Civil and Geomatics Engineering and Construction

The Department

The Department of Civil and Geomatics Engineering and Construction offers programs of study leading to the Bachelor of Science degrees in Civil Engineering, Geomatics Engineering, and Construction Management. Civil and Geomatics Engineering programs are accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (ABET) which represents the major professional engineering groups in the United States. The Management Specialty Program of the Bachelor of Science degree in Construction Management is accredited by the American Council for Construction Education, the professional accreditation organization of the construction industry.

Faculty and Facilities

The teaching and research specialties of the department's faculty cover every area of civil engineering, geomatics engineering, and construction. Most faculty members are licensed as civil engineers, land surveyors, or contractors and have a wide range of professional experience in engineering design, analysis, research and development, and project planning and management.

Excellent laboratory facilities exist for testing of soils and construction materials, hydraulics testing, and water quality analysis.

Mandatory Advising

It is the policy of the department that every student see his/her assigned adviser at least once during the academic year.

Administrative Academic Probation

A minimum GPA of 2.0 must be maintained in all courses taken in the College of Engineering and Computer Science. Students who fail to maintain a 2.0 GPA in courses within their major may be placed on administrative academic probation. Failure to eliminate the grade point deficiency could result in disqualification from the College of Engineering and Computer Science.

Civil Engineering

Civil engineering includes the research, development, planning, design, construction, and maintenance associated with urban development, water supply, structures, energy generation and transmission, water treatment and disposal, and transportation systems. The civil engineer deals with the function and safety of such public facilities as buildings, bridges, dams, pipelines, powerplants, highways, and harbors, and is concerned with the protection of the public against natural hazards of earthquakes, floods, landslides, and fires.

The graduate curriculum leading to an M.S. degree in Civil Engineering provides specialized training in the fields of structural engineering and applied mechanics, soil mechanics and foundation engineering, environmental engineering, water resources engineering, highway engineering, and geomatics engineering.

Career Opportunities

Employment opportunities for civil engineers in industry, state, and federal government agencies remain at a high level as a result of increasing urban growth and land development, and the recent emphasis on the maintenance and repair of the nationwide highway system. Civil engineers are also in demand to meet the growing challenge of mitigating environmental hazards.

Civil engineers frequently occupy positions in specialty areas such as environmental engineering, geotechnical engineering, structural engineering, transportation engineering, and water-resources engineering. Position titles for civil engineers, such as senior engineer or project engineer in specialty areas, typically reflect their rank within their organization.

Most civil engineering graduates have earned professional licenses as civil engineers within a few years of receiving their degrees.

College of Engineering
and Computer Science

Department of Civil and Geomatics Engineering and Construction
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B.S. in Civil Engineering

B.S. in Construction Management

B.S. in Geomatics Engineering

M.S. in Civil Engineering

Minor in Construction Management

Faculty

Mohamad A. Yousef, *Chair*
Howard C. Biddlecome
Chandra S. Brahma
James K. Crossfield
Ali El-Zeiny
Frank H. Goishi
R. Louis Gysler
Mushtaq Hussain
Magdi A. Khalifa
Jesus S. Larralde-Muro
Karl E. Longley
Riadh Munjy
Fareed W. Nader
Todd R. Sheller
C. Dennis Spring
William F. Wright

Mission of Civil Engineering

The mission of the Civil Engineering Program is to provide the educational environment necessary for civil engineering students to develop their personal potential to the greatest extent possible and to enrich the students' lives in a culturally diverse environment. Civil engineering also provides the high quality education required for the students to fully develop their professional qualities and skills to serve society.

The Civil Engineering Program's Educational Objectives

- Offer a broadly based curriculum to civil engineering students, including general education as well as civil engineering education.

- Provide a civil engineering curriculum that includes an appropriate balance of engineering fundamentals and practical applications. Engineering fundamentals are covered mostly in the lower-division courses while the practical applications are strategically developed from the freshman through the senior levels.
- Provide the students with hands-on experience through laboratory courses, term projects, senior projects, and extracurricular activities.
- Provide the students with the tools and skills required in professional practice and to make them aware of the necessity for a life-long learning approach in professional practice.
- Foster the development of sensitivity and awareness of the role of the professional civil engineer in society.
- Foster in the students the development of communication skills, responsibility, and dependability.
- Develop in the students the ability to effectively work in groups; multidisciplinary as well as multicultural groups.
- Develop in the students an understanding of the ethical, social, and political issues inherent in the civil engineering profession.

Bachelor of Science Degree Requirements

Civil Engineering Major — *Units*

Major requirements 69

C E 20, 85, 121L, 123, 123L, 124, 128, 129, 130, 132, 133, 142, 142L, 150, 180A, 180B, 185 ..... (34)
G M E 15 ..... (3)
ECE 70, 90 or 91 ..... (6)
I E 160, I E 182W ..... (5)
M E 26, 112, 136 ..... (9)
Technical Area Courses ..... (12)
Select mandatory technical area courses in one or more of the following groups subject to the *Design Courses* statement below.
Environmental and Water Resources: C E 140, 141, 143, 144
General Professional: C E 110, 161, 190, 191T
Geotechnical: C E 125, 134
Structures: C E 131, 135, 136, 137, 138
Geomatics: G M E 151, 173
Transportation: C E 151, 152, 153
Design Courses: at least 6 units of technical area courses must be selected from the following design courses: C E 125, 134, 135, 136, 141, 143, 144, 151

Other requirements 68

General Education
Select one course from each of the G.E. areas: Area A1, A2, B2, C1, D1, D2, D3. (See pages 92-94 for G. E. listings.)
The following courses are required to satisfy both G.E. and major requirements: MATH 75 [B4], CHEM 1A [B1], PHIL 20 [C2], C E 121 [IB], PHIL 120 [IC], PL SI 120 [M/I]
Additional requirements
GEOL 1; MATH 76, 77, 81; PHYS 4A, 4AL, 4B, 4C

Total 137

Note: Engineering majors are exempt from G.E. Area A3, third course Area C, Area E, and Area ID.

Advising Notes

1. Courses in mathematics, the physical sciences, or engineering taken ***CR/NC*** are not counted toward fulfillment of degree requirements in civil engineering.
2. Since the civil engineering major curriculum is very demanding, many students, especially those not fully prepared in mathematics, chemistry, and/or physics take $4\frac{1}{2}$ or more years to graduate rather than the traditional 4 years. Students not fully prepared in chemistry should consider taking CHEM 3A in lieu of CHEM 1A. If needed, students also may go to the Learning Resource Center in Lab School, Room 137 and request tutorial assistance.

See the catalog Web Site for recommended program at *http://www.csufresno.edu/catoffice/current/engcivrec.html.*

Master of Science in Civil Engineering

(See also *Admission to Graduate Standing, Advancement to Candidacy, Program Requirements*, and *Criteria for Thesis and Project.*)

Admission. The requirements for graduate admission to California State University, Fresno must be met. Also, applicants should possess a bachelor's degree in civil engineering, geomatics engineering, or a related field from an institution accredited by the Accreditation Board for Engineering and Technology and must have a 2.7 grade point average in the last 60 semester-units of engineering courses attempted, on the basis of 4.0 being ***A***, or the approval of the Graduate Committee of the Department of Civil and Geomatics Engineering. If an applicant's preparation is deemed insufficient by the Graduate Committee of the Department of Civil and Geomatics Engineering, the applicant is required to take additional courses which are specified in writing to remove the deficiency. Such courses, taken as an unclassified student, are in addition to the minimum of 30 semester hours credit for the master's degree in engineering. The department graduate program coordinator shall appoint an interim graduate adviser for each student when that student is accepted into the graduate program. The coordinator will take into account student interests and correlated faculty interests when making this appointment.

A student must satisfactorily complete a written examination administered by the department before being eligible for Advancement to Candidacy; this satisfies both the university's graduate writing requirement and demonstrates the student has sufficient technical proficiency to continue in the program.

Continuation in the Program. Prior to being admitted to classified standing, a student is required to take the Graduate Record Examination. The minimum grade considered passing is quantitative 450.

The student then should select a graduate adviser before completing 12 units of graduate study and advancing to candidacy. Other members of his or her graduate committee shall be selected in consultation with the graduate adviser if the student has selected Plan A. This committee shall consist of a total of three members, two of whom must be tenure/tenure track faculty. The graduate student shall notify the department's Graduate Committee with a letter signed by both the student and the graduate adviser of the membership of the students' Graduate Committee. This letter shall be placed in the student's academic folder.

A graduate student may change graduate advisers but such change must be approved by the department's Graduate Committee.

The student, together with his or her graduate adviser, completes a contract program within his or her first semester of coursework taken for graduate credit. This program must be approved by the department's Graduate Committee. A minimum of 12 semester hours must be earned before the average is determined.

Campus graduate disqualification procedures shall be enforced by the department graduate program coordinator if the GPA drops below 3.0 (4.0 scale) each semester and cumulatively throughout all graduate program coursework. Any semester for which the grade point average falls below 3.0 shall result in placing the affected graduate student on probation. Normally, a second consecutive offense shall lead to disqualification. Such probation shall be for at least one semester or shall continue until the cumulative grade point average has again been raised above 3.0.

Program. Each master's degree student selects, as early as possible during the first semester of attendance, and upon consulting with and securing the approval of the graduate adviser, a program best suited to the student's interests and objectives.

The M.S. degree in Civil Engineering requires the completion of 30 units following one of three programs of study.

See the catalog Web site for civil engineering and geomatics engineering technical area courses that may be applied to the program at *http://www.csufresno.edu/catoffice/current/engcivprog.html.*

Plan A (Thesis)	*Units*
a. 200-series C E courses[1]	**12-24**
b. 100-series C E or G M E technical area courses[2]	**0-6**
c. Courses outside the department[3]	**0-6**
d. Thesis	**6**
Total	**30**

Plan B (Project)	*Units*
a. 200-series C E courses[1]	**15-27**
b. 100-series C E or G M E technical area courses[2]	**0-6**
c. Courses outside the department[3]	**0-6**
d. Project	**3**
Total	**30**

Plan C (Comprehensive Exam)	*Units*
a. 200-series C E courses[1]	**18-30**
b. 100-series C E or G M E technical area courses[2]	**0-6**
c. Courses outside the department[3]	**0-6**
Total	**30**

Advising Notes

1. Graduate courses in civil engineering — select from C E 205, 206, 220, 230, 232, 233, 234, 235, 237, 240, 242, 245, 246A, 246B, 247, 251, 261, 271, 275, 280, 281, 283, 285, 286, 290, and 291T.
2. 100-series technical area courses in civil and geomatics engineering — select from C E 110, 125, 131, 134, 135, 136, 137, 138, 141, 143, 144, 151, 153, 191T; G M E 125, 126, 135, 140, 145, 152, 153, 161, 174, 175, 177, 191T; and M E 144.
3. 100-series and 200-series courses outside civil and geomatics engineering are in disciplines best suited to the students graduate program as approved by the program adviser. This includes mathematics, statistics, management, business, geology, physics, chemistry, health science, and biology.

COURSES

Civil Engineering (C E)

20. Engineering Mechanics: Statics (3)
Prerequisites: MATH 77 or concurrently; PHYS 4A. Analysis of force systems, equilibrium problems, section properties; graphic, algebraic, and vector methods of problem solution. (CAN ENGR 8)

29. Engineering Mechanics (3)
(See M E 29.)

85. Introduction to Civil Engineering (1)
The civil engineering profession and its role in society; creative thinking and critical thinking as integral parts of the engineering decision process; engineering methods of analysis; career opportunities. (Field trips required)

110. Computer Applications in Civil Engineering (3)
Prerequisites: ECE 70, C E 130. Use and modification of existing programs. Creation of new programs. Use of structured language, spreadsheets, and database management software. Interactive design and graphic displays. Design orientation. Term projects.

121. Mechanics of Materials (3)
Prerequisite: C E 20; C E 85 or concurrently. Applications of principles of mechanics to find stresses and deformations in machine and structural members.

121L. Mechanics of Materials Laboratory (1)
Prerequisite: C E 121 or concurrently. Application of principles and methods of testing to verify theory and determine limitations of principles of mechanics of materials. (3 lab hours)

123. Soil Engineering (3)
Prerequisites: C E 121; ECE 70. Physical and mechanical properties of soil as an engineering material; studies and design applications in permeability, one and two dimensional flows, seepage through earth dams and coffer dams, porewater pressure and excess porewater pressure; compressibility, stress-strain relationships and strength characteristics; computer-aided analysis case histories.

123L. Soil Engineering Laboratory (1)
Prerequisite: C E 121L, 123 or concurrently. Experiments to illustrate and amplify the principles of soil mechanics. (3 lab hours; field trips required)

124. Concrete Laboratory (1)
Prerequisite: C E 121L. Proportioning of concrete mixes; admixtures; workability tests; compressive, flexural, and tensile strength tests; reinforced concrete. (3 lab hours; field trips required)

125. Geotechnical Engineering Design (3)
Prerequisites: C E 123, ECE 70. Design and theory of embankment and cut slopes, surcharging and sand drains, dewatering systems and ground control, excavation and support systems, field compaction and grouting systems; construction considerations, computer-aided design, and case histories. (2 lecture, 3 lab hours)

127. Construction Soils and Foundation (3)
Not open to civil engineering majors. Prerequisite: upper-level standing. Physical and mechanical properties of soil, construction applications of soils engineering design, field control during construction, field problems and remedial measures, and case histories.

127L. Construction Soil Lab (1)
Not open to civil engineering majors. Corequisite: C E 127. Laboratory experiments and sessions to reinforce principles of soil mechanics as well as foundation design and illustrate the use of soil as a construction material. (3 lab hours and field trips required)

128. Civil Engineering Hydraulics (3)
Prerequisite: C E 85 or concurrently and M E 112 or concurrently. Fundamentals of civil engineering hydraulics with application to hydraulic structures.

129. Engineering Hydraulics Lab (1)
Prerequisite: C E 128 or concurrently. Experiments and demonstrations in fluid properties, flow management, pipe flow, open channel flow, pumps, and hydraulic scour. (3 lab hours)

130. Theory of Structures (3)
Prerequisite: C E 121. Trusses and frames analyzed by algebraic and graphic procedures; influence lines and live loading analysis; rigid frames analyzed by slope deflection and moment distribution. Introduction to matrix methods.

131. Intermediate Theory of Structures (3)
Prerequisite: C E 130. Analysis of statically indeterminate beams, trusses, and frames; advanced topics in slope deflection and moment distribution; matrix methods.

132. Reinforced Concrete Design (3)
Prerequisite: C E 130. Design of reinforced concrete structural elements using the Ultimate Strength Design Method. Introduction to the Alternate Method. Introduction to prestressed concrete. (2 lecture, 3 lab hours; field trips required)

133. Design of Steel Structures (3)
Prerequisite: C E 130. Design of steel members and systems for buildings. Design areas include: tension members, compression members, beams, beam-columns, connections and plate girders. (2 lecture, 3 lab hours)

134. Foundation Design (3)
Prerequisites: ECE 70, C E 123, 132 or concurrently. Design and theory of spread and continuous wall, rectangular, cantilever and trapezoidal footings; earth pressures and cantilever as well as gravity retaining walls; pile foundations; pile driving; construction considerations; load tests; subsurface investigations; case histories; and computer-aided design of foundations. (2 lecture, 3 lab hours)

135. Reinforced and Prestressed Concrete Design (3)
Prerequisite: C E 132. Design of typical reinforced concrete and prestressed concrete structures. (2 lecture, 3 lab hours; field trips required)

136. Design of Timber Structures (3)
Prerequisite: C E 130. Design of timber members and systems for buildings. Design areas include: loads, properties of wood, tension members, beams, columns, beam-columns, connections, diaphragms, shear walls, and glued laminated arches.

137. Seismic Design of Building Structures (3)
Prerequisites: C E 130, M E 112. Effects of earthquakes on structures. Introduction to structural dynamics. Response of structures. Seismic provisions of building codes. Basic concepts in seismic-resistant design. Detailing for seismic-resistant construction. Term project. (Field trips required)

138. Structural Mechanics (3)
Prerequisite: C E 130. Energy theorems and applications. Analysis of arches, beams on elastic foundations, cable stayed structures, and unsymmetrical bending of beams. Introduction to plastic theory of structures.

140. Hydrology (3)
Prerequisites: ECE 70, C E 128 or concurrently. The hydrologic cycle, atmospheric conditions, precipitation, infiltration, ground water, soil moisture, evaporation, runoff, streamflow, hydrographs, flood routing, hydrologic statistical analysis; applications to water resources planning and management. (Field trips required)

141. Water Resources Engineering (3)
Prerequisites: C E 128, 142 (or concurrently), I E 160 (or concurrently), M E 26. Hydraulic design of water distribution, sewerage, and drainage systems. Computer-assisted pipe network analysis. Pump applications. (2 lecture, 3 lab hours; field trips required)

142. Environmental Engineering (3)
Prerequisites: CHEM 1A; C E 128 or concurrently. Introduction to the principles and practices of environmental quality management, including water and air quality, waste management, and the environmental effects of engineered systems.

142L. Environmental Quality Laboratory (1)
Prerequisite: C E 142 or concurrently. Study and analysis of physical, chemical, and biological characteristics of air, water, and solid wastes. (Field trips required)

143. Engineering Hydraulics (3)
Prerequisite: C E 128. Design of pressure-conduit and open-channel flow systems with applications to hydraulic structures and control works, hydraulic power conversion, sediment transport, and channel stabilization.

144. Design of Water Quality Control Processes (3)
Prerequisites: C E 142 or permission of instructor; I E 160 (or concurrently). Analysis and design of selected physical, chemical, and biological facilities for water purification and wastewater treatment. (2 lecture, 2 lab hours) (Field trips required)

150. Transportation Planning and Design (3)
Prerequisite: G M E 15, upper-division standing. Geometric design of land transportation facilities, primarily road/street systems. Traffic theory and analysis, including statistical analysis of traffic parameters. Freeway and intersection capacity. Simple transportation demand forecast. (2 lecture, 3 lab hours)

151. Pavement Design (3)
Prerequisite: C E 123 or concurrently. Analysis of pavement structures. Factors affecting pavement performance. Structural design of flexible and rigid highway and airfield pavements. Pavement rehabilitation and repair.

152. Transportation Engineering Materials (3)
Prerequisite: C E 123. Properties and durability of Portland cement concrete. Properties and testing of aggregates for asphalts concrete. Asphalt cements and asphalt concrete performance. Traditional and SUPERPAVE mix design and specification of asphalt concrete. (2 lecture, 3 lab hours)

153. Traffic Operations and Control (3)
Prerequisite: C E 150. Transportation studies. Highway traffic characteristics. Highway system traffic analysis. Highway system capacity design. Traffic regulations and control.

161. Construction Engineering I (3)
Prerequisite: C E 123. Basics of civil engineering contracting, organization of construction firms, legal structures, project funding, cash flow, equipment costs, labor relations, and safety.

170. Pollution and Society (3)
Prerequisite: PL SI 2 or 101. Not open to civil engineering majors. Descriptive analysis of natural and human environments. Effects of pollution and related human activities. Pollution control strategies and technology. Rational environmental decision-making. (Field trips required)

180A. Project Design (1)
Prerequisites: senior standing in civil engineering; permission of instructor; C E 185 (may be taken concurrently). Student teams complete and orally defend proposal for a design project that includes several civil engineering specialties. Information gathering, time/resource management, and communication skills. (Formerly C E 191T)

180B. Senior Project (2)
Prerequisites: C E 180A; approved project proposal; I E 182W (may be taken concurrently). Synthesis of previous coursework into a civil engineering design project under the supervision of a faculty member. Group projects except by special permission. (Formerly C E 180)

185. Civil Engineering Practice (1)
Prerequisites: senior standing in civil engineering or permission of instructor; C E 180B concurrently. Practice of civil engineering; opportunities in civil engineering; transition from student to professional engineer; engineering ethics. Evaluation of design requirements, economic, and social considerations; student presentations.

190. Independent Study (1-3; max total 6)
See *Academic Placement — Independent Study.* Approved for ***SP*** grading.

191T. Topics in Civil Engineering (1-3; max total 6)
Prerequisite: permission of instructor. Investigation of selected civil engineering subjects not in current courses.

193. Internship in Civil Engineering (2-4)
Prerequisite: permission of adviser. Engineering practice in a consulting, industrial, or government work setting. Each cooperative internship period usually spans a summer-fall or spring-summer interval. This course cannot be used to meet graduation requirements. ***CR/NC*** grading only.

GRADUATE COURSES

(See *Course Numbering System.*)

Civil Engineering (C E)

205. Computing in Engineering Analysis (3)
Prerequisite: graduate status in engineering. Solution of engineering problems using digital computation. Modeling of engineering systems for numerical analysis.

206. Engineering Environmental Impact (3)
Evaluation of environmental impacts due to engineering projects. The incorporation of environmental considerations into engineering design. Alternative solutions to engineering problems. Case histories of selected engineering projects.

220. Advanced Foundation Engineering (3)
Prerequisite: graduate standing. Design of cantilevered and anchored sheet-pile walls; axial- and lateral-loaded pile groups; drilled piers; pile driving stresses and wave equation analysis; beams on elastic foundations; footings on expansive and non-uniform soils and on rock; and case histories.

230. Advanced Theory of Structures (3)
Prerequisite: graduate standing in engineering or permission of instructor. Analysis of indeterminate structures by force (flexibility) methods and by displacement (stiffness) methods; Matrix methods suitable for digital computer solutions. Virtual work, real and complementary energy. Classical structural theorems. Introduction to the finite element method.

232. Prestressed Concrete Design (3)
Prerequisite: graduate standing in engineering or permission of instructor. Structural behavior and design of prestressed concrete elements and systems — continuous beams, frames, slabs. Partial prestress. (Field trip[s] required)

233. Advanced Behavior and Design of Steel Structures (3)
Prerequisite: graduate standing in engineering or permission of instructor. Material behavior and design of basic structural units; plate girders; connections; inelastic buckling; composite design; plastic design; PΔ effect. Analysis and design of continuous structures, braced and unbraced frames; stability of steel structures. Critical study of the AISC specifications.

234. Theory of Plates and Shells (3)
Prerequisite: graduate standing in engineering or permission of instructor. Methods of calculating stresses and deformations in plates and shells used in engineering structures. Bending of circular and rectangular plates under various conditions. Membrane and flexural analysis of shells of revolution.

235. Finite Element Analysis (3)
Prerequisite: graduate standing in engineering or permission of instructor. Theoretical and conceptual bases for formulation of finite element representations in solid mechanics. Development of element stiffness matrices for plane stress and plane strain problems, bending of plates and deformation of shells.

237. Dynamics of Structures (3)
Analysis of structural members and systems subject to dynamic loads. Basic theory for single-degree-of-freedom and multi-degree-of-freedom analytical models; free vibration, harmonic and transient excitation, response spectrum, LaGrange's equations, earthquake analysis.

240. Engineering Hydrology (3)
Prerequisites: C E 128, 140. Analysis of the physical and stochastic processes governing the occurrence and movement of water in its natural environment. Applications to hydraulic engineering practice.

242. Water Resources Planning and Management (3)
Prerequisite: graduate standing in engineering or permission of instructor. A study of the interrelations of engineering, economic, legal, political, administrative, ecological, and social factors involved in the planning and management of water resources.

245. Advanced Unit Operations and Processes (3)
Prerequisites: C E 246A and 246B or concurrently. Analysis of the unit operations and unit processes used in the physical, chemical, and biological control of raw and waste waters quality. (2 lecture, 3 lab hours)

246A. Advanced Water Quality (3)
Prerequisite: C E 142 or permission of instructor. Theory and practice of physical/chemical processes for controlling water quality, including chemical equilibrium and kinetics; mass transfer mechanisms; physical separation processes; adsorption, exchange, and membrane-based processes; disinfection.

246B. Advanced Water Quality (3)
Prerequisites: C E 142 or permission of instructor; C E 246A recommended. Theory and practice of biological processes for controlling water quality, including suspended growth systems; attached growth systems; ponds; land treatment. Also sludge treatment processes, including biological stabilization, thickening, and dewatering; sludge disposal.

247. Solid Wastes Engineering (3)
Planning and design of waste collection and disposal systems. Waste segregation and energy impact related to recovery and recycling practices. Environmental impact and institutional issues related to solid and hazardous waste systems.

251. Advanced Boundary Law (3)
Prerequisite: G M E 151 or equivalent. Land and water boundary legal issues, both historical and new. Case investigations.

261. Geoprocessing (3)
Prerequisite: G M E 173 or equivalent. Integration of computer technologies for gathering, analyzing, and displaying data associated with the earth's spatial features. Engineering design problems dependent on competing factors.

271. Geodetic Systems Optimization (3)
Prerequisite: G M E 108 or equivalent. National geodetic networks; planimetric and vertical control systems; geodetic control densification; network optimization criteria and methodology.

275. Satellite Surveying (3)
Prerequisite: graduate standing. Discussion of GPS orbital theory, data collection and processing algorithms, network adjustments, project design and optimization techniques. Review of current research trends and applications. (Field trips required)

280. Surveying Engineering Seminar (1; max total 3)
Prerequisite: graduate standing. Current California State University, Fresno surveying engineering research presented and discussed by faculty and graduate students. Oral presentation and written report documenting ongoing research activities required.

281. Civil Engineering Seminar (1; max total 3)
Prerequisite: graduate standing. Presentations and discussion by faculty and practitioners on topics of current interest in the field. Students will make oral presentations and submit written reports documenting ongoing research activities or other appropriate topics.

283. Digital Remote Sensing (3)
Prerequisite: G M E 140 or equivalent. Quantitative approach in remote sensing; digital image characteristics, error correction, registration; geometric and radiometric image enhancement; image classification; system design; remote sensing and GIS.

285. Advanced Analytical Photogrammetry (3)
Prerequisite: G M E 125 or equivalent. Mathematical models in photogrammetry; bundle block adjustment, self-calibration; close-range photogrammetry; real time photogrammetry and data snooping. System design; hardware and software considerations in photogrammetry.

286. Geographic Information Systems Design (3)
Prerequisite: G M E 173 or equivalent. Data structures and algorithms, databases for GIS, error modeling and data uncertainty, visualization, data exchange and standards, the multipurpose cadaster, advanced analysis techniques.

290. Independent Study (1-3; max total 3)
Prerequisite: graduate status in engineering. See *Academic Placement — Independent Study*. Approved for ***SP*** grading.

291T. Topics in Engineering (1-3; max total 6)
Prerequisite: permission of instructor. Investigation of selected engineering topics. May be offered with a lab.

298. Project (3; max total 3)
Prerequisite: graduate status in engineering. See *Criteria For Thesis and Project.* Independent investigation of advanced character such as analysis and/or design of special engineering systems or projects; critical review of state of the art of special topics, as the culminating requirement for the master's degree. Abstract required. Approved for ***SP*** grading.

299. Thesis (2-6; max total 6)
Prerequisite: See *Criteria For Thesis and Project.* Preparation, completion, and submission of an acceptable thesis for master's degree. Approved for ***SP*** grading.

IN-SERVICE COURSES

(See *Course Numbering System.*)

Civil Engineering (C E)

311. Professional Examination Review (2; may be repeated in different fields)
Prerequisite: bachelor's degree in engineering or eligibility to take state registration examinations. Review of engineering fundamentals for those qualified to take the state examination for certification as engineer-in-training; or review in a specific field (civil, electrical, mechanical, or other) for those preparing to take the examination for registration as professional engineer.

321. Professional Engineering Seminar (1-3; may be repeated in different fields)
Prerequisite: bachelor's degree in engineering or related field, or experience as a professional engineer. Latest developments in various specialized areas of professional engineering practice; new materials, design and construction methods, equipment, devices, and procedures.

Geomatics Engineering

Geomatics engineers manage the global spatial infrastructure. This effort includes real property boundary determination, digital mapping, Geographic Information Systems (GIS), Global Positioning Systems (GPS), remote sensing, photogrammetric mapping, applications programming, project management, and construction layout activities. Students use a wide selection of specialized equipment while acquiring a solid theoretical background. Integration of geomatics engineering design concepts spans a sequence of courses throughout the curriculum. Intensive design coursework during the senior year provides a culminating focus. Coursework containing design components includes the following: Computer-Aided Mapping (G M E 66) first year; Route and Construction Surveying (G M E 40) second year; Stereophotogrammetry (G M E 123) and Digital Mapping (G M E 126) third year; Subdivision Design (G M E 159) and two upper-level technical design courses — Senior Project (G M E 180) and Project Design (G M E 181) — senior year.

Career opportunities for specialists in geomatics engineering continue to grow with rapid advancements in analytical photogrammetry, geographic information systems, and inertial and satellite positioning technologies. Most graduates of this program have been employed by federal and state government agencies, the petroleum industry, and other private industries.

Mission of Geomatics Engineering

The mission of the Geomatics Engineering Program is to provide educational experience that enriches the lives of students. The program teaches necessary discipline related knowledge and skills to prepare students for their profession. Students learn how to protect the health and welfare of the public while expanding their base of knowledge through research and scholarship.

Educational Objectives of the Instructional Program

- Provide a broad based curriculum in geomatics engineering that generates graduates having competency in boundary surveying, geographic information systems (GIS), photogrammetry, digital mapping, and geodesy (GPS).
- Provide graduates with the knowledge and skills necessary to pursue professional careers in the geomatics engineering arena.
- Provide graduates with the educational rigor necessary to prepare them for graduate educational experiences in geomatics education or related fields if desired.

- Provide students with leadership opportunities associated with geomatics engineering related student clubs (SAGE, ACSM, CLSA, ASPRS, etc.), the Annual Geomatics Engineering Conference, *The Foresight!* magazine and external professional forums.
- Provide students with hands on laboratory experiences associated with each of the competency areas outlined in number one in this list.
- Provide students with meaningful design experiences associated with each of the curricular competency areas outlined in number one in this list.
- Provide students with multidisciplinary design team experiences while demonstrating effective communication skills and a knowledge of contemporary issues.
- Provide students with an understanding of professional and ethical responsibility.
- Provide students with a recognition of the need for, and the ability to engage in, lifelong learning.
- Provide students with the broad education necessary to understand the impact of engineering solutions in a global and social context.

Bachelor of Science Degree Requirements

Geomatics Engineering Major — *Units*

Major requirements 70

G M E 1, 15, 15L, 16, 16L, 34, 40, 50, 61, 66, 102, 123, 125, 126, 135, 143, 151, 159, 173, 180, 181 ..... (53)

I E 160 ..... (2)

Engineering Science ..... (3)
Select one course from the following: C E 20, 29, 150; M E 26, 29, 31; ECE 90 or 91

Technical Courses ..... (12)
Select mandatory technical courses from the following list subject to the *Design Courses* statement listed below: G M E 100, 101, 105, 109, 114, 129, 140, 145, 152, 153, 161, 174, 175, 177, 190, 191T; C E 121, 150, 161; C SCI 115, 124, 150, 172; CONST 114, 122, 124; B A 154; CRP 100; FIN 180, 181; MATH 101, 121; MGT 104; PHYS 110

Design Courses: At least 6 units of technical courses must be selected from the following design courses: G M E 145, 153, 161, 175

Other requirements 63

General Education
Select one course from each of the G.E. areas: Area A1, A2, B2, C1, D1, D2, D3. (See pages 92-94 for G. E. listings.)
The following courses are required to satisfy both G.E. and major requirements: MATH 75 [B4], CHEM 3A [B1], PHIL 20 [C2], G M E 108 [IB], PHIL 120 [IC], PL SI 120 [M/I]

Additional requirements
GEOL 1; MATH 76, 77; PHYS 4A, 4AL, 4B, 4C

Total 133

Note: Engineering majors are exempt from G.E. Area A3, third course Area C, Area E, and Area ID.

See the catalog Web Site for recommended program at *http://www.csufresno.edu/catoffice/current/enggeorec.html*.

Advising Notes

1. Courses in engineering, computer science, mathematics, the physical sciences, and mandatory technical courses taken *CR/NC* are not counted toward fulfillment of degree requirements in geomatics engineering.
2. All geomatics engineering students must consult with their academic advisers at least once each year.
3. The geomatics engineer major curriculum is very demanding. Many students, especially those not fully prepared in mathematics and physics take $4^{1}/_{2}$ or more years to graduate rather than the traditional four years. If necessary, students may go to the Learning Resource Center in Lab School, Room 137 and request tutorial assistance.
4. The upper-division writing skills requirement can be met by passing the university examination or by completing I E 182W with a letter grade of ***C*** or higher no sooner than the term in which 60 units of coursework are completed.

COURSES

Geomatics Engineering (G M E)

1. Introduction to Geomatics Engineering (1)
An introduction to geomatics engineering philosophical thought; geomatics engineering profession and career opportunities; professional ethics and safety; creative and critical thinking applied to the geomatics engineering decision-making process. (Formerly S E 1)

5. Critical Reasoning (3)
Fundamentals of analysis and evaluation in the context of technology. Evaluating the viewpoints of experts. Patterns of deductive and inductive arguments. Common fallacies of reasoning. G.E. Foundation A3. (Formerly S E 5)

11. Construction Surveying (2)
Prerequisite: MATH 5. Principles of surveying measurements; distances, directions, elevations, reduction of surveying data; planimetric mapping. Construction applications. (Formerly S E 11)

11L. Construction Surveying Laboratory (1)
Prerequisite: G M E 11 or concurrently. Field practice in measurements of distance and use of level, transit, and tape in solution of construction surveying problems. (3 lab hours; field trips required) (Formerly S E 11L)

15. Engineering Surveying (3)
Prerequisite: MATH 5. Principles of surveying measurements for distance, direction, elevation, and position; geometry of the single aerial photograph; topographic and planimetric mapping, GIS/LIS, horizontal curves, vertical curves, earthwork and engineering applications. (Formerly S E 15)

15L. Engineering Surveying Laboratory (1)
Prerequisite: G M E 15 or concurrently. Field practice in geomatics measurement, construction stakeout, and curve alignment problems. (3 lab hours; field trips required) (Formerly S E 15L)

16. Municipal Surveying (1)
Prerequisites: G M E 15. Instrumentation; automated electronic survey data collection; local plane control survey, land survey, GIS overlay mapping and astronomy for azimuth applications. (Formerly S E 16)

16L. Municipal Surveying Laboratory (1)
Prerequisite: G M E 16 or concurrently. Field and office practice in instrumentation; automated electronic survey data collection; local plane control survey, land survey, GIS overlay mapping and astronomy for azimuth applications. (3 lab hours; field trips required) (Formerly S E 16L)

23L. Geomatics Statistics Lab (1)
Concepts of measurements and error; reliability of measurements, probability theory, preanalysis of geomatics measurements, statistical analysis of measurements, hypothesis testing, analysis of variance, error ellipses, experimental design. (3 lab hours; field trips required) (Formerly S E 23L)

34. Adjustment Computations (3)
Prerequisites: G M E 15, 61, MATH 76. Error theory, adjustment of simple survey networks, and matrix methods; digital computer solutions of geomatics computation and adjustment problems. (Formerly S E 34)

40. Route and Construction Surveying (3)
Prerequisites: G M E 15, 15L or permission of instructor. Computations and theory covering surveys for highway, irrigation, rail, pipeline, and other transportation alignment projects. Includes computer solutions and applications. (2 lecture, 3 lab hours; field trips required) (Formerly S E 141, S E 40)

50. Land Surveying (3)
Prerequisite: G M E 15. The United States Public Land Survey System with special emphasis on California; introduction to the California Land Surveyors Act, Certified, A.L.T.A. and mortgage surveys; sectionalized land subdivision, corner restoration, resurveys, evidence, and descriptions. (Field trips required) (Formerly S E 50)

61. Microcomputers in Engineering (3)
Prerequisite: G M E 15 or concurrently. Microcomputer operating systems; introduction to high level computer languages, file processing, program documentation, testing, and debugging. (Formerly S E 61)

66. Computer-Aided Mapping (2)
Prerequisite: G M E 15 or concurrently. Principles of computer map creation and design; interactive editing of digital map and graphic data; graphic input to Geographic Information Systems; includes comprehensive computer mapping design experience. (Formerly S E 66)

73. Geomatics (3)
Introduction to Geographic and Land Information Systems; software and hardware issues; practical exercises. (Formerly S E 73)

100. Land and Society (3)
Prerequisite: junior standing. How private land ownership rights have shaped the development of our nation into a superpower; the effects of virtually "free" western land; land tenure systems and land ethics; current state, national and international societal trends and implications. (Formerly S E 100)

101. Creative Thinking (3)
Prerequisites: GE B4 completed, ENGL 1. Development of a process for creative thinking. Styles of thinking. Obstacles to overcome. Divergent versus convergent thinking. Idea stimulation. Gaining acceptance for new ideas. (Formerly S E 101)

102. Geodetic Surveying (3)
Prerequisites: G M E 16, 16L, 34. Horizontal and vertical geodetic networks for deformation, industrial tooling and local area applications; theory and application of State Plane Coordinate systems. (2 lecture, 3 lab hours; field trips required) (Formerly S E 102)

105. Futuristics (3)
Prerequisites: GE B4 completed, ENGL 1. Study of the future with emphasis on technology; growth curves, trend extrapolation, analytical models; breakthroughs; Delphi techniques; cross-impact matrix; flow diagrams and relevance trees; decision making. (Formerly S E 105)

108. Geodesy (3)
Prerequisites: MATH 77, PHYS 4A, 4AL, G M E 34. Size and shape of the earth; three-dimensional coordinate systems; computations on the spheroid; reduction to plane coordinates; introduction to differential equations, gravity modeling and gravity measurements. (Formerly S E 108)

109. Geodetic Astronomy (3)
Prerequisite: G M E 108. Celestial sphere, star, and earth coordinates; altitude and hour-angle methods of solar observation; astronomical and instrumental corrections to observations; time systems; determination of latitude, longitude, and azimuth. (2 lecture, 3 lab hours) (Formerly S E 109)

114. GPS Navigation (3)
Prerequisite: permission of instructor. Theory and concepts of navigation systems emphasizing real-time GPS. Design of air, sea, and land navigation applications, including automatic vehicle location and navigation (AVLN). (2 lecture, 3 lab hours; field trips required) (Formerly S E 114)

123. Stereo-Photogrammetry (3)
Prerequisites: G M E 15, 34 or concurrently. Imaging systems; image quality. Theory of stereo-photogrammetry; orientation of stereo-model. Design and operating principles of stereoplotters. Photogrammetric mapping; orthophoto mapping. Project planning. (2 lecture, 3 lab hours; field trips required) (Formerly S E 123)

125. Analytical Photogrammetry (3)
Prerequisites: G M E 123, 135. Introduction to analytical photogrammetry; strip and block aerial triangulation. Design and operating principles of analytical plotters. Introduction to soft-copy photogrammetry. (2 lecture, 3 lab hours; field trips required) (Formerly S E 125)

126. Digital Mapping (3)
Prerequisites: G M E 123, 173 or concurrently. Design of data input, editing, display and processing mechanisms for digital mapping applications; hardware considerations and software design for DTM applications. (2 lecture, 3 lab hours; field trips required) (Formerly S E 126)

129. Industrial Photogrammetry (3)
Prerequisites: G M E 125, 135. Photogrammetric principles applied to close range applications; calibration of non-metric imaging systems; simultaneous bundle adjustment of a photo block; use of additional camera and block parameters in adjustment; design of photogrammetric systems for industrial process monitoring; case studies. (Field trips required) (Formerly S E 129)

135. Advanced Adjustment Computations (3)
Prerequisites: G M E 34, MATH 77. Statistics, propagation of errors, advanced theory of least squares optimization algorithms. Computer programming for complex surveying and photogrammetry adjustment applications. Project design. (Formerly S E 135)

140. Earth Resources Surveying (3)
Prerequisite: junior standing or permission of instructor. Extraction of quantitative data from aerial and space imagery for monitoring environment and management of earth resources. Data input for Geographic Information Systems. (Formerly S E 140)

143. Satellite Geodesy (3)
Prerequisites: G M E 102, 108, 135. Motion of a satellite, orbit geometry and perturbations; time measuring systems; global geodesy model; reduction and adjustment of GPS and other satellite observation data;

differential equations of orbit relaxation; GPS network optimization; data transformation. (Field trips required) (Formerly S E 148, S E 143)

145. Geopositioning (3)
Prerequisites: G M E 143. Design of planning, data collection, data processing and network adjustment applications; kinematic and real-time GPS applications; case studies. (2 lecture, 3 lab hours; field trips required) (Formerly S E 145)

151. Boundary Control and Legal Principles (3)
Prerequisite: G M E 50 or permission of instructor. Legal principles that control the boundary location of real property. (Formerly S E 151)

152. Real Property Descriptions (3)
Prerequisite: G M E 151 or permission of instructor. Theory and practice of real property descriptions and recording systems; metes and bounds, United States Public Land Survey System, lot and block and other styles investigated; practical exercises and case studies. (Field trips required) (Formerly S E 152)

153. Boundary Survey Design (3)
Prerequisite: G M E 151 or permission of instructor. Design of evidence gathering, resurvey, retracement, and analysis techniques for complex United States Public Land Survey System, metes and bounds, riparian, mineral, land grant and fraudulent surveys; case studies. (Field trips required) (Formerly S E 153)

159. Subdivision Design (3)
Prerequisites: G M E 40, 151. Subdivision map act, local subdivision regulations, title search, zoning study. Tentative and final subdivision layout, map drafting, computerized subdivision design, and drafting; environmental impact study. (2 lecture, 3 lab hours; field trips required) (Formerly S E 159)

161. Data Interface Design (3)
Prerequisites: G M E 16, 135. Development and design of data collector software; file system generation, manipulation and transfer; microcomputer interface to data collector, electronic total station, digitizer, stereo/mono comparator and stereo-plotters. (2 lecture, 3 lab hours) (Formerly S E 161)

173. Introduction to GIS (3)
Prerequisites: G M E 15 and 66 or M E 26, or permission of instructor. Data quality and accuracy, privacy, ethics, institutional, governmental and technological issues associated with GIS; hardware and software considerations for geodetically controlled cadastral, resource and environmental GIS applications; existing system case studies. (Field trips required) (Formerly S E 173)

174. GIS Applications (3)
Prerequisite: G M E 173. Use of available GIS. Applications software; spatial analysis, simulation modeling and system evaluation; practical applications to specific GIS scenarios; creation, manipulations, maintenance and analysis of geodetic, cadastral, administrative, resource and environmental overlays. (2 lecture, 3 lab hours; field trips required) (Formerly S E 174)

175. GIS Design (3)
Prerequisite: G M E 173. Application of data quality, accuracy, ethics and liability issues to the design of integrated Geographic Information Systems; integrated data structure, algorithm, and database considerations; major design team GIS development project required. (2 lecture, 3 lab hours; field trips required) (Formerly S E 175)

177. GIS Database Design (3)
Prerequisites: G M E 135, 173. GIS database structure and design; design, use, maintenance and mutation of comprehensive relational and spatial database structures for GIS applications; structured query language; hardware implications and case studies of existing GIS software packages; creation of new GIS applications software (Formerly S E 177)

180. Senior Project (2)
Prerequisites: G M E 123, 135, 143, 151, 173; approved subject; I E 182W or Upper Division Writing Exam or concurrently; G M E 181 concurrently. Study of a problem under supervision of a faculty member; final typewritten report required. Individual project except by special permission. G M E 180 and G M E 181 satisfy the senior major requirement for the B.S. in Geomatics Engineering. (Field trips required) (Formerly S E 180)

181. Project Design (3)
Prerequisite: G M E 123, 135, 143, 151, 173. Design of control, boundary location, and photogrammetric systems. Evaluation of design requirements, economic, and social considerations. Case Studies. Student presentations. G M E 180 and 181 satisfy the senior major requirement for the B.S. in Geomatics Engineering. (Field trips required) (Formerly S E 181)

190. Independent Study (1-3; max total 6)
See *Academic Placement — Independent Study*. Approved for ***SP*** grading. (Formerly S E 190)

191T. Topics in Geomatics Engineering (1-3; max total 6)
Prerequisite: permission of instructor. Investigation of selected geomatics engineering subjects not in current courses. (Formerly S E 191T)

193. Internship in Geomatics Engineering (2-4)
Prerequisite: permission of adviser. Engineering practice in a consulting, industrial, professional, or government work setting. Internship periods usually span a summer-fall or spring-summer interval. A report will be required of the student at the termination of each implemented experience. This course cannot be used to meet graduation requirements. ***CR/NC*** grading only. (Formerly S E 193)

Construction Management

The management Specialty Program of the Bachelor of Science degree in Construction Management is accredited by the American Council for Construction Education, the professional accreditation organization of the construction industry.

Students in construction management (CM) are exposed to a wide variety of topics, ranging from courses in management and administration of construction companies, projects, people, and equipment to courses focusing on specific techniques for project planning and control work improvement and estimating. The Construction Management program also provides opportunities to develop a strong background in computer applications in construction. Computer skills combined with a solid management and technical background are major assets of the construction management graduate.

Career Opportunities

Opportunities for construction management graduates are excellent. Examples of positions held by construction management graduates are project manager, construction manager, project administrator, estimator, scheduler, architectural representative, project superintendent, and construction administrator. Students should consider this challenging, satisfying, and high-paying profession.

Mission of Construction Management

The mission of the Construction Management Program is to prepare students for

employment at the professional level in the discipline of construction and its related field. The program places emphasis on the acquisition of both fundamental theoretical knowledge and the application of current practices in the field.

The program strives to provide assistance to the student in the development of personal qualities including human sensitivity, disciplined reasoning, and communications.

Educational Objectives of the Instructional Program

- Provide students with the ability to recognize and independently diagnose construction related problems accurately, develop creative alternatives, and implement practical and effective solutions.
- The students will demonstrate the ability to plan, schedule and control work activities, motivate and provide accurate and timely constructive alternatives, and implement practical and effective solutions.
- Provide students with the ability to apply construction related techniques, skills, and tools to construction materials as necessary for the managed construction project.
- Provide students with the ability to understand technical issues related to the fields of architecture, engineering, business and construction accounting, and finance. Work effectively and efficiently with personnel from these disciplines to properly apply related fundamentals, techniques, and procedures.
- Provide students with the ability to apply basic construction related design theory within the areas of structural, mechanical, electrical, thermodynamics, civil, and soil mechanics.

Bachelor of Science Degree Requirements

Construction Management Major

Units

Major requirements 75
Construction Core ..... (48)
CONST 1, 5, 10, 15, 42, 43, 50, 105, 107, 114, 116, 120, 122, 124, 162, 164
C E 127; G M E 11, 11L; ACCT 3; MGT 104 ..... (12)
Technical Specialty ..... (15)
Select one:
Architecture
CONST 31, 32, 131, 132, 134
Management
CONST 144, 150, 151, 166; FIN 180
Other requirements 56-57*
General Education ..... (51)
Additional requirements
MATH 72 or 75; PHYS 2A; ECON 40 or 50
Select one from CHEM 3A, GEOL 1, MATH 76, PHYS 2B
Remaining degree requirements 0-1
(See *Degree Requirements*); upper-division writing skills by examination
Total 132

*This total indicates that nine units from MATH 75, CHEM 2A or GEOL 1 or PHYS 2A, and ECON 40 or 50 in Additional Requirements are being used to satisfy the General Education requirement of 51 units.

Advising Notes

1. Courses in mathematics, the physical sciences, or construction taken *CR/NC* are not counted toward fulfillment of degree requirements in construction.
2. Since the construction major curriculum is very demanding, some students, especially those not fully prepared in mathematics, chemistry, and/or physics may take more than the traditional four years to graduate.
3. The upper-division writing skills requirement can be met by passing the university examination or by completing I E 182W with a letter grade of *C* or higher no sooner than the term in which 60 units of coursework are completed.
4. Other construction specialties may be developed under department advisement.

See the catalog Web Site for recommended program at *http://www.csufresno.edu/catoffice/current/engconrec.html.*

Construction Management Minor

Students from interrelated disciplines will acquire professional and specialized construction knowledge and skills. Preparation for participation in the building-related professions leads to careers in solving the infrastructure needs of society and the environment.

Units

Required Core courses 15
CONST 5, 10, 42, 50, 120
Additional elective courses 6
The student will select two additional construction courses in consultation with a faculty adviser. Emphasis may be placed upon a variety of specialization areas.
Total 21

Note: The Construction Management Minor also requires a 2.0 GPA and 6 upper-division units in residence.

COURSES

Construction Management (CONST)

1. Construction Management Orientation (3)
Orientation to essential elements of professional practice in construction management. Construction-related regulatory requirements. Ethics, business, safety, and personnel practices. Management techniques and interaction with professional organizations and associations.

5. Construction Materials (3)
Introduction to basic construction materials: concrete, masonry, metals, woods, thermal materials, finishes, equipment, and specialties. (2 lecture, 2 lab hours; field trips)

10. Estimating and Bidding (3)
Prerequisites: CONST 5, 42. Basic methods used to evaluate, fix cost, calculate worth, make accurate quantity take-offs and labor time estimates; preparing bids for prospective buyers. (6 lab hours)

15. Construction Management Software (3)
Introduction to construction industry software and project documentation. Basic instruction in estimating, scheduling, design, and project control software. Designed to provide an overview of those particular software packages used in subsequent construction management coursework. (2 lecture, 2 lab hours)

31. Architectural Graphics (3)
Introduction to basic techniques and media used in architectural graphic communication including: perspective techniques, sciagraphy, models, and photography; emphasis on various ways of making drawn representations of architectural design proposals. (6 lab hours)

32. Architectural Design (3)
Introduction to architectural design theory; analysis of architectural design problems, assessment of human needs, establishment of architectural design criteria and development of architectural design concept. (6 lab hours)

42. Architectural Drawing (3)
Architectural drafting techniques and standards progressing from fundamentals to details in the area of light construction design through the use of sketching, drafting methods, and computer aided design. Study includes the application of building codes and regulations. (6 lab hours)

43. Computer-Aided Construction Detailing (3)
Prerequisite: CONST 42. Application of computers to planning and details for wood, concrete, masonry, and steel structures. (6 lab hours) (Formerly CONST 142)

50. Basic Building Systems (3)
Exploration of theoretic principles relating to the various building systems. (2 lecture, 2 lab hours; field trips)

105. Construction Structures (3)
Prerequisites: CONST 5, 50; PHYS 2A; MATH 71 and 72 or 75. Properties, strength, and functional applications of basic construction materials: woods, metals, and concrete. Recent developments in new materials and applications. (2 lecture, 2 lab hours; field trips)

107. Advanced Construction Structures (3)
Prerequisite: CONST 105. Analysis of construction materials in its application to different structural systems. (2 lecture, 2 lab hours)

114. Construction Management (3)
Prerequisite: senior standing in construction. The construction manager's relation to internal organization, owner, architect, engineer, public, press, legal aid, unions, trades, equipment, utilities, insurance, finances, government, and others.

116. Scheduling and Control (3)
Prerequisites: CONST 15. Critical path method; planning, scheduling, and control of construction projects including logic, time assignment and computation, analysis, replanning, diagramming practices, monitoring and updating, computer utilization; role of management. (2 lecture, 2 lab hours)

120. Construction Contracts and Specifications (3)
Principles and methods for developing and applying construction contracts and specifications, including bidding requirements, bonds and insurance, certificates, agenda, change orders, general and supplemental conditions, and CSI specifications. (2 lecture, 2 lab hours)

122. Construction Laws (3)
Orientation to the rules and regulations governing construction industry practices and activities including contractors license law, state lien laws, health and safety regulations, personnel relations and supervision, workers compensation, employment insurance, and taxes.

124. Construction Labor Law (3)
Study of federal and state labor-oriented regulations as applied to construction industry practices. Interaction between technical and legal aspects of collective bargaining, pre-hire agreements, hiring hall referrals, open shop construction, work force management, labor standards, employment discrimination, strikes, and picketing.

131. Advanced Architectural Graphics (3)
Prerequisite: CONST 31. Architectural graphic techniques as tools of three dimensional analysis and representation in the design process. (6 lab hours)

132. Advanced Architectural Design (3)
Prerequisite: CONST 32. Development of understanding of the forces affecting the man-made environment through function identification, systems analysis, and development of architectural design solutions to problems at an intermediate level of complexity. (6 lab hours)

134. Architectural Design Problems (3)
Prerequisites: senior standing or permission of instructor; CONST 132. Conceptual planning and design of a large scale architectural project responding to the social and cultural context of the environment. Employing team research and analysis leading to the design and presentation on individual solutions with graphic and three-dimensional techniques. Satisfies the senior major requirement for the architecture specialty of the B.S. in Construction Management. (6 lab hours)

144. Construction Site Planning and Development (3)
Prerequisite: CONST 43; senior standing. Analysis of land development; site investigation, grading, street piping systems, and landscaping. (2 lecture, 2 lab hours; field trips)

150. Heavy Construction (3)
Prerequisites: senior standing or permission of instructor; CONST 105, 116, 120. Problems and methods of solutions in the construction of heavy buildings; site, excavations, foundations, framework, heavy timber, reinforced concrete, structural steel, masonry construction and related elements. Satisfies the senior major requirement for the B.S. in Construction Management. (2 lecture, 2 lab hours; field trips)

151. Heavy Building Construction (3)
Prerequisites: senior standing or permission of instructor; CONST 50. Problems and methods of solution in heavy construction from earth moving, paving, compacting to tunneling; administrative procedures, quantity surveying, estimating, scheduling, and bidding. Satisfies the senior major requirement for the B.S. in Construction Management. (2 lecture, 2 lab hours; field trips)

162. Mechanical Systems (3)
Prerequisites: CONST 1, 5, and 50. Mechanical systems for heating, ventilating, air conditioning, plumbing, storm drainage, and sewage disposal systems in commercial, industrial, residential construction; heat loss and gain, solar systems, mechanical system sizing, and life cycle cost analysis. Lectures, field trips, and guest speakers.

164. Building Electrical Systems (3)
Electrical systems for power, light, heat, signals, and communications in commercial, industrial, and residential buildings. (2 lecture, 2 lab hours; field trips)

166. Advanced Mechanical Systems (3)
Prerequisite: CONST 162. Construction application of water systems, plumbing and storm drainage, and sewage disposal systems.

190. Independent Study (1-3; max total 6)
See *Academic Placement — Independent Study*. Approved for ***SP*** grading. (Course fee variable)

191T. Technical Topics in Construction (1-3; max total 6)
Prerequisite: permission of instructor. Investigation and analysis of selected subjects in construction. (2-6 lab hours)

193. Internship/Work Experience (3-6; max total 6)
Open only to construction majors. Prerequisites: junior standing and permission of instructor. Supervised work experience in construction related industries. Periodic consultations with instructor.