590 Directed Research (1-12) Research leading to the master's degree. Maximum units which may be applied to the degree to be determined by the department. Graded CR/NC.

594abz Master's Thesis (2-2-0) Credit on acceptance of thesis. Graded IP/CR/NC.

596 Chemical Reactions in the Atmosphere (3) (Enroll in ENE 596)

599 Special Topics (2-4, max 9) Course content will be selected each semester to reflect current trends and developments in the field of chemical engineering.

690 Directed Research (1-4) Laboratory study of specific problems by candidates for the degree Engineer in Chemical Engineering. Graded CR/NC.

790 Research (1-12) Research leading to the doctorate. Maximum units which may be applied to the degree to be determined by the department. Graded CR/NC.

794abcdz Doctoral Dissertation (2-2-2-2-0) Credit on acceptance of dissertation. Graded IP/CR/NC.

Civil Engineering

Kaprielian Hall 210
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Chair: L. Carter Wellford, Ph.D.

Faculty
Professors: Ahmed Abdel-Ghaffar, Ph.D.; James C. Anderson, Ph.D.*; Jean-Pierre Bardet, Ph.D.; George V. Chilingar, Ph.D. *(Petroleum Engineering);* Joseph S. Devinny, Ph.D. *(Environmental Engineering);* Peter Gordon, Ph.D. *(Policy, Planning, and Development; Economics);* Genevieve Giuliano, Ph.D. *(Policy, Planning, and Development);* Ronald C. Henry, Ph.D. *(Environmental Engineering);* Jiin-Jen Lee, Ph.D., P.E. *(Environmental Engineering)*;* Geoffrey R. Martin, Ph.D.; Sami F. Masri, Ph.D. *(Mechanical Engineering);* James Moore, Ph.D. *(Policy, Planning, and Development);* William J. Petak, D.P.A. *(Policy, Planning, and Development);* Massoud Pirbazari, Ph.D. *(Environmental Engineering, Associate Director of Environmental Engineering);* Costas Synolakis, Ph.D. *(Aerospace Engineering);* Mihailo Trifunac, Ph.D.; Firdaus E. Udwadia, Ph.D. *(Mechanical Engineering);* L. Carter Wellford, Ph.D. *(Chair) (Director of Environmental Engineering);* Hung Leung Wong, Ph.D.*; Teh Fu Yen, Ph.D. *(Environmental Engineering)*

Associate Professors: Vincent W. Lee, Ph.D.; Najmedin Meshkati, Ph.D., C.P.E. *(Industrial and Systems Engineering);* Constantinos Sioutas, Sc.D.; Yan Xiao, Ph.D., P.E.

Assistant Professor: Erik A. Johnson, Ph.D.

Adjunct Professor: Gregg E. Brandow, Jr., Ph.D., P.E.

Research Professor: Dennis E. Williams

Research Associate Professors: Robert Nigbor, Ph.D., P.E.; Craig Taylor, Ph.D.; Maria I. Todorovska, Ph.D.

Research Assistant Professors: John Caffrey, Ph.D., Le Dam Hanh, Ph.D.; John A. Kuprenas, D.Eng., P.E.; Philip M. Fine, Ph.D.; Jennifer N. Swift, Ph.D.

Senior Lecturer: Henry M. Koffman, P.E.

Emeritus Professors: Mihran S. Agbabian, Ph.D., P.E.; Edwin L. Bidwell, Ph.D.; Kenneth C. Reynolds, Sc.D.; Paul Seide, Ph.D.; Victor I. Weingarten, Ph.D.

*Recipient of university-wide or school teaching award.

Chi Epsilon Civil Engineering Honor Society
Chi Epsilon is dedicated to the purpose of maintaining and promoting the status of civil engineering as a profession. Chi Epsilon was organized to recognize the characteristics of the individual civil engineer deemed to be fundamental to the successful pursuit of an engineering career and to aid in the development of those characteristics in the civil engineering student. To contribute to the improvement of the profession, Chi Epsilon fosters the development and exercise of sound traits of character and technical ability among civil engineers.

Chi Epsilon is based on broad principles of scholarship, character, practicality and sociability. Civil engineering students who rank in the upper one-third of the junior or senior class are eligible for membership. These qualifications will make one eligible but not necessarily acceptable. Each member must be well skilled in all four of the basic principles.

Degree Requirements

Educational Program Objectives
The undergraduate programs in Civil Engineering have the following objectives:

(1) Graduates will be expected to compete effectively in the world of rapid technological changes and to become leading professionals in industrial, academic or government institutions.

(2) Graduates will be prepared to tailor their undergraduate studies to embark into the engineering professions, or to continue their graduate studies in engineering, or to enter related areas like computer science, business, law, medicine or a field of their choice and interest

(3) Graduates will have demonstrated proficiency in mathematics, science and engineering principles to effectively solve engineering problems encountered in work and practice.

(4) Graduates will have the ability to communicate both verbally and orally and to function effectively as individuals or as members of multidisciplinary teams in a world of rapid technological changes and global competition.

(5) Graduates will understand the importance of contemporary engineering issues, decisions, risks and benefits in a global social and environmental context, as well as the importance of personal and professional ethics.

(6) Graduates will have the knowledge to design all or part of a system to meet the required constraints and specifications, as well as the desired economic, social, ethical, political, environmental and other necessary considerations.

(7) Graduates will have the capacity to conduct and design laboratory experiments with available state-of-the-art equipment, and to use the techniques to analyze and interpret the experimental data.

Bachelor of Science in Civil Engineering (131 Unit Program)

A cumulative grade point average of C (2.0) is required for all courses taken at USC as well as for all courses taken within the Department of Civil Engineering. In addition, a minimum grade of C must be earned in each of the following courses: CE 205, CE 225, CE 309 and CE 325. See also common requirements for undergraduate degrees section, page 476.

FIRST YEAR, FIRST SEMESTER		UNITS
CE 106	Design and Planning of Civil Engineering Systems	2
CHEM 105aL CHEM 115aL	General Chemistry, or Advanced General Chemistry	4
MATH 125	Calculus I	4
WRIT 140*	Writing and Critical Reasoning	4
General education*	Social Issues	4
		18

FIRST YEAR, SECOND SEMESTER		UNITS
CE 107	Introduction to Civil Engineering Graphics	3
CE 108	Introduction to Computational Methods in Civil Engineering	2
MATH 126	Calculus II	4
PHYS 151L**	Fundamentals of Physics I: Mechanics and Thermodynamics	4
		13

SECOND YEAR, FIRST SEMESTER		UNITS
CE 205	Statics	2
MATH 226	Calculus III	4
PHYS 152L	Fundamentals of Physics II: Electricity and Magnetism	4
General education		8
		18

SECOND YEAR, SECOND SEMESTER		UNITS
AME 310	Engineering Thermodynamics I	3
CE 225	Mechanics of Deformable Bodies	3
CHEM 105bL CHEM 115bL	General Chemistry, or Advanced General Chemistry, or	
GEOL 305	Introduction to Engineering Geology, or	
PHYS 153L	Fundamentals of Physics III: Optics and Modern Physics	4
MATH 245	Mathematics of Physics and Engineering I	4
General education		4
		18

THIRD YEAR, FIRST SEMESTER		UNITS
CE 309	Fluid Mechanics	3
CE 325	Dynamics	3
CE 358	Theory of Structures I	3
CE 471	Principles of Transportation Engineering	3
EE 202L EE 326L	Linear Circuits, or Essentials of Electrical Engineering	4
		16

THIRD YEAR, SECOND SEMESTER		UNITS
CE 334L	Mechanical Behavior of Materials	3
CE 402	Computer Methods in Engineering	3
ISE 460 CE 404	Engineering Economy, or Fundamentals of Law for Engineers	3
Elective	Civil Engineering	3
Kernel course***		3
		15

FOURTH YEAR, FIRST SEMESTER		UNITS
CE 408	Risk Analysis in Civil Engineering	3
CE 453	Water Quality Control	3
CE 467L	Geotechnical Engineering	4
Elective	Civil Engineering	3
Kernel course***		3
		16

FOURTH YEAR, SECOND SEMESTER		UNITS
CE 451	Water Resources Engineering	4
CE 480	Structural Systems Design	3
WRIT 340	Advanced Writing	3
General education		4
Kernel course***		3
		17

*Taken concurrently.

**Satisfies a general education requirement for Category III.

***Kernels must be selected from the following list of design courses: CE 409abL, CE 429, CE 456, CE 457, CE 465, CE 476, CE 478, CE 466.

The Department of Civil Engineering must approve all curricula leading to a degree; please note this includes transfer credit and units for courses waived for subject credit only, which have been approved through the Degree Progress Department.

Bachelor of Science in Civil Engineering (Construction Engineering Emphasis)

A cumulative grade point average of C (2.0) is required for all courses taken at USC as well as for all courses taken within the Department of Civil Engineering. In addition, a minimum grade of C must be earned in each of the following courses: CE 205, CE 225, CE 309 and CE 325. See also common requirements for undergraduate degrees section, page 476.

FIRST YEAR, FIRST SEMESTER		UNITS
CE 106	Design and Planning of Civil Engineering Systems	2
CHEM 105aL CHEM 115aL	General Chemistry, or Advanced General Chemistry	4
MATH 125	Calculus I	4
WRIT 140*	Writing and Critical Reasoning	4
General education*	Social Issues	4
		18

FIRST YEAR, SECOND SEMESTER		UNITS
CE 107	Introduction to Civil Engineering Graphics	3
CE 108	Introduction to Computational Methods in Civil Engineering	2
MATH 126	Calculus II	4
PHYS 151L**	Fundamentals of Physics I: Mechanics and Thermodynamics	4
		13

SECOND YEAR, FIRST SEMESTER		UNITS
CE 205	Statics	2
CE 460	Construction Engineering	3
MATH 226	Calculus III	4
PHYS 152L	Fundamentals of Physics II: Electricity and Magnetism	4
General education		4
		17

SECOND YEAR, SECOND SEMESTER		UNITS
AME 310	Engineering Thermodynamics I	3
CE 225	Mechanics of Deformable Bodies	3
GEOL 305Lx	Introduction to Engineering Geology	4
MATH 245	Mathematics of Physics and Engineering I	4
General education		4
		18

THIRD YEAR, FIRST SEMESTER		UNITS
CE 309	Fluid Mechanics	3
CE 325	Dynamics	3
CE 358	Theory of Structures I	3
CE 471	Principles of Transportation Engineering	3
EE 202L EE 326L	Linear Circuits, or Essentials of Electrical Engineering	4
		16

THIRD YEAR, SECOND SEMESTER		UNITS
CE 334L	Mechanical Behavior of Materials	3
CE 462	Construction Methods and Equipment	3
ISE 460 CE 404	Engineering Economy, or Fundamentals of Law for Engineers	3
General education		4
Kernel course***		3
		16

FOURTH YEAR, FIRST SEMESTER		UNITS
CE 408	Risk Analysis in Civil Engineering	3
CE 409aL	Computer Aided Design	3
CE 412	Construction Law and the Property Development Process	3
CE 461	General Construction Estimating	3
CE 467L	Geotechnical Engineering	4
		16

FOURTH YEAR, SECOND SEMESTER		UNITS
CE 451	Water Resources Engineering	4
CE 480	Structural Systems Design	3
WRIT 340	Advanced Writing	3
General education		4
Kernel course***		3
		17

*Taken concurrently.

**Satisfies a general education requirement for Category III.

***Kernels must be selected from the following list of design courses: CE 456, CE 457, CE 465, CE 466, CE 476, CE 478. Students must select one course from CE 456, CE 457 or CE 478.

The Department of Civil Engineering must approve all curricula leading to a degree; please note this includes transfer credit and units for courses waived for subject credit only, which have been approved through the Degree Progress Department.

Bachelor of Science in Civil Engineering (Structural Engineering Emphasis)

A cumulative grade point average of C (2.0) is required for all courses taken at USC as well as for all courses taken within the Department of Civil Engineering. In addition, a minimum grade of C must be earned in each of the following courses: CE 205, CE 225, CE 309 and CE 325. See also common requirements for undergraduate degrees section, page 476.

FIRST YEAR, FIRST SEMESTER		UNITS
CE 106	Design and Planning of Civil Engineering Systems	2
CHEM 105aL CHEM 115aL	General Chemistry, or Advanced General Chemistry	4
MATH 125	Calculus I	4
WRIT 140*	Writing and Critical Reasoning	4
General education*	Social Issues	4
		18

FIRST YEAR, SECOND SEMESTER		UNITS
CE 107	Introduction to Civil Engineering Graphics	3
CE 108	Introduction to Computational Methods in Civil Engineering	2
MATH 126	Calculus II	4
PHYS 151L**	Fundamentals of Physics I: Mechanics and Thermodynamics	4
		13

SECOND YEAR, FIRST SEMESTER		UNITS
CE 205	Statics	2
MATH 226	Calculus III	4
PHYS 152L	Fundamentals of Physics II: Electricity and Magnetism	4
General education		8
		18

SECOND YEAR, SECOND SEMESTER		UNITS
AME 310	Engineering Thermodynamics I	3
CE 225	Mechanics of Deformable Bodies	3
GEOL 305	Introduction to Engineering Geology	4
MATH 245	Mathematics of Physics and Engineering I	4
General education		4
		18

THIRD YEAR, FIRST SEMESTER		UNITS
CE 309	Fluid Mechanics	3
CE 325	Dynamics	3
CE 358	Theory of Structures I	3
CE 456	Design of Steel Structures	3
EE 202L EE 326L	Linear Circuits, or Essentials of Electrical Engineering	4
		16

THIRD YEAR, SECOND SEMESTER		UNITS
CE 334L	Mechanical Behavior of Materials	3
CE 402	Computer Methods in Engineering	3
CE 457	Reinforced Concrete Design	3
CE 458	Theory of Structures II	3
ISE 460	Engineering Economy	3
		15

FOURTH YEAR, FIRST SEMESTER		UNITS
CE 408	Risk Analysis in Civil Engineering	3
CE 409aL	Computer Aided Design	3
CE 460	Construction Engineering	3
CE 467	Geotechnical Engineering	4
CE 478	Timber and Masonry Design	3
		16

FOURTH YEAR, SECOND SEMESTER		UNITS
CE 451	Water Resources Engineering	4
CE 459	Introduction to Structural Dynamics	3
CE 480	Structural Systems Design	3
WRIT 340	Advanced Writing	3
General education		4
		17

*Taken concurrently.

**Satisfies a general education requirement for Category III.

The Department of Civil Engineering must approve all curricula leading to a degree; please note this includes transfer credit and units for courses waived for subject credit only, which have been approved through the Degree Progress Department.

Bachelor of Science in Civil Engineering (Water Resources Engineering Emphasis)
A cumulative grade point average of C (2.0) is required for all courses taken at USC as well as for all courses taken within the Department of Civil Engineering. In addition, a minimum grade of C must be earned in each of the following courses: CE 205, CE 225, CE 309 and CE 325. See also common requirements for undergraduate degrees section, page 476.

FIRST YEAR, FIRST SEMESTER		UNITS
CE 106	Design and Planning of Civil Engineering Systems	2
CHEM 105aL CHEM 115aL	General Chemistry, or Advanced General Chemistry	4
MATH 125	Calculus I	4
WRIT 140*	Writing and Critical Reasoning	4
General education*	Social Issues	4
		18

FIRST YEAR, SECOND SEMESTER		UNITS
CE 107	Introduction to Civil Engineering Graphics	3
CE 108	Introduction to Computational Methods in Civil Engineering	2
MATH 126	Calculus II	4
PHYS 151L**	Fundamentals of Physics I: Mechanics and Thermodynamics	4
		13

SECOND YEAR, FIRST SEMESTER		UNITS
CE 205	Statics	2
MATH 226	Calculus III	4
PHYS 152L	Fundamentals of Physics II: Electricity and Magnetism	4
General education		8
		18

SECOND YEAR, SECOND SEMESTER		UNITS
AME 310	Engineering Thermodynamics I	3
CE 225	Mechanics of Deformable Bodies	3
CHEM 105bL CHEM 115bL	General Chemistry, or Advanced General Chemistry, or	
GEOL 305	Introduction to Engineering Geology, or	
PHYS 153L	Fundamentals of Physics III: Optics and Modern Physics	4
MATH 245	Mathematics of Physics and Engineering I	4
General education		4
		18

THIRD YEAR, FIRST SEMESTER		UNITS
CE 309	Fluid Mechanics	3
CE 325	Dynamics	3
CE 358	Theory of Structures I	3
CE 471	Principles of Transportation Engineering	3
EE 202L EE 326L	Linear Circuits, or Essentials of Electrical Engineering	4
		16

THIRD YEAR, SECOND SEMESTER		UNITS
CE 334L	Mechanical Behavior of Materials	3
CE 402	Computer Methods in Engineering	3
ISE 460	Engineering Economy	3
Elective	Civil Engineering	3
Kernel course***		3
		15

FOURTH YEAR, FIRST SEMESTER		UNITS
CE 408	Risk Analysis in Civil Engineering	3
CE 453	Water Quality Control	3
CE 467L	Geotechnical Engineering	4
Elective	Civil Engineering	3
Kernel course***		3
		16

FOURTH YEAR, SECOND SEMESTER		UNITS
CE 451	Water Resources Engineering	4
CE 485	Wastewater Treatment Design	3
WRIT 340	Advanced Writing	3
General education		4
Kernel course***		3
		17

*Taken concurrently.

**Satisfies a general education requirement for Category III.

***Kernels must be selected from the following list of design courses: CE 465, CE 466 or CE 476.

The Department of Civil Engineering must approve all curricula leading to a degree; please note this includes transfer credit and units for courses waived for subject credit only, which have been approved through the Degree Progress Department.

Bachelor of Science in Civil Engineering (Building Science) (135 Unit Program)
A cumulative grade point average of C (2.0) is required in all courses taken at USC, as well as for all courses taken within the Department of Civil Engineering. In addition, a minimum grade of C must be earned in each of the following courses: CE 205, CE 225, CE 309 and CE 325. See also the common requirements for undergraduate degrees section, page 476.

FIRST YEAR, FIRST SEMESTER		UNITS
CE 106	Design and Planning of Civil Engineering Systems	2
CHEM 105aL CHEM 115aL	General Chemistry, or Advanced General Chemistry	4
MATH 125	Calculus I	4
WRIT 140*	Writing and Critical Reasoning	4
General education*	Social Issues	4
		18

FIRST YEAR, SECOND SEMESTER		UNITS
ARCH 114	Architecture: Culture and Community	2
CE 107	Introduction to Civil Engineering Graphics	3
CE 108	Introduction to Computer Methods in Civil Engineering	2
MATH 126	Calculus II	4
PHYS 151L****	Fundamentals of Physics I: Mechanics and Thermodynamics	4
		15

SECOND YEAR, FIRST SEMESTER		UNITS
ARCH 205aL**	Building Science I	4
CE 205	Statics	2
MATH 226	Calculus III	4
PHYS 152L	Fundamentals of Physics II: Electricity and Magnetism	4
General education		4
		18

SECOND YEAR, SECOND SEMESTER		UNITS
AME 310	Engineering Thermodynamics I	3
ARCH 205bL**	Building Science I	4
CE 225	Mechanics of Deformable Bodies	3
GEOL 305	Introduction to Engineering Geology, or	
PHYS 153L	Fundamentals of Physics III: Optics and Modern Physics	4
MATH 245	Mathematics of Physics and Engineering I	4
		18

THIRD YEAR, FIRST SEMESTER		UNITS
ARCH 305aL**	Building Science II	4
CE 309	Fluid Mechanics	3
CE 325	Dynamics	3
CE 358	Theory of Structures I	3
CE 456	Design of Steel Structures	3
		16

THIRD YEAR, SECOND SEMESTER		UNITS
ARCH 214b	History of Architecture	4
ARCH 305bL**	Building Science II	4
CE 334L	Mechanical Behavior of Materials	3
CE 457	Reinforced Concrete Design	3
General education		4
		18

FOURTH YEAR, FIRST SEMESTER		UNITS
ARCH 405aL**	Building Science III	4
CE 408	Risk Analysis in Civil Engineering	3
CE 467L	Geotechnical Engineering	4
Civil Engineering elective***		3
General education		4
		18

FOURTH YEAR, SECOND SEMESTER		UNITS
ARCH 405bL**	Building Science III	4
CE 458	Theory of Structures II	3
WRIT 340	Advanced Writing	3
General education		4
		14

*Taken concurrently.

**The School of Architecture requires a minimum grade of C in ARCH 205ab, ARCH 305ab and ARCH 405ab in order to continue in the building science design sequence.

***The Civil Engineering elective must be selected from the following courses: CE 409a, CE 451, CE 453, CE 460 and CE 471.

****Satisfies general education Category III.

Bachelor of Science in Civil Engineering (Environmental Engineering) (130 Unit Program)

A cumulative grade point average of C (2.0) is required for all courses taken at USC as well as for all courses taken within the Department of Civil Engineering. In addition, a minimum grade of C must be earned in each of the following courses: CE 205, CE 225, CE 309 and CE 325. See also common requirements for undergraduate degrees section, page 476.

FIRST YEAR, FIRST SEMESTER		UNITS
CE 110	Introduction to Environmental Engineering	4
MATH 125	Calculus I	4
WRIT 140*	Writing and Critical Reasoning	4
General education*	Social Issues	4
		16

FIRST YEAR, SECOND SEMESTER		UNITS
CE 108	Introduction to Computer Methods in Civil Engineering	2
CE 210L	Introduction to Environmental Engineering Microbiology	3
CHEM 105aL	General Chemistry, or	
CHEM 115aL	Advanced General Chemistry	4
MATH 126	Calculus II	4
PHYS 151L**	Fundamentals of Physics I: Mechanics and Thermodynamics	4
		17

SECOND YEAR, FIRST SEMESTER		UNITS
CE 205	Statics	2
CHEM 105bL	General Chemistry, or	
CHEM 115bL	Advanced General Chemistry	4
MATH 226	Calculus III	4
PHYS 152L	Fundamentals of Physics II: Electricity and Magnetism	4
General education		4
		18

SECOND YEAR, SECOND SEMESTER		UNITS
AME 310	Engineering Thermodynamics	3
CE 225	Mechanics of Deformable Bodies	3
ENE 400	Environmental Engineering Principles	3
MATH 245	Mathematics of Physics and Engineering I	4
PHYS 153L	Fundamentals of Physics III: Optics and Modern Physics, or	
GEOL 305	Introduction to Engineering Geology	4
		17

THIRD YEAR, FIRST SEMESTER		UNITS
CE 309	Fluid Mechanics	3
CE 325	Dynamics	3
CE 358	Theory of Structures I	3
WRIT 340	Advanced Writing	3
General education		4
		16

THIRD YEAR, SECOND SEMESTER		UNITS
CE 334L	Mechanical Behavior of Materials	3
CE 451	Water Resources Engineering	4
CE 453	Water Quality Control	3
ISE 460	Engineering Economy, or	
CE 404	Fundamentals of Law for Engineers	3
Kernel course***		3
		16

FOURTH YEAR, FIRST SEMESTER		UNITS
CE 408	Risk Analysis in Civil Engineering	3
CE 467L	Geotechnical Engineering	4
General education		4
Kernel course***		3
		14

FOURTH YEAR, SECOND SEMESTER		UNITS
CE 463L	Water Chemistry and Analysis	3
CE 485	Wastewater Treatment Design	3
ENE 428	Air Pollution Fundamentals	3
General education		4
Kernel course***		3
		16

*Taken concurrently.

**Satisfies a general education requirement for Category III.

***Kernels must be selected from the following design courses: CE 409aL, CE 443, CE 457, CE 465, CE 466, CE 476, CE 484 and ENE 429.

Bachelor of Science in Environmental Engineering (132 Unit Program)

The degree has two tracks: Track I: Environmental Systems and Processes; Track II: Environmental Biotechnology. A cumulative scholarship average of C (2.0) is required for all courses taken at USC as well as for all courses taken in the Civil Engineering Department. In addition, a minimum grade of C must be earned in each of the following courses: CE 205 and ENE 410. See also common requirements for undergraduate degrees section, page 476.

FIRST YEAR, FIRST SEMESTER		UNITS
CE 110	Introduction to Environmental Engineering	4
MATH 125	Calculus I	4
WRIT 140*	Writing and Critical Reasoning	4
General education*	Social Issues	4
		16

FIRST YEAR, SECOND SEMESTER		UNITS
CE 108	Introduction to Computer Methods in Civil Engineering	2
CE 210L	Introduction to Environmental Engineering Microbiology	3
CHEM 105aL	General Chemistry	4
MATH 126	Calculus II	4
PHYS 151L**	Fundamentals of Physics I: Mechanics and Thermodynamics	4
		17

SECOND YEAR, FIRST SEMESTER		UNITS
CE 205	Statics	2
CHEM 105bL	General Chemistry	4
MATH 226	Calculus III	4
PHYS 152L	Fundamentals of Physics II: Electricity and Magnetism	4
General education		4
		18

SECOND YEAR, SECOND SEMESTER		UNITS
ENE 400	Environmental Engineering Principles	3
MATH 245	Mathematics of Physics and Engineering	4
Track Requirement		8
Track I:		
BISC 220L	General Biology: Cell Biology and Physiology	4
General Education		4
Track II:		
BISC 320L	Molecular Biology	4
CHEM 322aL	Organic Chemistry	4
		15

THIRD YEAR, FIRST SEMESTER		UNITS
CE 453	Water Quality Control	3
ENE 410	Environmental Fluid Mechanics	3
WRIT 340	Advanced Writing	3
Track Requirement		7-8
Track I:		
CHEM 322aL	Organic Chemistry	4
ENE 428	Air Pollution Fundamentals	3
Track II:		
CHEM 322bL	Organic Chemistry	4
General education		4
		16-17

THIRD YEAR, SECOND SEMESTER		UNITS
CE 451	Water Resources Engineering	4
GEOL 305Lx	Introduction to Engineering Geology	4
General Education		4
Track Requirement		4-6
Track I:		
CE 408	Risk Analysis in Civil Engineering	3
Kernel course***		3
Track II:		
BISC 330L	Biochemistry	4
		16-18

FOURTH YEAR, FIRST SEMESTER		UNITS
CE 465	Water Supply and Sewerage System Design	3
CE 484	Water Treatment Design	3
CHE 330	Chemical Engineering Thermodynamics	4
ISE 460	Engineering Economy, or	
CE 404	Fundamentals of Law for Engineers	3
PTE 463L	Introduction to Transport Processes in Porous Media	3
		16

FOURTH YEAR, SECOND SEMESTER		UNITS
CE 463L	Water Chemistry and Analysis	3
CE 485	Wastewater Treatment Design	3
ENE 429	Air Pollution Control	3
General education		4
Track Requirement		3-4
Track I:		
ENE 486	Solid and Hazardous Waste Engineering	3
Track II:		
ENE 487	Environmental Biotechnology and Bioremediation	3
ENE 495	Seminars in Environmental Engineering	1
		16-17

*Taken concurrently.

**Satisfies a general education requirement for Category III.

***One Kernel course must be selected from the following list of courses for Track I: CE 402, CE 409aL, CE 443 or CHE 442.

Bachelor of Science in Civil Engineering (Information Management) (134 Unit Program)

A cumulative grade point average of C (2.0) is required in all courses taken at USC, as well as for all courses taken within the Department of Civil Engineering. In addition, a minimum grade of C must be earned in each of the following courses: CE 205, CE 225, CE 309 and CE 325. See also the common requirements for undergraduate degrees, page 476.

FIRST YEAR, FIRST SEMESTER		UNITS
CE 106	Design and Planning of Civil Engineering Systems	2
CHEM 105aL CHEM 115aL	General Chemistry, or Advanced General Chemistry	4
MATH 125	Calculus I	4
WRIT 140*	Writing and Critical Reasoning	4
General Education*	Social Issues	4
		18

FIRST YEAR, SECOND SEMESTER		UNITS
CSCI 101L	Fundamentals of Computer Programming	3
CE 107	Introduction to Civil Engineering Graphics	3
MATH 126	Calculus II	4
PHYS 151L**	Fundamentals of Physics I: Mechanics and Thermodynamics	4
		14

SECOND YEAR, FIRST SEMESTER		UNITS
CE 205	Statics	2
CSCI 102L	Data Structures	4
MATH 226	Calculus III	4
PHYS 152L	Fundamentals of Physics II: Electricity and Magnetics	4
General education		4
		18

SECOND YEAR, SECOND SEMESTER		UNITS
CE 225	Mechanics of Deformable Bodies	3
CE 460	Construction Engineering	3
CSCI 201L	Principles of Software Development	4
GEOL 305 PHYS 153L	Introduction to Engineering Geology, or Fundamentals of Physics III: Optics and Modern Physics	4
MATH 245	Mathematics of Physics and Engineering I	4
		18

THIRD YEAR, FIRST SEMESTER		UNITS
CE 309	Fluid Mechanics	3
CE 325	Dynamics	3
CE 358	Theory of Structures I	3
General education		4
General education		4
		17

THIRD YEAR, SECOND SEMESTER		UNITS
CE 334L	Mechanical Behavior of Materials	3
CE 402	Computer Methods in Engineering	3
GEOG 381L	Geographic Information Science	4
WRIT 340	Advanced Writing Course	3
Design**	Design elective #1	3
		16

FOURTH YEAR, FIRST SEMESTER		UNITS
CE 408	Risk Analysis in Civil Engineering	3
CE 467L	Geotechnical Engineering	4
CE 471	Principles of Transportation Engineering	3
CE 477	Civil Infrastructure Information Systems	3
Design**	Design elective #2	3
		16

FOURTH YEAR, SECOND SEMESTER		UNITS
CE 480	Structural Systems Design	3
CE elective		3
CSCI 485 IOM 435	File and Database Management, or Business Database Systems	4
Design**	Design elective #3	3
General education		4
		17

*Taken concurrently.

**The Design electives must be selected from the following courses: CE 409a, CE 456, CE 457, CE 478, CE 465, and CE 476.

***Satisfies a general education requirement for Category III.

One general education elective must also satisfy the diversity requirement or additional units will be required.

Minor in Environmental Engineering

See listing on page 541.

Minor in Construction Planning and Management

This program covers the most current theories and practice of construction planning and management. The program provides a valuable adjunct credential to professional school students pursuing careers in business administration, public administration, environmental studies, and other areas; and a unique opportunity for professional focus to students in the USC College of Letters, Arts and Sciences.

Construction activities are complex. In contemporary society, effective planning and management of these activities requires specialized knowledge of the technical, economic and policy environment. This program couples the knowledge of how construction activities are organized with a broader understanding of the urban system in which construction projects are embedded. With the exception of statistics, all of the required courses are within the Department of Civil Engineering and the USC School of Policy, Planning, and Development.

Any USC undergraduate who has completed the equivalent of two full-time semesters in good standing is eligible to pursue the minor program. This minor program is rigorous enough to serve as an introductory credential for students subsequently electing to pursue advanced studies in development, urban planning, construction management or allied fields.

Courses required

Seven courses consisting of at least 23 units are required for the minor.

Statistics

Students must complete an advisor approved course in statistics. Candidate courses include ECON 317, EE 364, ISE 220, PPD 404x, PSYCH 274, SOCI 314 and similar courses. The statistics course must be at least three units.

CORE COURSES		UNITS
CE 460	Construction Engineering	3
CE 461	General Construction Estimating	3
CE 462	Construction Methods and Equipment	3
PPD 304	Property Rights, Governance and the Environment	4
PPD 358	Urban and Regional Economics	4
		17

ELECTIVES (SELECT ONE)		UNITS
CE 404	Fundamentals of Law for Engineers	3
CE 412	Contracts and Specifications	3
CE 472	Construction Labor Management	3
PPD 437	Advanced Finance and Investment for Planning and Development	4

Advisement is provided by the Department of Civil Engineering. Students will normally complete statistics before enrolling in CE 461 but can be permitted to complete statistics as a corequisite subject to advisor approval. CE 460 is a prerequisite for CE 461 for the purposes of the minor. Students are also advised to take CE 460 before taking CE 462. Students electing PPD 437 must have completed PPD 358.

Master of Science in Civil Engineering

The Master of Science in Civil Engineering is awarded in strict conformity with the general requirements of the USC School of Engineering. A student may receive the Master of Science in Civil Engineering with a special option by specializing in one of the following courses of study: construction; earthquake engineering; geotechnical engineering; ocean engineering; structural engineering; structural mechanics; environmental engineering; transportation engineering; and water resources. Students specializing in the transportation option must include in their program either four units of CE 590 or CE 594ab.

A general Master of Science in Civil Engineering without special designation is also given. Specific course requirements (at least 15 units) for a degree with special designation may be secured by request from the Department of Civil Engineering.

A student who wishes to pursue the Master of Science in Civil Engineering without special designation and who has an interest in public works may take a selected sequence of 12 units in the USC School of Policy, Planning, and Development. For further information, see the Public Administration Professional Sequence section in the School of Policy, Planning, and Development, page 764.

Master of Science in Applied Mechanics

Students possessing a bachelor's degree in aerospace engineering, civil engineering, mechanical engineering, mathematics, or physics may work toward the Master of Science in Applied Mechanics. A student may be required to satisfy certain deficiencies considered prerequisite to the listed courses.

The Master of Science in Applied Mechanics is awarded in strict conformity with the general requirements for the Master of Science in Civil Engineering, except as modified by the following specific requirements. Students must include in their course work: (1) AME 530ab, CE 507, CE 508, CE 525ab, and CE 541b; (2) at least six units of electives from the following: CE 541a, CE 542, CE 543; (3) other electives may be substituted on approval of department chair; (4) there is no thesis option.

Master of Science in Environmental Engineering

Students with a bachelor's degree in engineering or science may work toward the Master of Science in Environmental Engineering. Students with degrees in fields other than engineering or science may be admitted on the recommendation of a program advisor and program director. Selection of courses will be determined through consultation with a program advisor to provide a maximum of training in the student's area of interest in environmental problems.

Master of Engineering in Environmental Quality Management

Environmental engineers with purely scientific and technological backgrounds are often excluded from certain high-level professional managerial positions in the manufacturing industry, public utilities or governmental agencies, although they are generally preferred for engineering, scientific and research positions. Their exclusion from these positions is often attributed to inadequate preparation in areas deemed important in recent years, including the following: project management, regulatory compliance, strategic and financial planning, decision making and human relations. Thus, effective and efficient management of modern environmental engineering projects requires broad technical knowledge and diverse skills in the above aspects. The Master of Engineering degree program in Environmental Quality Management intends to bridge the gap between the essentials of hard-core engineering and project management. The program is intended to provide the student with cutting edge instruction in the art and science of environmental management. It is also directed at teaching and training students how to integrate environmental considerations in the early planning of projects to improve environmental compatibility, reduce risks and incur financial savings in businesses and industries.

REQUIRED CORE COURSES		UNITS
ENE 495	Seminars in Environmental Engineering	1
ENE 510	Water Quality Management and Practice	3
ENE 518	Environmental Systems Engineering and Management	3
ENE 535	Applied Air Quality Management	3
MPW 950	Technical Writing	3
		13

ENGINEERING ELECTIVE OPTION (TECHNICAL ELECTIVE COURSES; CHOOSE ONE)		UNITS
CE 504	Solid Waste Management	3
CSCI 576	Multimedia Systems Design	3
ENE 501	Waste Minimization and Resource Recovery	3
ENE 502	Environmental and Regulatory Compliance	3
ENE 505	Energy and Environment	3
ENE 506	Ecology for Environmental Engineers	3
ENE 516	Hazardous Waste Management	3
ENE 526	Environmental Pollutants: Monitoring and Risk Assessment	3

BUSINESS COMMUNICATION/MANAGEMENT AND ORGANIZATION ELECTIVE (CHOOSE ONE)		UNITS
BUCO 445	Oral Communication in Business	4
BUCO 485	Business Communication Management	4
MOR 469	Negotiation and Persuasion	4

BUSINESS ADMINISTRATION AND ENTREPRENEURSHIP/ MANAGEMENT AND ORGANIZATION ELECTIVE (CHOOSE ONE)		UNITS
BAEP 451	The Management of New Enterprises	4
MOR 462	Management Consulting	4

PROJECT COURSE		UNITS
ENE 590	Directed Research	6

The approved project work will be a research activity designed for about 3-4 months during the summer period, performed by the student under the direction and supervision of a full-time faculty member. The work will involve the participation of leading professionals from the private industry and/or governmental agencies with whom the faculty member might maintain a professional relationship. The project will address an area of importance and primary interest to the industrial entity in question. It is believed that this type of partnership will be mutually beneficial to the graduating student, private industry and university faculty in generating a friendly and long-term professional relationship among them.

Master of Construction Management

Students possessing a bachelor's degree and with sufficient training in capital management and statistics may pursue the Master of Construction Management. This is an interdisciplinary degree program offered jointly by the Department of Civil Engineering and the USC School of Policy, Planning, and Development. A single application is made to the Department of Civil Engineering. The purpose of the Master of Construction Management program is to educate and train multidisciplinary professionals to understand and execute the broad array of technical and non-technical activities associated with construction management. The program provides special attention to the function of the constructor in real estate development. The core of the program is drawn from the MSCE program in construction engineering and management, and from the USC School of Policy, Planning, and Development's Master of Real Estate Development program.

CORE CURRICULUM		UNITS
ARCH 511L	Seminar: Building Systems	4
CE 501	Functions of the Constructor	3
CE 502	Construction Accounting and Finance, or	
GSBA 510	Accounting Concepts and Financial Reporting	3
CE 556ab	Project Cost Estimating, Control, Planning and Scheduling	3-3
ISE 460	Engineering Economy, or	3
RED 541	Finance Fundamentals for Real Estate Development	2
RED 509	Market Analysis for Real Estate	4
RED 598	Real Estate Product Development	2
Additional advisor approved technical and advanced electives		9
Total minimum units		33-34

The minimum requirement for the Master of Construction Management degree is 33-34 units. At least three elective courses totaling at least 9 units are required for this degree. These may be taken from the Department of Civil Engineering, other engineering departments, the USC School of Policy, Planning, and Development, the USC School of Architecture, the USC Davis School of Gerontology, the USC Law School or the USC Marshall School of Business subject to advisor approval. Admission to some classes requires advanced prerequisites and is subject to availability and approval of the instructor.

General Requirements

Residence and Course Load

The normal time required for earning the Master of Construction Management is three semesters, including one summer semester beginning in July and continuing through the spring semester ending in May. Students are expected to participate in extracurricular activities associated with the Master of Construction Management program, including the speaker series and field trips. A candidate must complete the last four semester units of course work at USC.

Students who wish a leave of absence for a semester or longer must request it from the chairman of the Civil Engineering Department in writing. Such leaves may be granted for up to one year.

For further information see the USC School of Policy, Planning, and Development section, page 764.

Master of Engineering in Computer-Aided Engineering

The Master of Engineering program educates and trains multidisciplinary professionals in the use of computational techniques in the planning, design and management of engineering projects. The emphasized computer-aided engineering subjects are modeling, simulation, visualization, optimization, artificial intelligence and advanced design, documentation, manufacturing and information management. The program provides the graduate with advanced education in a particular engineering subject area, associated with aerospace, civil or mechanical engineering. This advanced engineering education is coupled with an intensive concentration in computational procedures appropriate for that subject area. The program also includes substantial project work to provide a background in the application of CAE techniques in real world situations.

For further information see the listing under Computer-Aided Engineering, page 520.

Master of Engineering in Structural Design

The Master of Engineering program emphasizes the design of engineered structural systems. The design of new structures and the upgrading of existing structures, for adverse loading conditions, requires additional studies which extend beyond the basic concepts stressed in an undergraduate program. Modern computational methods will be used to evaluate the functional demands on the designed system, and a comprehensive design project will be used to integrate the concepts presented during the course of study. The program is focused on the needs of students who are planning to enter professional practice and not continue for a more advanced degree and on the needs of practicing engineers who have been out of school for several years and who want to upgrade their engineering skills.

The course of study requires the successful completion of 30 semester units. It is designed to be completed in one year of study, including the design project which must be taken during the first, seven-week summer session.

REQUIRED COURSES (18 UNITS)		UNITS
CE 458	Theory of Structures II	3
CE 459	Introduction to Structural Dynamics	3
CE 488	Computer Applications in Structural Analysis and Design	3
CE 537	Advanced Reinforced Concrete	3
CE 538	Prestressed Concrete	3
CE 539	Advanced Steel Structures	3
CE 549	Building Design Project	3

ELECTIVE COURSES (4 COURSES, 12 UNITS)		UNITS
CE 480	Structural Systems Design	3
CE 482	Foundation Design	3
CE 501	Function of the Constructor	3
CE 525b	Engineering Analysis	3
CE 528	Seismic Analysis and Design of Reinforced Concrete Bridges	3
CE 536	Structural Design for Dynamic Loads	3
CE 540	Limit Analysis of Structures	3

Engineer in Civil Engineering

Requirements for the Engineer in Civil Engineering are the same as set forth in the general requirements.

Doctor of Philosophy in Civil Engineering and Doctor of Philosophy in Engineering (Environmental Engineering)

The Doctor of Philosophy with a major in civil engineering and the Doctor of Philosophy with a major in engineering (environmental engineering) are also offered. See general requirements for graduate degrees.

Areas of specialization for Doctor of Philosophy level students are: structural engineering, structural mechanics, earthquake engineering, coastal engineering, water resources engineering, soil mechanics and foundation engineering, hydrology, hydrodynamics and transportation.

Certificate in Computer-Aided Engineering
The Certificate in Computer-Aided Engineering is a limited version of the Master of Engineering in Computer-Aided Engineering program. It is designed to focus on providing an understanding of the overall field of computer-aided engineering. It includes a course covering the necessary computer science skills and a course introducing basic simulation techniques used in computer-aided engineering. In addition, the certificate provides knowledge in the use of CAE tools in a project environment. See the listing under Computer-Aided Engineering, page 520.

Graduate Certificate in Transportation Systems
The graduate certificate in Transportation Systems is an interdisciplinary program administered by the Department of Civil Engineering. The certificate program allows students to specialize in transportation applications, while simultaneously receiving a degree in their home department. The certificate in Transportation Systems combines elements of transportation engineering with transportation policy, planning and project management. The program is especially appropriate for students intending to pursue careers as developers of transportation technologies, or as implementors of technologies within government agencies.

Students electing the certificate program apply to the Department of Civil Engineering. Course prerequisites for the program are:

(1) one course in statistics or uncertainty, equivalent to ISE 225, PPD 404x or CE 408;

(2) one course in engineering economy, equivalent to ISE 460;

(3) one course in microeconomics, equivalent to ECON 203; and

(4) one course in a high level programming language, such as C or Fortran.

These prerequisites may be satisfied after enrollment in the certificate program by taking the indicated courses or their equivalent. Graduate students cannot receive credit for courses numbered below 400. Detailed admissions requirements are published by the Department of Civil Engineering.

Qualified students holding a bachelor's degree also have the option of enrolling in the certificate program without receiving a separate graduate degree.

The curriculum consists of five graduate courses for a total of 17 units.

CERTIFICATE REQUIREMENTS		UNITS
CE 519	Transportation Engineering	3
CE 585	Traffic Engineering and Control	3
ISE 515	Institutional and Policy Issues in Transportation	3
PLUS 580	Urban Transportation Planning and Management	4
PLUS 581	Institutional and Policy Issues in Transportation	4

Courses of Instruction

CIVIL ENGINEERING (CE)

The terms indicated are *expected* but are not *guaranteed*. For the courses offered during any given term, consult the *Schedule of Classes*.

105L Surveying for Civil Engineering (2, Fa) Plane surveying, measurement of distances and angles, horizontal curves, surveying computations. Laboratory.

106 Design and Planning of Civil Engineering Systems (2) History of civil engineering; introduction to the synthesis and design of systems dependent upon civil engineering technology; the structuring, modeling, and simulation of such systems.

107 Introduction to Civil Engineering Graphics (3, FaSp) Graphic communication and drawing; use of instruments, lettering, dimensioning, and detailing of engineering drawing; free-hand sketching, drafting, and modeling.

108 Introduction to Computer Methods in Civil Engineering (2, Fa) Computer programming, organization of problems for computational solution, flow charts, programming; numerical methods; analysis and solution of civil engineering problems.

110 Introduction to Environmental Engineering (4, Fa) Basic concepts of environmental engineering. Local and global environmental pollution; scientific, social, legal and political aspects of environmental issues; air/water/land pollution and control technologies.

205 Statics (2) Statics of particles and rigid bodies; equivalent force systems; distributed forces; applications to trusses, frames, machines, beams, and cables; friction; moments of inertia. *Corequisite:* PHYS 151*L*.

210L Introduction to Environmental Engineering Microbiology (3, Sp) Principles of environmental microbiology; waterborne pathogens; microorganisms and air pollution; microorganisms in soil; water pollution microbiology; biodegradation of hazardous chemicals; eutrophication. *Prerequisite:* CE 110; *corequisite:* CHEM 105*aL* or CHEM 115*aL*.

225 Mechanics of Deformable Bodies (3) Analysis of stress and strain; axial, flexural, and torsional behavior of slender bars; elastic deflections; combined stresses; introduction to elastic stability and energy methods. *Prerequisite:* CE 205.

306L Civil Engineering Measurement Systems (3) Mensuration and instrumentation for civil engineering practice. Cadastral, route, and construction surveying systems. Professional responsibility, managerial and supervisory controls for field surveying operations. *Prerequisite:* CE 105*L*.

309 Fluid Mechanics (3, FaSp) Fluid statics; relative velocity field; total acceleration; divergence theorem; conservation of mass, energy, and momentum applied to engineering problems in laminar and turbulent flow. *Prerequisite:* MATH 126; *corequisite:* CE 325.

325 Dynamics (3) Elements of vector algebra; dynamics of particles, systems of particles and rigid bodies; kinematics; momentum relations, energy methods; vibrations; Euler's equations of motion. *Prerequisite:* CE 205.

334L Mechanical Behavior of Materials (3, Sp) Measurement of stress and strain; tensile, impact, creep, and fatigue behavior; statistical methods, brittle fracture; properties of structural materials. *Prerequisite:* CE 225 or ME 204.

358 Theory of Structures I (3, Fa) Deformations and deflections of elastic systems; statically indeterminate beams, arches, and frames; secondary stresses. *Prerequisite:* CE 225.

390 Special Problems (1-4) Supervised, individual studies. No more than one registration permitted. Enrollment by petition only.

402 Computer Methods in Engineering (3, FaSp) Fundamentals of analog and digital computers; simulation of nonlinear physical systems; numerical analysis and solution of engineering problems. *Prerequisite:* CE 108 and MATH 245.

404 Fundamentals of Law for Engineers (3, Sp) Legal problems confronting the engineer in his professional environment and daily life. Survey of the legal system and how it operates.

406 Microcomputer Applications in Civil Engineering (3) Solution of civil engineering problems using microcomputers; frame analysis, beam and column design; common database problems, solution of large numerical problems using limited computer resources.

407 Analytical Mechanics (3) Principles of dynamics; Lagrange equations; Hamilton's principle; rigid body dynamics; gyroscopic motion; wave propagation; vibrations of multidegree freedom systems. *Prerequisite:* CE 228.

408 Risk Analysis in Civil Engineering (3, Fa) Realization of nondeterministic problems in civil engineering; quantitative analysis of structural and system reliability; optimal design and design with specified risk.

409abL Computer Aided Design (3-3, FaSp) Applications of interactive computer graphics to design problems; automated drafting; 3-D graphic algorithms. Analysis of design process from information processing viewpoint. *Prerequisite:* CE 225.

412 Construction Law and the Property Development Process (3, Fa) Legal aspects of property development and construction: land use, construction practices and specifications, architecture and engineering contracts, agency, subcontracting, professional registration, liability, insurance, liens, and bonds. *Recommended preparation:* CE 404 or a general business law course.

428 Mechanics of Materials (3) Analysis of stress and deformation; equations of elasticity; bending of beams; elastic instability; torsion problems; introduction to plates and shells; elastic wave propagation; numerical methods. *Prerequisite:* CE 225.

429 Structural Concept Design Project (3) Synthesis of structural systems to meet strength and stiffness requirements; RFPs; structural behavior; concept generation; preliminary analysis; trade-off studies; evaluation criteria; project management. *Prerequisite:* AME 353 or CE 358.

443 Environmental Chemistry (3, FaSp) Chemistry of water, gas, liquid and solid wastes. Chemical principles applicable to environmental engineering. *Prerequisite:* CHEM 105*bL* or CHEM 115*bL*.

451 Water Resources Engineering (4, Sp) Discussion of broad perspective on control and utilization of water resources; hydrology, probability concept, economic study, hydraulic structures, multiple purpose water resources projects. *Prerequisite:* CE 309.

453 Water Quality Control (3, FaSp) Water quality criteria and fundamental of acceptability. Natural purification of surface waters. Processes employed in the treatment of waste waters for disposal or re-use. *Prerequisite:* CHEM 105*aL* or CHEM 115*aL* and CE 309.

456 Design of Steel Structures (3, Fa) Analysis and design of steel structures; beam-columns, plate girders, and frames; multistory design project. *Prerequisite:* CE 358.

457 Reinforced Concrete Design (3, Sp) Strength and deformation of reinforced concrete; beams in flexure and shear; bond and development of bars; deflections; columns; slabs; footings; introduction to prestressed concrete. *Prerequisite:* CE 225.

458 Theory of Structures II (3, Sp) Matrix algebra; stiffness method; force method; computer analysis of planar structures. *Prerequisite:* CE 108 and CE 358 or AME 150*L* and AME 353.

459 Introduction to Structural Dynamics (3, Sp) Response of single and multiple degree of freedom systems to dynamic excitation; structural modeling and approximate solutions; introduction to earthquake resistant design. *Corequisite:* CE 458.

460 Construction Engineering (3) Introduction to the construction processes; estimating and bidding, construction administration, planning and scheduling, equipment and methods, labor relations, cost control systems, and safety.

461 General Construction Estimating (3) Theory of estimating. Quantity surveying; unit cost synthesis and analysis. Bid organization and preparation; competitive simulations and exercises. *Prerequisite:* departmental approval.

462 Construction Methods and Equipment (3) Current procedures in selected fields of construction; organization and planning; equipment economics; machinery.

463L Water Chemistry and Analysis (3, FaSp) Chemistry of water purification technology and water pollution control. Chemical processes in natural and engineering aquatic environments; physical/chemical and biological characterization of water and wastewater. *Prerequisite:* CE 453, CHEM 105*b* or CHEM 115*bL*.

464 Geotechnical Engineering (3) Fundamentals of soil mechanics and foundation engineering; soil classification, seepage, stress-strain behavior, shear strength, consolidation, design of retaining structures and foundations, and slope stability.

465 Water Supply and Sewerage System Design (3, Fa) Design of water supply systems, storm drains, sanitary sewers, and lift stations. *Prerequisite:* CE 453.

466 Design of Free-Surface Hydraulic Systems (3) Hydrological and hydraulic design for uniform and non-uniform flows, channel transition, sedimentation controls, design discharge for tributary watersheds, flood routing, flood detention, computer aided design. *Prerequisite:* CE 309.

467L Geotechnical Engineering (4, Fa) Fundamentals of geotechnical engineering; soil classification, seepage, stress-strain behavior, shear strength, consolidation, design of retaining structures and foundations, and slope stability. Soil testing. (Duplicates credit in CE 464 and CE 468.) *Prerequisite:* CE 225.

468L Experimental Soil Mechanics (3) Laboratory testing of soils and computer processing of experimental measurements, soil classification, compaction tests, permeability tests, unconfined compression, direct sheet, consolidation, triaxial tests. *Prerequisite:* CE 464.

471 Principles of Transportation Engineering (3, Fa) Planning, design, construction, maintenance, and operation of facilities for air, water, rail, and highway transit systems.

472 Construction Labor Management (3) Unionism in construction. Craft tradition, objectives, regulation, motivation, labor force economics, productivity, and technical change. Hiring systems, supervision of project labor operations, jurisdictional administration.

476 Design of Pressurized Hydraulic Systems (3) Application of hydraulic principles to the engineering design of hydraulic structure with pressurized flow, piping network, water hammer, surge suppression, pumps and turbines, manifold hydraulic design. *Prerequisite:* CE 309.

477 Civil Infrastructure Information Systems (3, Fa) Information systems and their use in the planning, design, construction, and operation of civil infrastructure projects. Project management and knowledge management for infrastructure systems development. *Prerequisite:* CSCI 201, CE 402.

478 Timber and Masonry Design (3, Fa) Characteristics and properties of wood; beams, columns, trusses, connectors, and diaphragms. Properties of masonry, working stress and strength design, seismic design requirements.

480 Structural Systems Design (3, Sp) Evaluate, design and analyze buildings. Organize and perform calculations for vertical loads, wind loads, and seismic loads on building projects. *Prerequisite:* CE 456, CE 457, or CE 478.

482 Foundation Design (3) Analysis and design principles of building foundations, including spread footings, piles, drilled shafts, sheetpile walls and retaining structures. *Prerequisite:* CE 467.

484 Water Treatment Design (3) Predesign studies, precipitation softening, coagulation and flocculation, sedimentation, filtration, sludge handling, chlorination, chloramination, ozonation; plant hydraulics, flow measurement, pumps, instrumentation and control, tertiary treatment. *Prerequisite:* CE 453.

485 Wastewater Treatment Design (3) Process kinetics, mass balance, reactor design, pretreatment, clarification, chemical treatment, biological treatment (aerobic and anaerobic), disinfection, sludge treatment, nitrogen and phosophorus removal, carbon adsorption. *Prerequisite:* CE 453.

488 Computer Applications in Structural Analysis and Design (3) Application of existing computer programs to the analysis and design of complex structures.

490x Directed Research (2-8, max 8) Individual research and readings. Not available for graduate credit. *Prerequisite:* departmental approval.

499 Special Topics (2-4, max 8) Course content to be selected each semester from recent developments in civil engineering and related fields.

501 Functions of the Constructor (3) Systems, processes, and constraints governing the initiation, direction, engineering, and delivery of major construction projects. Professional construction management, responsibilities, and practice.

502 Construction Accounting and Finance (3) Cost control, finance, and engineering economy for construction operations.

503 Microbiology for Environmental Engineers (3) Basic microbiology of water, air, and soil. Application of microbiology to the practice of environmental pollution control.

504 Solid Waste Management (3) Characterization, production, storage, collection, and transport of solid wastes; alternative disposal methods; design principles and environmental impact; management of radiological solid wastes.

505 Heavy Construction Operations and Methods (3, Sp) Methods and operations involved in constructing hardrock and soft ground tunnels, shafts, bridge piers in water, and design-construction of concrete formwork and shoring.

506 Heavy Construction Estimating (3) Methods engineering, work analysis and pricing for route construction. Grading, draining, paving, haul economy, plant-materials production, pipeline and bridge building. *Prerequisite:* CE 462.

507 Mechanics of Solids I (3, Fa) Analysis of stress and strain; constitutive equations for elastic materials; plane stress and strain; torsion; introduction to plates and shells; energy methods.

508 Mechanics of Solids II (3) Thermal stresses; introduction to elastic stability; yield criteria; constitutive equations for elastoplastic materials; elastoplastic stress analysis; viscoelasticity and creep. *Prerequisite:* CE 507 or CE 428.

509 Mechanics of Solids III (3) Advanced topics in mechanics of solids; complex variable methods for plane problems; three-dimensional problems; introduction to fracture mechanics. *Prerequisite:* CE 507.

510 Groundwater Management (3) Groundwater hydrology, aquifer testing technology, groundwater quality and contamination, geophysical method, well design and development, basin water balance, computer modeling, legal aspects, groundwater management system.

511 Flood Control Hydrology (3) Flood frequency, storm characteristics, net rain; surface drainage, peak discharge, flood runoff.

512ab Special Topics in Hydrology (3-3) *a:* Topics in the hydrology of groundwater and low flow. *b:* Topics in the hydrology of floods and surface drainage.

513L Instrumental Methods for Environmental Analysis (3) Advanced techniques in gas, water, liquid, and solid waste analysis; theoretical and experimental consideration of electrometric, photometric, manometric, and chromatographic techniques for measurements of environmental pollution. Lecture, 2 hours; laboratory, 3 hours. *Prerequisite:* CE 463*L*.

514ab Advanced Sanitary Engineering Design (3-3, FaSp) Design of water and waste treatment works. *Prerequisite:* CE 453.

516 Geohydrology (3) Principles of groundwater motion; acquifer characteristics, prospecting, practical engineering problems, well design, maintenance and rehabilitation; hydrodynamic dispersion, field testing essentials and procedures, groundwater quality, artificial recharge.

517 Industrial and Hazardous Waste Treatment and Disposal (3, 2 years, Sm) Physical, chemical, and biological treatment processes for industrial and hazardous wastes; pretreatment systems, biodegradation of toxic chemicals; groundwater and soil decontamination; biofilters for air decontamination. *Prerequisite:* CE 463*L*.

519 Transportation Engineering (3) Principles of analysis and planning. Characteristics of transportation systems. Urban and regional systems. Relationship between environment and transportation systems. Estimating the impact of decisions.

520ab Ocean and Coastal Engineering (3-3) Linear and nonlinear wave theories with engineering applications; wind waves; wave spectra; wave interactions with marine structures; ship mooring, harbor resonance; sediment transport; diffusion processes. *Corequisite:* AME 530*a*.

522 Groundwater Hydrologic Modeling (3) Simulation of groundwater hydrologic processes through mathematical, analog, and physical models.

523 Physical Processes of Environmental Engineering (3, Sp) Environmental reactor design, coagulation, flocculation, sedimentation, filtration, adsorption, solid waste management (drying, centrifugation, incineration), membrane processes, advanced water treatment; mathematical modeling of physical processes. *Prerequisite:* CE 463*L*.

525ab Engineering Analysis (3-3) Typical engineering problems discussed on a physical basis. Setup and solution of problems by means of the existing mathematical tools.

526 Hydraulic Structures (3) Technical and economic analysis of hydraulic structures for water power, irrigation, and flood control; masonry, earth and rock-fill dams, outlet works. *Prerequisite:* CE 466 and CE 476.

528 Seismic Analysis and Design of Reinforced Concrete Bridges (3) Fundamental concepts, methods and current codes used in the analysis and design of reinforced concrete bridge structures. Experimental and earthquake observations of bridge performance. *Prerequisite:* CE 457; *recommended preparation:* CE 538.

529ab Finite Element Analysis (3-3) Basic concepts; stiffness method; variational methods; displacement method; isoparametric formulation; plane stress and strain; plates and shells; dynamics; stability; nonlinear analysis, heat transfer; computer applications.

530 Nonlinear Mechanics (3) Nonlinear problems in structural dynamics; elastic-plastic response; approximate methods of nonlinear analysis; stability theory; stability of periodic nonlinear oscillations; Liapounov's method; nonlinear buckling problems.

531 Soil Mechanics (3) Soil formation; clay mineralogy; steady state seepage; mechanical coupling between interstitial water and soil skeleton; experimental soil behavior and its modeling with constitutive equations. *Prerequisite:* CE 464.

532 Principles of Foundation Engineering (3) Fundamental methods in foundation engineering; plastic collapse, limit equilibrium, bearing capacity, slope stability; soil-structure interaction; application of numerical methods, finite differences and finite elements. *Prerequisite:* CE 464.

533 Geotechnical Earthquake Engineering (3, Sp) Provides a design-oriented understanding of the "state-of-the-practice" of soil mechanics and foundation engineering aspects of earthquake engineering.

534 Design of Earth Structures (3, Sp) Designed to provide a thorough understanding of the analytical and design principles underlying the construction of a broad range of earth structures.

535ab Earthquake Engineering (3-3) Fundamentals of earthquake engineering; characteristics of earthquakes; seismicity; response of linear and nonlinear multidegree systems; basic concepts in earthquake-resistant design; foundation problems.

536 Structural Design for Dynamic Loads (3) Earthquake resistant design criteria with application to steel reinforced concrete and timber structures. Design of blast resistant structures and structures subject to impact loads. *Prerequisite:* CE 459 or CE 541*a*.

537 Advanced Reinforced Concrete (3) Behavior of reinforced concrete members in terms of strength and deformation; relationship between behavior and building code requirements.

538 Prestressed Concrete (3) Fundamental principles of prestressing by pre- and post-tensioning; elastic and time dependent losses; stress analysis and design of prestressed and precast concrete structures.

539 Advanced Steel Structures (3) Design of tubular members and plate girders; design for torsional and seismic loads; general flexural theory; introduction to plastic design; connections.

540 Limit Analysis of Structures (3) Plastic analysis and design of frames. Fundamental theorems of plastic analysis; general methods of plastic analysis, design requirements, minimum weight design theorems and applications, shakedown theorems.

541ab Dynamics of Structures (a: 3, Fa; b: 3, Sp) *a:* Forced vibrations of discrete MDOF systems; modal analysis; energy methods; analytical dynamics; vibration of continuous systems; wave propagation; computational techniques; application of commercial software tools. *b:* Continuous system responses; approximate methods; introduction to structural control; random vibration concepts; response of continuous systems to random excitation; nonlinear systems (geometric theory), (approximate methods). *Prerequisite:* CE 541*a*.

542 Theory of Plates (3) Theory of plate bending; rectangular and circular plates; anisotropic plates; energy methods; numerical methods; large deformations; sandwich plates. *Prerequisite:* CE 428 or CE 507.

543 Stability of Structures (3) Critical loads of columns, beams, thin-wall bars, plates, shells; stability of frames and trusses; effect of inelastic behavior of materials; effect of dynamic loading.

544 Theory of Shell Structures (3) General bending theory of shells; membrane theory; shells of revolution; numerical methods; dynamic response. *Prerequisite:* CE 428 or CE 507.

545ab Advanced Finite Element Method in Structural and Continuum Mechanics (3-3) *a:* Finite elements in nonlinear mechanics, elasticity, plasticity, viscoelasticity; advanced finite element applications in fracture mechanics, heat transfer, fluid mechanics; computational implementation of finite element method. *Prerequisite:* 529*a*. *b:* Mathematical aspects of the finite element method; correctness of discretizations for elliptic, parabolic, and hyperbolic equations; accuracy and convergence considerations; stability of time dependent algorithms. *Prerequisite:* CE 545*a*.

546 Structural Mechanics of Composite Materials (3) Applications and manufacturing of composites: anisotropic materials; laminated composite plates and shells; buckling and dynamics; strength and failure; interlaminar stresses; delamination; thermal properties; design considerations.

547 Engineering Rock Mechanics (3) Basic characteristics of rocks; mechanical behavior of rocks, deformation, strength, and rock fracture; engineering applications, mining, excavation, tunneling, drilling, blasting, cutting and slope stability. *Prerequisite:* CE 464.

549 Building Design Project (3, Sm) Integrated design project following design office procedures. A building will be designed in detail using the team approach. Capstone for M.Eng. in Structural Design. *Prerequisite:* CE 488 or CE 458, CE 537, CE 539, CE 549.

550 Computer-Aided Engineering (3, Fa) Basic concepts of computer-aided engineering. Modeling; simulation; visualization; optimization; artificial intelligence; manufacturing; information management. Organization and management of computer-aided engineering projects.

551 Computer-Aided Engineering Project (3, Sp) Computer-aided engineering in a project environment. Responding to RFPs; conceptual design; preliminary analysis; overall and detailed analysis and design; trade-off studies; project management; project presentation.

552 Managing and Financing Public Engineering Works (3) Tools for improving the efficiency and effectiveness of public engineering works, taking into account the political and policy context. Graduate standing. *Recommended preparation:* microeconomic theory.

553 Chemical and Biological Processes in Environmental Engineering (3) Chemistry of softening, coagulation, disinfection, oxidation, corrosion control, dry and wet combustion and ion exchange; aerobic and anaerobic processes and the ecology of liquid and solid waste treatment. *Prerequisite:* CE 453.

554 Risk and Reliability Analysis for Civil Infrastructure Systems (3, Sp) Elements of feasibility, reliability, and risk analysis of civil infrastructure systems, simulation, optimization, life-cycle cost, evaluation and decision making.

555 Underwater Structures (3) Loads on underwater structures; stress analysis of typical structural elements; buckling problems; dynamic response. *Prerequisite:* CE 507.

556ab Project Cost Estimating, Control, Planning, and Scheduling (3-3, FaSp) Fundamental principles and practices of cost estimating, budgeting, and cost control of construction projects. Case studies and software exercises based on project data. Graduate standing in engineering, architecture, business or urban and regional planning required.

557 Advanced Building Estimating (3) Processes in compiling a bid for construction of non-residential building.

558 International Construction and Engineering (3, FaSp) Business development and project management in international markets. Topics include marketing, planning, contracts and negotiations, procurement, logistics, personnel and financing. Construction operations in adverse environments. Graduate standing in engineering, architecture, business, or urban planning required.

559 Strategic Planning in Construction Engineering (3) Elements and techniques of strategic planning for construction engineering. Fundamentals of engineering as a service sector enterprise. Assessment of markets (including international issues), competitors, and technology. Aspects of overseas engineering business. Management of technology and the role of R&D. Emphasis on concepts. *Recommended preparation:* CE 502.

560 Simulation of Civil Infrastructure Systems Performance (3, Sp) Time/space and frequency/wave number domain analysis, spectral representation of wind, earthquake and other natural loads, FEM techniques for system response simulation.

562ab Hydromechanics (3-3) Analytical solution of civil engineering problems concerned with hydraulic flow; water hammer, free-surface flow, waves and see page flow; application of theory to research and design.

563 Chemistry and Biology of Natural Waters (3, 2 years, Fa) Chemical and biological limnology; cycles of carbon, nitrogen, phosphorous, sulfur, and other biologically-mediated chemical transformations; effect of pollution on biology and chemistry of natural waters. *Prerequisite:* CE 443 and CE 453.

564 Methods for Assessment and Protection of Environmental Quality (3, Sp) Natural ecosystems, technologies for control and remediation of air, water, and soil pollution; natural hazards and urban lifeline systems; Design For The Environment (DFE).

565 Wave Propagation in Solids (3) Elastic waves in infinite and semi-infinite regions; plates and bars; steady-state and transient scattering; dynamic stress concentration; viscoelastic and plastic bodies.

572 Construction Labor Management (2) Unionism in construction. Craft tradition, objectives, regulation, motivation, labor force economics, productivity, and technical change. Hiring systems, supervision of project labor operations, jurisdictional administration.

579 Introduction to Transportation Planning Law (3) Federal and state statutory and regulatory requirements affecting California transportation systems, including transportation planning and funding law; and government contracting, environmental, and civil rights requirements.

583 Design of Transportation Facilities (3) Planning, design, staging, construction, test, and maintenance of the public works and facilities for land, water, and air transportation. *Prerequisite:* CE 519, CE 457, or departmental approval.

585 Traffic Engineering and Control (3) Conceptual engineering geometric design, installation, and calibration of vehicular storage and traffic controls; safe flow optimization of vehicles on various thoroughfares. *Prerequisite:* CE 471, ISE 220.

586x Management for Engineers (4) (Enroll in AME 589*x*)

587 Transportation Energy Analysis (3) Energy consumption and socioeconomic impacts of past, present, and future transportation systems; analysis of alternatives between energy-intensive and low-cost transportation modes.

589 Port Engineering: Planning and Operations (3, Sp) Physical and operational characteristics of marine ports; impact analysis of modern logistics on port operation, planning and management; optimization and efficiency solutions for container terminals.

590 Directed Research (1-12) Research leading to the master's degree. Maximum units which may be applied to the degree to be determined by the department. Graded CR/NC.

594abz Master's Thesis (2-2-0) Credit on acceptance of thesis. Graded IP/CR/NC.

599 Special Topics (2-4, max 9) Course content will be selected each semester to reflect current trends and developments in the field of civil engineering.

640 Advanced Theory of Elasticity (3) Curvilinear tensors; equations of nonlinear elasticity; elementary solutions; small deformations superimposed on large deformations; bifurcation of equilibrium states; nonlinear shell theory. *Prerequisite:* CE 507.

690 Directed Research (1-4, max 8) Laboratory study of specific problems by candidates for the degree Engineer in Civil Engineering. Graded CR/NC.

694abz Thesis (2-2-0) Required for the degree Engineer in Civil Engineering. Credit on acceptance of thesis. Graded IP/CR/NC.

790 Research (1-12) Research leading to the doctorate. Maximum units which may be applied to the degree to be determined by the department. Graded CR/NC.

794abcdz Doctoral Dissertation (2-2-2-2-0) Credit on acceptance of dissertation. Graded IP/CR/NC.

Computer-Aided Engineering

Degree Requirements

Kaprielian Hall 210
(213) 740-0603
FAX: (213) 744-1426
Email: civileng@usc.edu

Master of Engineering in Computer-Aided Engineering

The Master of Engineering program educates and trains multidisciplinary professionals in the use of computational techniques in the planning, design and management of engineering projects. The computer-aided engineering tools which are emphasized are modeling, simulation, visualization, optimization, artificial intelligence and advanced design, documentation, manufacturing and information management. The program provides the graduate with a credential which represents the completion of advanced training in a particular engineering application area, coupled with an intensive concentration in computational procedures appropriate for that application area. The focus of the program is on advanced engineering design involving aerospace, civil and mechanical engineering systems. The program includes substantial project work designed to provide a background in the application of CAE techniques in real world situations. This program is not oriented to the engineering of electrical or computer systems. The USC School of Engineering, through the Department of Electrical Engineering, offers various programs which focus on computer-aided engineering techniques related to electrical and computer engineering projects.

The minimum requirement for the Master of Computer-Aided Engineering is 30 units. The curriculum has three segments: computer-aided engineering core, the discipline specific core and the computational electives.

Computer-Aided Engineering Core
Fifteen units are required, including courses emphasizing graduate level mathematics, basic computer science principles, an introduction to simulation, an overview of computer-aided engineering techniques, and computer-aided engineering projects. The core involves the choice of two simulation courses — CE 529a, which involves finite element analysis and a structural orientation, and AME 535a, which involves a fluid mechanics orientation.

The Master of Engineering program involves major design project work in the computer-aided engineering overview course, CE 550, and in the computer-aided engineering project course. Students have a choice of project courses. CE 551 is a generic course incorporating structural, fluid and thermal projects. AME 535b focuses entirely on fluid mechanics projects. Some students may wish to pursue specialized projects not covered in either of these courses. They may complete a specialized project by taking the AME or CE 590 directed research courses through an appropriate advisor.

CAE CORE CURRICULUM		UNITS
AME 526	Engineering Analytical Methods, or	
CE 525b	Engineering Analysis	3
AME 535a	Introduction to Computational Fluid Mechanics, or	
CE 529a	Finite Element Analysis	3
AME 535b	Introduction to Computational Fluid Mechanics, or	
AME 590	Directed Research, or	
CE 551	Computer-Aided Engineering Project, or	
CE 590	Directed Research	3
CE 550	Computer-Aided Engineering	3
CSCI 455x	Introduction to Programming Systems Design	4

Discipline Specific Core
Six units are required involving advanced graduate level engineering courses. These courses are designed to focus on fundamental theory rather than design or computational techniques. All courses are to be taken from the same basic discipline, selected by the student. The possible basic disciplines include structural and solid mechanics, fluid mechanics, thermal analysis and combustion, geomechanics, and other areas of applied mechanics. The student is provided with a list of the acceptable courses in each discipline. In general, these lists include courses from the Departments of Aerospace and Mechanical Engineering and Civil Engineering.

Computational Electives
Nine units are required involving advanced graduate level engineering courses which focus on computational procedures. The student is provided with lists of acceptable computational electives. These electives are designed to cover the computational areas of geometric modeling, simulation, visualization, optimization, artificial intelligence and advanced design, documentation, manufacturing and information management. The student is permitted to spread electives over multiple computational areas.

Certificate in Computer-Aided Engineering

The Certificate in Computer-Aided Engineering provides students possessing a bachelor's degree in civil engineering, mechanical engineering or aerospace engineering, with a specialized education covering the use of computational techniques in the planning and design of engineering projects. This program is closely related to the Masters of Engineering in Computer-Aided Engineering program. For a student pursuing a master's degree in some other area, the certificate makes it possible to add, at a reasonable cost, a credential representing advanced training in computer-aided engineering.

The Certificate in Computer-Aided Engineering involves 12 units of course work.

PREREQUISITE		UNITS
CSCI 455x	Introduction to Programming Systems Design, or equivalent courses covering undergraduate computer science topics including programming principles, data structures and software engineering	

CAE CORE CURRICULUM		UNITS
AME 535a	Introduction to Computational Fluid Mechanics, or	
CE 529a	Finite Element Analysis	3
AME 535b	Introduction to Computational Fluid Mechanics, or	
CE 551	Computer-Aided Engineering Project	3
CE 550	Computer-Aided Engineering	3

COMPUTATIONAL ELECTIVE

One course to be selected from a list of advanced courses covering the computational techniques most important in computer-aided engineering.