural Fire Engineering. 3.0 Credits.
This course will discuss the analysis and design of structures exposed to fire. It will cover the fundamentals of fire behavior, heat transfer, the effects of fire loading on materials and structural systems, and the principles and design methods for fire resistance design. Particular emphasis will be placed on the advanced modeling and computational tools for performance-based design. Applications of innovative methods for fire resistance design in large structural engineering projects, such as stadiums and tall buildings, will also be presented.
Prerequisites: NA
Corequisites: NA
Instructor(s): T. Gernay
Area: Engineering
Writing Intensive.

EN.560.637. Preservation Engineering in the Urban Context. 3.0 Credits.
Technical expertise is fundamental to design and construction within and around historic buildings in the urban context. This course will cover topics related to both design and construction. For below-grade engineering, the course will cover underpinning, bracket piles, secant piles, slurry walls, tie-backs and general shoring approaches to building below or adjacent to existing constructions. For upward additions to existing construction, the course covers strengthening techniques (including temporary shoring and bracing, temporary access options, and temporary protection) and the requirements of the International Existing Building Code (IEBC). Each class will provide both technical guides and case studies, offering perspectives from guest speakers practicing the diverse range of professions tasked to meet this challenge. In lieu of a final exam, students will be required to submit a final paper/project. The final class meeting will be held in New York City and will include site visits to ongoing construction that exemplify the course material. Class meets on 3/2, 3/9, 4/6, and 4/13.
Prerequisites: NA
Corequisites: NA
Instructor(s): J. Matteo
Area: Engineering
NA.

EN.560.641. Equilibrium Models in Systems Engineering. 3.0 Credits.
Provide an introduction to equilibrium problems involving systems. The course will start with an introduction to optimization theory followed by various equilibrium problems including market, spatial, and network models. Solution techniques to these types of problems will be discussed, along with applications to systems engineering.
Prerequisites: NA
Corequisites: NA
Instructor(s): S. Siddiqui
Area: Engineering
NA.

EN.560.645. Topics in Optimization: Integer and Robust Optimization. 3.0 Credits.
The goal of this course is to introduce various advanced topics in optimization, including integer optimization, robust optimization, and inverse optimization. The course covers theoretical aspects of modeling and solution methods, as well as foundations and tips for practical examples. Enrollees are expected to have completed EN.553.761 or a comparable course on Linear Programming.
Prerequisites: EN.553.761 Or Instructor Permission.
Corequisites: NA
Instructor(s): K. Ghobadi
Area: NA
NA.

EN.560.650. Operations Research. 3.0 Credits.
An introduction to operations research and its applications. The course will review the basics of mathematical modelling, linear programming, primal and dual Simplex methods, post-optimization analysis, decomposition methods, and heuristic methods along with sample applications. Course meets with EN.560.450
Prerequisites: NA
Corequisites: NA
Instructor(s): K. Ghobadi
Area: Engineering
NA.

EN.560.653. An Introduction to Network Modeling. 3.0 Credits.
Many real-world problems can be modeled using network structures, and solved using tools from network theory. For this reason, network modeling plays a critical role in various disciplines ranging from physics and mathematics, to biology and computer science, and almost all areas of social science. This course will provide an introduction to network theory, network flow algorithms, modeling processes on networks and examples of empirical network applications spanning transport, health and energy systems.
Prerequisites: NA
Corequisites: NA
Instructor(s): L. Gardner
Area: Engineering, Quantitative and Mathematical Sciences
NA.

EN.560.658. Natural Disaster Risk Modeling. 3.0 Credits.
This course will: • Introduce the student to disaster risk modeling process, including: - Structure of catastrophe models. Uses in loss estimation and mitigation. - Study and modeling of hazards (esp. hurricanes and earthquakes; also flood, landslide, and volcanic) - Vulnerability assessment: simulation of building damage, and estimation of post-disaster injuries and casualties. - Exposure modeling (building typology distribution). - Introduction to disaster economic loss modeling: - Interpretation of risk metrics (return periods, PML, AAL, VaR, TVaR), traditional values of losses, their uncertainty, and applicability to management and financial decision making process. - Elements of present and future risk: climate and exposure changes. - Student will gain introductory experience in the use of GIS and simulation with Matlab.
Prerequisites: NA
Corequisites: NA
Instructor(s): G. Pita
Area: Engineering
NA.
EN.560.667. Topology Optimization and Design for Additive Manufacturing. 3.0 Credits.
This course will discuss the computational design tool of topology optimization and its application to the design of “structures”, including structural systems, complaint mechanisms, multifunctional devices, and material architectures. Particular emphasis will be placed on the emerging trend known as Design for Additive Manufacturing (AM), and the role of topology optimization in guiding the design of parts to be fabricated by AM processes (3D printing, Selective Laser Sintering, etc). The course will largely focus on design problems concerned with mechanical properties, with extensions to fluidic, thermal, optical, etc. properties also discussed. The course assumes some familiarity with finite element methods and assumes no prior coursework in optimization. 
Prerequisites: NA
Corequisites: NA
Instructor(s): J. Guest
Area: Engineering
NA.

EN.560.691. Graduate Seminar. 1.0 Credit.
Graduate students are expected to register for this course each semester. Both internal and outside speakers are included. 
Prerequisites: NA
Corequisites: NA
Instructor(s): NA
Area: NA
NA.

EN.560.692. Civil Engineering Graduate Seminar. 1.0 Credit.
Seminar series of speakers on various aspects of civil engineering. Different speakers are invited each semester. Full time civil engineering graduate students must enroll in the seminar course every semester unless excused by the Department. 
Prerequisites: NA
Corequisites: NA
Instructor(s): S. Gaitanaros
Area: NA
NA.

EN.560.724. Cold-Formed Steel Structures. 3.0 Credits.
Practical introduction to the analysis, design, and experimentation of cold-formed steel members and structures. Followed by an in-depth treatment of the theories which underpin modern analytical and computational tools used in exploring cold-formed steel behavior, and an introduction to topics under current research. 
Prerequisites: NA
Corequisites: NA
Instructor(s): B. Schafer
Area: NA
NA.

EN.560.730. Finite Element Methods. 3.0 Credits.
Variational methods and mathematical foundations, Direct and Iterative solvers, 1-D Problems formulation and boundary conditions, Trusses, 2-D/ 3D Problems, Triangular elements, QUAD4 elements, Higher Order Elements, Element Pathology, Improving Element Convergence, Dynamic Problems. 
Prerequisites: NA
Corequisites: NA
Instructor(s): S. Ghosh
Area: NA
NA.

EN.560.731. Structural Stability. 3.0 Credits.
Prerequisites: NA
Corequisites: NA
Instructor(s): B. Schafer
Area: NA
NA.

EN.560.740. Optimization and Learning. 3.0 Credits.
This course offers an optimization perspective of machine learning. We use fundamental, bottom-up optimization methods to introduce formal concepts in machine learning. The course then builds on these fundamentals to show how optimization formulations can be used to improve the performance and interpretation of machine learning models. Applications to energy and healthcare systems will be provided. A background in optimization is preferred, but no background in machine learning is required. Programming experience is a pre-requisite. 
Prerequisites: NA
Corequisites: NA
Instructor(s): S. Siddiqui
Area: Engineering
Writing Intensive.

EN.560.762. Mechanics of Architected Materials. 3.0 Credits.
This upper level graduate course will focus on the linear and nonlinear mechanics of a wide range of architected materials; we aim to cover: linear elastic properties of 2D and 3D cellular solids, micromechanics and homogenization, localization, microscopic and macroscopic instabilities, natural architected materials (bone, wood, nacre), wave propagation in lattices and phononics, mechanical metamaterials, and nanostructured materials (carbon nanotubes pillars, DNA origami). 
Prerequisites: NA
Corequisites: NA
Instructor(s): S. Gaitanaros
Area: Engineering
NA.

EN.560.770. Advanced Finite Element Methods and Multi-Scale Methods. 3.0 Credits.
Addresses advanced topics in various areas of the finite element methodology. Covers a range of topics, viz. element stability and hourglass control, adaptive methods for linear and nonlinear problems, mixed and hybrid element technology, eigen-value problems, multi-scale modeling for composites and polycrystalline materials. Recommended Course Background: EN.530.730 or EN.560.730
Prerequisites: NA
Corequisites: NA
Instructor(s): S. Ghosh
Area: NA
NA.
EN.560.772. Non-Linear Finite Elements. 3.0 Credits.
This course will discuss state of the art theoretical developments and modeling techniques in nonlinear computational mechanics, for problems with geometric and material nonlinearities. Large deformation of elastic-plastic and visco-plastic materials, contact-friction and other heterogeneous materials like composites and porous materials will be considered. A wide variety of applications in different disciplines, e.g. metal forming, composite materials, polycrystalline materials will be considered.
Prerequisites: NA
Corequisites: NA
Instructor(s): S. Ghosh
Area: NA
NA.

EN.560.826. Graduate Independent Study. 1.0 - 3.0 Credits.
Independent Study.
Prerequisites: NA
Corequisites: NA
Instructor(s): Staff
Area: Engineering
NA.

EN.560.835. Graduate Research. 3.0 - 20.0 Credits.
NA
Prerequisites: NA
Corequisites: NA
Instructor(s): Staff
Area: NA
NA.

EN.560.836. Graduate Research. 3.0 - 20.0 Credits.
NA
Prerequisites: NA
Corequisites: NA
Instructor(s): Staff
Area: NA
NA.

EN.560.890. Independent Study. 1.0 - 3.0 Credits.
NA
Prerequisites: NA
Corequisites: NA
Instructor(s): B. Schafer; M. Shields
Area: NA
NA.

Cross Listed Courses

Earth Planetary Sciences
AS.270.205. Introduction to Geographic Information Systems and Geospatial Analysis. 3.0 Credits.
The course provides a broad introduction to the principles and practice of Geographic Information Systems (GIS) and related tools of Geospatial Analysis. Topics will include history of GIS, GIS data structures, data acquisition and merging, database management, spatial analysis, and GIS applications. In addition, students will get hands-on experience working with GIS software.
Prerequisites: NA
Corequisites: NA
Instructor(s): X. Chen
Area: Engineering, Natural Sciences
NA.

Environmental Health and Engineering
EN.570.351. Introduction to Fluid Mechanics. 3.0 Credits.
Introduction to the use of the principles of continuity, momentum, and energy to fluid motion. Topics include hydrostatics, ideal-fluid flow, laminar flow, turbulent flow. Recommended Course Background: Statics, Dynamics, and AS.110.302
Prerequisites: Students must have completed Lab Safety training prior to registering for this class. To access the tutorial, login to myLearning and enter 458083 in the Search box to locate the appropriate module.
Corequisites: NA
Instructor(s): H. Rajaram
Area: Engineering
NA.