

# Department of Civil and Environmental Engineering

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- Functioned as efficient, reliable team members in the evaluation, planning and design, construction, or operation and maintenance of civil infrastructure systems,
- Demonstrated their belief in lifelong education by expanding their body of knowledge, maturing professionally, and progressing toward licensure as professional engineers,
- Assumed leadership roles in their workplace by exercising initiative and responsible stewardship, and
- Employed the human touch in engaged involvement in their professions and communities.

## Civil Engineering Specializations

Civil engineering is a broad field of study. All students that pursue the *Bachelor of Civil Engineering* degree are required to take introductory courses in surveying, construction engineering, geotechnical engineering, environmental engineering, hydraulics, structural analysis, transportation engineering, and civil engineering materials. Beyond these courses, students satisfy curriculum requirements by selecting elective courses to broaden their civil engineering knowledge while strengthening their understanding in specific areas.

**Students may choose to focus on one of the following specializations:**

- Construction Engineering
- Environmental Engineering
- Geotechnical Engineering
- Pavements and Materials Engineering
- Site Engineering and Land Development
- Structural Engineering
- Transportation Engineering
- Water Resources Engineering

## Construction Engineering Specialization

Construction engineers plan, oversee, and manage the construction efforts associated with building new or rehabilitating existing buildings, bridges, roads, and other facilities. The *Construction Engineering* specialization provides future construction engineers and managers with the ability to manage construction projects. It also develops the ability to collaborate with other civil engineering professionals to solve problems associated with projects and understand the engineering science to effectively implement the solutions. This specialization provides a strong fundamental background for graduate study in construction engineering and project management.

**Students in this specialization take:**

Code	Title	Hours
CIVL 4420	Project Management	3
CIVL 4600	Reinforced Concrete Design	3
CIVL 5810	Pavement Des And Construction	3
CIVL 4490	Design-Build Project	3
CIVL 5440	Const Equipment And Methods	3
Construction Engineering Elective (see list below)		3

These six courses serve as Breadth Electives I–III, the Senior Design Project, and Technical Electives I–II in the *Bachelor of Civil Engineering* curriculum requirements.

## Construction Engineering Electives (select one)

Code	Title	Hours
CIVL 5420	Const Proj Scheduling & Contro	3
CIVL 5430	Construction Safety	3
CIVL 5450	Erosion & Sediment Control	3
CIVL 5460	Project Estimating	3
CIVL 5690	Timber Design	3
CIVL 5480	Legal Aspects of CE Practice	3

## Environmental Engineering Specialization

Environmental engineers apply scientific and engineering principles to assess, manage, and design sustainable environmental systems for the protection of human and ecological health. The *Environmental Engineering* specialization prepares students for entry-level positions in this area, including water and wastewater treatment, and provides a fundamental background for graduate study.

### Students in this specialization take:

Code	Title	Hours
CIVL 4210	Water and Wastewater	3
CIVL 5120	Hydrologic Analysis & Modeling	3
CIVL Breadth Elective (see list below)		3
CIVL 4220	Enviro Engineering Design	3
Environmental Engineering Elective I (see list below)		3
Environmental Engineering Elective II		3

These six courses serve as Breadth Electives I–III, the Senior Design Project, and Technical Electives I–II in the *Bachelor of Civil Engineering* curriculum requirements.

### CIVL Breadth Electives for Environmental Engineering (select one)

Code	Title	Hours
CIVL 4310	Geotechnical Engineering II	3
CIVL 4420	Project Management	3
CIVL 5810	Pavement Des And Construction	3
CIVL 4600	Reinforced Concrete Design	3
CIVL 4650	Structural Steel Design	3
CIVL 4530	Geometric Design	3

### Environmental Engineering Electives (select two)

Code	Title	Hours
CIVL 4230	Urban Hydraulic System Design	3
CIVL 5110	Open Channel Hydraulics	3
CIVL 5130	Hydr Design Press Systems	3
CIVL 5150	Groundwater Hydraulics	3
CIVL 5160	Stormwater Mngmt & Modeling	3
CIVL 5170	Num. Sol. Hydro-Env. Applic.	3
CIVL 5210	Chemical Prin Of Enviro Engr	3
CIVL 5230	Enviro Health Engineering	3
CIVL 5240	Air Pollution	3
CIVL 5250	Bio Prin Of Enviro Engr	3
CIVL 5260	Surface Water Quality Modeling	3
CIVL 5330	Landfills	3
CIVL 5410	Gis In Civil Engineering	3

## Geotechnical Engineering Specialization

Geotechnical engineers deal with the analysis, design, and construction of earth and earth-supported structures. Geotechnical engineers work on foundations, dams, levees, landfills, landslides, and roadways. The *Geotechnical Engineering* specialization provides a strong fundamental background for graduate study in geotechnical engineering while preparing students for entry-level positions in this area. Geotechnical engineers may also work in the area of geoenvironmental engineering, which focuses on application of geotechnical and geological principles to problems related to the protection of human health and the environment. Students interested in geoenvironmental engineering should consult with a geotechnical faculty member to identify appropriate courses.

**Students in this specialization take:**

Code	Title	Hours
CIVL 4310	Geotechnical Engineering II	3
CIVL 5810	Pavement Des And Construction	3
CIVL 4600	Reinforced Concrete Design	3
CIVL 4690	Structural Design Project	3
Geotechnical Engineering Elective I (see list below)		3
Geotechnical Engineering Elective II		3

These six courses serve as Breadth Electives I–III, the Senior Design Project, and Technical Electives I–II in the *Bachelor of Civil Engineering* curriculum requirements.

**Geotechnical Engineering Electives (select two)**

Code	Title	Hours
CIVL 5150	Groundwater Hydraulics	3
CIVL 5330	Landfills	3
CIVL 5340	Geosynthetics & Soil Improveme	3
CIVL 5350	Earth Retaining Structures	3

**Pavements & Materials Engineering Specialization**

Pavements and materials engineers design, build, and maintain pavement infrastructure for highways, airports, parking lots, and port facilities. This includes design and characterization of the constituent materials, pavement construction, integration and application of materials in engineered pavement structures, and management of pavement infrastructure. The *Pavements & Materials* specialization prepares students for entry-level positions in this area and provides a strong fundamental background for graduate study in pavements and materials.

**Students in this specialization take:**

Code	Title	Hours
CIVL 4310	Geotechnical Engineering II	3
CIVL 4530	Geometric Design	3
CIVL 5810	Pavement Des And Construction	3
CIVL 4590	Transportation Design Project	3
Pavements & Materials Elective I (see list below)		3
Pavements & Materials Elective II		3

These six courses serve as Breadth Electives I–III, the Senior Design Project, and Technical Electives I–II in the *Bachelor of Civil Engineering* curriculum requirements.

**Pavements & Materials Engineering Electives (select two)**

Code	Title	Hours
CIVL 4420	Project Management	3
CIVL 5340	Geosynthetics & Soil Improveme	3
CIVL 5630	Advanced Concrete Materials	3
CIVL 5820	Design of Asphalt Paving	3

**Site Engineering and Land Development Specialization**

This specialization addresses site planning and land development for a variety of settings: commercial, industrial, municipal, recreational, and residential. Site design engineers apply geometric, hydraulic, hydrologic, materials, and transportation principles to address roadways, parking, stormwater management, sanitary sewage, grading/earthwork, utilities, and erosion and sediment control when developing land for client/public use. The *Site Engineering and Land Development* specialization prepares students for entry-level positions in this area while providing a foundation for graduate study.

**Students in this specialization take:**

<b>Code</b>	<b>Title</b>	<b>Hours</b>
CIVL 4230	Urban Hydraulic System Design	3
CIVL 4530	Geometric Design	3
CIVL 4420	Project Management	3
CIVL 4590	Transportation Design Project	3
BSEN 5560	Site Design for Biosystems	3
Site Engineering and Land Development Elective (see list below)		3

These six courses serve as Breadth Electives I–III, the Senior Design Project, and Technical Electives I–II in the *Bachelor of Civil Engineering* curriculum requirements.

**Site Engineering and Land Development Electives**

<b>Code</b>	<b>Title</b>	<b>Hours</b>
CIVL 5120	Hydrologic Analysis & Modeling	3
CIVL 5130	Hydr Design Press Systems	3
CIVL 5150	Groundwater Hydraulics	3
CIVL 5160	Stormwater Mngmt & Modeling	3
CIVL 5410	Gis In Civil Engineering	3
CIVL 5450	Erosion & Sediment Control	3
CIVL 5460	Project Estimating	3
CIVL 5480	Legal Aspects of CE Practice	3
CIVL 5810	Pavement Des And Construction	3

**Structural Engineering Specialization**

Structural engineers design new structures—such as buildings, bridges, and stadiums—to withstand loads and natural hazards. They also evaluate and improve the capabilities of existing structures. The *Structural Engineering* specialization provides a strong fundamental background for graduate study in structural engineering while preparing students for entry-level positions in this area.

**Students in this specialization take:**

<b>Code</b>	<b>Title</b>	<b>Hours</b>
CIVL 4600	Reinforced Concrete Design	3
CIVL 4310	Geotechnical Engineering II	3
CIVL 4420	Project Management	3
CIVL 4690	Structural Design Project	3
CIVL 4650	Structural Steel Design	3
Structural Engineering Elective		3

These six courses serve as Breadth Electives I–III, the Senior Design Project, and Technical Electives I–II in the *Bachelor of Civil Engineering* curriculum requirements.

**Structural Engineering Electives**

<b>Code</b>	<b>Title</b>	<b>Hours</b>
CIVL 5600	Adv Reinforced Concrete Design	3
CIVL 5620	Prestressed Concrete Design	3
CIVL 5630	Advanced Concrete Materials	3
CIVL 5640	Structural Masonry Design	3
CIVL 5650	Advanced Steel Design	3
CIVL 5660	Bridge Engineering	3
CIVL 5670	Advanced Structural Analysis	3
CIVL 5690	Timber Design	3
CIVL 5700	Design For Lateral Loads	3

CIVL 5710	Structural Repair	3
CIVL 5720	Reliability of Structures	3

### Transportation Engineering Specialization

Transportation engineers forecast, design, analyze, and manage transportation systems to support the safe, efficient, and environmentally-friendly movement of people and materials. The *Transportation Engineering* specialization incorporates mathematical and scientific principles that allow graduates to pursue careers in general transportation network design and planning, facilities planning, site evaluation, transportation management systems, needs projections and analysis, and analysis of costs. This specialization provides a strong fundamental background for graduate study in transportation engineering.

#### Students in this specialization take:

Code	Title	Hours
CIVL 4530	Geometric Design	3
CIVL 4420	Project Management	3
CIVL 5810	Pavement Des And Construction	3
CIVL 4590	Transportation Design Project	3
Transportation Engineering Elective I (see list below)		3
Transportation Engineering Elective II		3

These six courses serve as Breadth Electives I–III, the Senior Design Project, and Technical Electives I–II in the *Bachelor of Civil Engineering* curriculum requirements.

#### Transportation Engineering Electives (select two)

Code	Title	Hours
CIVL 4500	Traffic Engr Fundamentals	3
CIVL 4520	Airport Design	3
CIVL 5410	Gis In Civil Engineering	3
CIVL 5500	Traffic Engineering Analysis	3
CIVL 5560	Multimodal Transport Planning	3
CIVL 5580	Intelligent Transport Sys	3
CIVL 5420	Const Proj Scheduling & Contro	3

### Water Resources Engineering Specialization

Water resources engineers design, evaluate, maintain, and operate the water systems in natural and built environments. Applying mathematical and scientific principles, water resources engineers conceive and design new water infrastructure for collecting, storing, moving, conserving, and controlling surface water, pressurized water, and groundwater. This includes water quality control, water cycle management, management of human and industrial water requirements, water delivery, and flood control. The Water Resources Engineering specialization provides a strong fundamental background for graduate study in water resources engineering while preparing students for entry-level positions in this area.

#### Students in this specialization take:

Code	Title	Hours
CIVL 5110	Open Channel Hydraulics	3
CIVL 4230	Urban Hydraulic System Design	3
CIVL Breadth Elective		3
CIVL 4220	Enviro Engineering Design	3
Water Resources Engineering Elective I (see list below)		3
Water Resources Engineering Elective II		3

These six courses serve as Breadth Electives I–III, the Senior Design Project, and Technical Electives I–II in the *Bachelor of Civil Engineering* curriculum requirements.

**CIVL Breadth Electives for Water Resources Engineering (select one)**

Code	Title	Hours
CIVL 4310	Geotechnical Engineering II	3
CIVL 4420	Project Management	3
CIVL 5810	Pavement Des And Construction	3
CIVL 4600	Reinforced Concrete Design	3
CIVL 4650	Structural Steel Design	3
CIVL 4530	Geometric Design	3

**Water Resources Engineering Electives (select two)**

Code	Title	Hours
CIVL 5120	Hydrologic Analysis & Modeling (preferred)	3
CIVL 5150 or GEOL 5100	Groundwater Hydraulics (preferred) Hydrogeology	3
CIVL 5130	Hydr Design Press Systems	3
CIVL 5160	Stormwater Mngmt & Modeling	3
CIVL 5170	Num. Sol. Hydro-Env. Applic.	3
CIVL 5260	Surface Water Quality Modeling	3
CIVL 5410	Gis In Civil Engineering	3
CIVL 5450	Erosion & Sediment Control	3

**Majors**

- Civil Engineering ([http://bulletin.auburn.edu/undergraduate/samuelginncollegeofengineering/departmentofcivilengineering/civilengineering\\_major/](http://bulletin.auburn.edu/undergraduate/samuelginncollegeofengineering/departmentofcivilengineering/civilengineering_major/))

**Courses**

**CIVL 2010 SURVEYING (3)** LEC. 2. LAB. 3. Pr. (ENGR 1110 or ENGR 1113) and (MATH 1610 or MATH 1613 or MATH 1617) and (COMP 1200 or COMP 1220 or COMP 1230). Civil engineering surveying theory and practice including history of land surveys and U.S. datums; field measurements, office calculations and graphical/digital presentation of spatial data.

**CIVL 3010 CIVIL ENGINEERING ANALYSIS (4)** LEC. 3. LAB. 3. Pr. MATH 2650 and (COMP 1200 or COMP 1220 or COMP 1230) and (ENGR 2050 or ENGR 2053) and STAT 3010. Applications of calculus and ordinary differential equations, numerical methods, vector algebra, and linear algebraic expressions to practical civil engineering problems. Heavy emphasis on computerized techniques and civil engineering software.

**CIVL 3110 HYDRAULICS (4)** LEC. 3. LAB. 3. Pr. (ENGR 2010 or ENGR 2200) and MATH 2650 and P/C ENGR 2350 and P/C CIVL 3010. Pr. ENGR 2010 is only allowed for students who transfer into Civil Engineering. Students already enrolled in Civil Engineering should take ENGR 2200. Introduction to fluid mechanics, fluid properties, hydrostatics, kinematics, dynamics, energy equation, ideal flow and energy losses. Applications of fluid mechanics, pipe flow, fluid measurements, pumps, open channel flow, dimensional analysis and theory of modeling.

**CIVL 3220 WATER AND WASTE TREATMENT (4)** LEC. 3. LAB. 3. Pr. CHEM 1040 and BIOL 3200. Fundamentals of potable water treatment and wastewater treatment and disposal. Treatment systems; operation/ process physics, chemistry, and biology; operation and maintenance issues; regulatory requirements. Credit will not be given to students majoring in Civil Engineering.

**CIVL 3230 ENVIRONMENTAL ENGINEERING (4)** LEC. 3. LAB. 3. Pr. BSEN 3310 or CIVL 3010 or ENGR 2200 and CHEM 1040 or CHEM 1043. Fundamental principles of environmental engineering, including basic environmental chemistry and microbiology; materials and energy balances; diffusion; chemical equilibrium; kinetics; and chemical reaction engineering.

**CIVL 3310 GEOTECHNICAL ENGINEERING I (4)** LEC. 3. LAB. 3. Pr. (CHEM 1040 or CHEM 1043) and ENGR 2070. Soil-forming processes, physical properties of soils, subsurface investigations, clay mineralogy, soil classification, permeability, effective stress, consolidation theory, time-settlement analysis, compaction, shear strength, geosynthetics.

- CIVL 3410 CONSTRUCTION ENGINEERING (3)** LEC. 3. Pr. CIVL 2010 and P/C CIVL 3010. Basic concepts of the construction industry, contractual methods, estimating and scheduling.
- CIVL 3510 TRANSPORTATION ENGINEERING (4)** LEC. 4. Pr. CIVL 2010 and STAT 3010. Introduction to transportation engineering practice with emphasis on highway facility design, traffic operations, and life-cycle costing.
- CIVL 3610 STRUCTURAL ANALYSIS (4)** LEC. 3. LAB. 3. Pr. ENGR 2070 and P/C CIVL 3010. Basic structural analysis of determinate and indeterminate structures, deflections by moment-area and virtual work, influence lines, force method and moment-distribution methods of analysis.
- CIVL 3820 CIVIL ENGINEERING MATERIALS (3)** LEC. 2. LAB. 3. Pr. P/C CIVL 3310. Introduction to common materials used in construction of civil facilities including highways; aggregate, concrete, asphalt, and steel.
- CIVL 4210 WATER AND WASTEWATER TREATMENT AND DESIGN (3)** LEC. 3. Pr. CIVL 3230. Departmental approval. The fundamentals of theory, design, and operation of water and wastewater treatment systems are covered.
- CIVL 4211 WATER AND WASTEWATER LABORATORY (1)** LAB. 3. Pr. CHEM 1040 and BIOL 3200. Coreq. CIVL 4210. Introduction to analytical techniques used to assess water quality. Credit will not be given to students majoring in Civil Engineering.
- CIVL 4220 ENVIRONMENTAL ENGINEERING DESIGN (3)** LEC. 3. Pr. CIVL 4210 or CIVL 4230. Process design of environmental engineering systems.
- CIVL 4230 URBAN HYDRAULIC SYSTEM DESIGN (3)** LEC. 3. Pr. CIVL 3230 and CIVL 3110. Engineering approaches to designing and managing urban water supply, sanitary sewer, storm water collection systems and flood control works.
- CIVL 4310 GEOTECHNICAL ENGINEERING II (3)** LEC. 3. Pr. CIVL 3310. Analysis and design in geotechnical engineering based on principles of soil mechanics and soil behavior. Problems of slope stability, earth pressure and design of earth retaining structures, foundation bearing capacity and settlement.
- CIVL 4420 PROJECT MANAGEMENT (3)** LEC. 3. Pr. CIVL 3410. Planning and management of construction/engineering projects and organizations, project management techniques, skills, and applications.
- CIVL 4490 DESIGN-BUILD PROJECT (3)** LEC. 3. Pr. CIVL 4420. Develop a design-build proposal for a civil engineering improvement including engineering study, consideration of alternative designs, and formal written and oral presentation.
- CIVL 4500 TRAFFIC ENGINEERING FUNDAMENTALS (3)** LEC. 3. Pr. CIVL 3510. The fundamental elements of traffic engineering including traffic operations and traffic control devices.
- CIVL 4520 AIRPORT DESIGN (3)** LEC. 3. Pr. CIVL 3510. Departmental approval. An analysis of the elements affecting the design of airports including forecasting, runway configuration, capacity analyses, geometric design of runways and taxiways, pavement design and airfield drainage.
- CIVL 4530 GEOMETRIC DESIGN (3)** LEC. 3. Pr. CIVL 3510. An analysis of the elements affecting the location and design of rural highways, urban highways and arterial streets including design controls and criteria.
- CIVL 4590 TRANSPORTATION DESIGN PROJECT (3)** LEC. 3. Pr. CIVL 4530. Individual senior design project requiring the development of plans for a roadway over a large land segment: horizontal and vertical curves in accord with State and AASHTO standards; topographic terrain features; historical preservation area; minimum elevation; intersection design; earthwork balance.
- CIVL 4600 REINFORCED CONCRETE DESIGN (3)** LEC. 3. Pr. CIVL 3610. Concrete and reinforcing steel properties; analysis and design of reinforced concrete beams, one-way slabs, columns and footings; anchorage of reinforcement.
- CIVL 4650 STRUCTURAL STEEL DESIGN (3)** LEC. 3. Pr. CIVL 3610. Steel properties. Design and analysis of structural steel members in tension, compression, shear, flexure and combined compression and flexure. Bolted and welded connections.
- CIVL 4690 STRUCTURAL DESIGN PROJECT (3)** LEC. 3. Pr. CIVL 4600. Execution of a comprehensive design of a major structure. Emphasis on the design process, creative thinking, analysis, synthesis, teamwork and communications.
- CIVL 4960 SPECIAL PROBLEMS (1-3)** LEC. Departmental approval. Individual student endeavor under staff supervision involving advanced special problems in civil engineering. Course may be repeated for a maximum of 6 credit hours.

**CIVL 4997 HONORS THESIS (1-3) IND.** Pr. Honors College. Departmental approval.. Course may be repeated for a maximum of 6 credit hours.

**CIVL 5110 OPEN CHANNEL HYDRAULICS (3) LEC.** 3. Pr. CIVL 3110. Application of continuity, energy, and momentum analyses to problems of open channel flow. Topics include rapidly and gradually varied flow, unsteady flow, flood routing, computational methods, design concepts and applications. Credit will not be given for both CIVL 5110 and CIVL 6110/ CIVL 6116.

**CIVL 5120 HYDROLOGIC ANALYSIS AND MODELING (3) LEC.** 3. Pr. CIVL 3110 and STAT 3010. Hydrologic cycle, hydrologic frequency analysis, precipitation, infiltration, runoff hydrograph, flood routing, urban hydrology, watershed hydrologic modeling, and computer modeling applications. Departmental approval. May count either CIVL 5120 or CIVL 6120.

**CIVL 5130 HYDRAULIC DESIGN OF PRESSURIZED SYSTEMS (3) LEC.** 3. Pr. CIVL 3110. Pressurized flow applications; pump-pipeline design optimization; multiple reservoir operation; flow measurement/control systems; distribution manifolds; fundamentals of unsteady flows. Departmental approval. May count either CIVL 5130 or CIVL 6130.

**CIVL 5150 GROUNDWATER HYDRAULICS (3) LEC.** 3. Pr. CIVL 3110. Mechanics of groundwater flow, definitions, conservation of mass, Darcy's law, confined and unconfined flow, steady and transient flow, groundwater transport. Credit will not be given for both CIVL 5150 and CIVL 6150/CIVL 6156.

**CIVL 5160 STORMWATER MANAGEMENT AND MODELING (3) LEC.** 3. Pr. CIVL 3110. Introduction of current stormwater management practices (e.g., lower impact development and green infrastructures) and polices, rainfall analysis with different inter-event dry period, flood analysis, stormwater runoff hydrograph modeling (rainfall loss, overland flow hydrograph, unit hydrograph theory, and hydrograph routing), stormwater quality modeling (pollutant buildup, washoff, and transport), peak discharge control using detention ponds, and various best management practices for stormwater volume and quality control. May count either CIVL 5160, CIVL 6160, or CIVL 6166.

**CIVL 5170 NUMERICAL SOLUTIONS FOR HYDRO-ENVIRONMENTAL APPLICATIONS (3) LEC.** 3. Pr. CIVL 3110 and CIVL 3230. Theoretical and numerical solutions of various problems in water resources and environmental engineering using computational tools. Development of simple codes and spreadsheet-based tools for the description and prediction of flows, contaminant spreading, and other relevant processes in natural and built systems. May count either CIVL 5170 or CIVL 6170/6176.

**CIVL 5210 CHEMICAL PRINCIPLES OF ENVIRONMENTAL ENGINEERING (3) LEC.** 3. Pr. CIVL 3230. Fundamentals of aquatic chemistry as applied to environmental engineering: chemical thermodynamics, acid/base equilibrium, solution/dissolution chemistry, redox equilibrium, and chemical kinetics. Departmental approval. Credit will not be given for both CIVL 5210 and CIVL 6210/CIVL 6216.

**CIVL 5230 ENVIRONMENTAL HEALTH ENGINEERING (3) LEC.** 3. Application of engineering methodology in environmental health; communicable disease control, insect and rodent control, solid and hazardous wastes, noise, radiological health, legal and administrative considerations, etc. Departmental approval. Credit will not be given for both CIVL 5230 and CIVL 6230/CIVL 6236.

**CIVL 5240 AIR POLLUTION (3) LEC.** 3. Nature, sources and effects of air pollutants; effects of atmospheric conditions on dispersion; dispersion modeling, theory and design of control devices; legal/ administrative control. Departmental approval. Credit will not be given for both CIVL 5240 and CIVL 6240/CIVL 6246.

**CIVL 5250 BIOLOGICAL PRINCIPLES OF ENVIRONMENTAL ENGINEERING (3) LEC.** 3. Pr. CIVL 3230. Fundamentals of aquatic biology and microbiology as applied to environmental engineering: microbial growth, microbial metabolism, microbial population dynamics, wastewater treatment microbiology, environmental impacts, toxicity testing, and biomonitoring. Departmental approval. Credit will not be given for both CIVL 5250 and CIVL 6250/CIVL 6256.

**CIVL 5260 SURFACE WATER QUALITY MODELING (3) LEC.** 3. Pr. CIVL 3230. Water uses and water quality goals, objectives, and criteria of natural aquatic systems. Principles of surface water quality modeling and waste load allocation. Physical, chemical, biological, and hydrological considerations relating to the fate and transport of pollutants in water environment.

**CIVL 5330 LANDFILLS (3) LEC.** 3. Pr. CIVL 3310. Landfill siting design, construction and operational practices; regulations, terminology, closure regulations and procedures. Credit will not be given for both CIVL 5330 and CIVL 6330/CIVL 6336.

**CIVL 5340 GEOSYNTHETICS AND SOIL IMPROVEMENT (3) LEC.** 3. Pr. CIVL 3310. Use of geosynthetics in civil engineering design: reinforcement, retaining walls, filtration, slopes, roads and erosion control. Evaluation and testing of geosynthetics. Improvement of soil properties for civil engineering design: principles and practice of densification, grouting, reinforcement, stone columns, soil nailing. Credit will not be given for both CIVL 5340 and CIVL 6340/CIVL 6346.



**CIVL 5350 EARTH RETAINING STRUCTURES (3)** LEC. 3. Pr. CIVL 3310. Analysis and design of earth retaining structures. Shear strength; earth pressure theory; gravity, mechanically stabilized, flexible sheet, and anchored structures. May count either CIVL 5350 or CIVL 6350/CIVL 6356.

**CIVL 5410 GEOGRAPHIC INFORMATION SYSTEMS IN CIVIL ENGINEERING (3)** LEC. 3. Pr. CIVL 2010. Departmental approval. Basic principles and the development of geographic information systems and practical experiences in the field of civil engineering. Credit will not be given for both CIVL 5410 and CIVL 6410.

**CIVL 5420 CONSTRUCTION PROJECT SCHEDULING AND CONTROL (3)** LEC. 3. Pr. CIVL 3410 and CIVL 4420. Principles related to planning, scheduling and control of civil engineering projects. Deterministic and probabilistic methods of scheduling, resource usage optimization. May count either CIVL 5420 or CIVL 6420.

**CIVL 5430 CONSTRUCTION SAFETY AND HEALTH MANAGEMENT (3)** LEC. 3. Pr. CIVL 3410. Departmental approval. Various causes of construction accidents and adopted strategies for preventing worksite injuries and illness are investigated. Emphasis on OSHA standards, insurance, and health and safety hazards. Credit will not be given for both CIVL 5430 and CIVL 6430/CIVL 6436.

**CIVL 5440 CONSTRUCTION EQUIPMENT AND METHODS (3)** LEC. 3. Pr. CIVL 3410. Selection of equipment for heavy construction operations, production rates, owning and operating costs, fleet management. May count either CIVL 5440 or CIVL 6440/CIVL 6446.

**CIVL 5450 EROSION AND SEDIMENT CONTROL TECHNOLOGIES IN CONSTRUCTION (3)** LEC. 3. Pr. CIVL 3410. Process of erosion, sediment transport, and sedimentation along with strategies adopted to prevent and manage erosion on construction sites. May count either CIVL 5450 or CIVL 6450.

**CIVL 5460 PROJECT ESTIMATING (3)** LEC. 3. Pr. CIVL 3410. Conceptual and definitive estimates, overhead and profit determination; claim change order pricing. May count either CIVL 5460 or CIVL 6460.

**CIVL 5480 LEGAL ASPECTS OF CIVIL ENGINEERING PRACTICE (3)** LEC. 3. Pr. CIVL 3410. Covered is the law of contracts, agency, association, property, and labor law, studied generally and in the context that the practicing civil engineer encounters them. Departmental approval. May count either CIVL 5480 or CIVL 6480/CIVL 6486.

**CIVL 5500 TRAFFIC ENGINEERING ANALYSIS (3)** LEC. 3. Pr. CIVL 3510. Capacity analysis of rural and suburban highways, 2-lane highways, freeways, weaving sections, ramps and intersections. May count either CIVL 5500 or CIVL 6500/CIVL 6506.

**CIVL 5510 TRAFFIC CONTROL SYSTEMS DESIGN (3)** LEC. 3. Pr. CIVL 3510 and STAT 3010. Fundamental design concepts for highway traffic control systems. Control requirements and warrants; hardware operation and equipment selection; development and implementation of timing plans for isolated intersections and intersection networks. May count either CIVL 5510 or CIVL 6510/CIVL 6516.

**CIVL 5560 PLANNING FOR MULTIMODAL TRANSPORTATION SYSTEMS (3)** LEC. 3. Pr. CIVL 3510 and STAT 3010. The planning process for urban and regional transportation development. Topics include planning objectives and data requirements; planning inventories; modeling of trip-making behavior, development and evaluation of alternate plans; multimodal applications, including railway operations.

**CIVL 5580 INTELLIGENT TRANSPORTATION SYSTEMS (3)** LEC. 3. Pr. CIVL 3510. Departmental approval. Introduction to intelligent transportation systems, covering applications of information and communication technologies to transportation, with emphasis on operations of traffic management and traveler information systems. Credit will not be given for both CIVL 5580 and CIVL 6580/CIVL 6586.

**CIVL 5600 ADVANCED REINFORCED CONCRETE DESIGN (3)** LEC. 3. Pr. CIVL 4600. Analysis and design of continuous beams and one-way slabs, bond and development length, torsion, slenderness effects in columns, two-way slabs, footings, and retaining walls. May count either CIVL 5600 or CIVL 6600/CIVL 6606.

**CIVL 5620 PRESTRESSED CONCRETE DESIGN (3)** LEC. 3. Pr. CIVL 4600. Properties and behavior of pre-stressed concrete, pre-stressing systems and end anchorages, analysis and design of beams for flexure and shear, camber and deflection, cable lay-out, pre-stressed concrete slabs. May count either CIVL 5620 or CIVL 6620/CIVL 6626.

**CIVL 5630 ADVANCED CONCRETE MATERIALS (3)** LEC. 3. Pr. CIVL 3820. Comprehensive coverage of concrete materials. Topics include cement and aggregate properties; concrete microstructure; mechanical properties; supplementary cementing materials; chemical admixtures; durability issues; special concretes. May count either CIVL 5630 or CIVL 6630/CIVL 6636.

**CIVL 5640 STRUCTURAL MASONRY DESIGN (3)** LEC. 3. Pr. CIVL 4600. Properties of masonry component materials; behavior and design of unreinforced and reinforced masonry assemblages and structures. May count either CIVL 5640 or CIVL 6640/CIVL 6646.

**CIVL 5650 ADVANCED STEEL DESIGN (3)** LEC. 3. Pr. CIVL 4650. Composite construction, open web joists, torsion, plate girders, plastic analysis and design, highway bridges, computer applications. May count either CIVL 5650 or CIVL 6650/CIVL 6656.

**CIVL 5660 BRIDGE ENGINEERING (3)** LEC. 3. Pr. CIVL 4600 and CIVL 4650. The modern approach to design, evaluation, and rehabilitation of bridges, including design of abutments, piers, concrete deck slabs, non-composite and composite steel girders, and prestressed concrete girders.

**CIVL 5670 ADVANCED STRUCTURAL ANALYSIS (3)** LEC. 3. Pr. CIVL 3610. Analysis of continuous beams and frames by slope-deflection method. Analysis of beams, trusses, grids, and frames by direct stiffness method. Buckling of planar frames. Use of structural analysis software. May count either CIVL 5670 or CIVL 6670/CIVL 6676.

**CIVL 5690 TIMBER DESIGN (3)** LEC. 3. Pr. CIVL 3610. Properties and behavior of timber and plywood; design of timber beams, columns, floor and wall assemblies and wood formwork; timber trusses and laminated arches. May count either CIVL 5690 or CIVL 6690/CIVL 6696.

**CIVL 5700 DESIGN FOR LATERAL LOADS (3)** LEC. 3. Pr. CIVL 3610 and (CIVL 4600 or CIVL 4650). Wind meteorology and loadings, effects of wind loadings, building code wind pressures and load provisions, fundamentals of structural vibrations, earthquake characteristics and loadings, building code earthquake provisions, building lateral load resisting systems. May count either CIVL 5700 or CIVL 6700/CIVL 6706.

**CIVL 5710 STRUCTURAL REPAIR (3)** LEC. 3. Pr. CIVL 4600. Evaluation of causes of distress; condition; repair materials; methods of repair; protection methods; and structural strengthening in structural concrete applications. May count either CIVL 5710 or CIVL 6710/CIVL 6716.

**CIVL 5720 RELIABILITY OF STRUCTURES (3)** LEC. 3. Pr. CIVL 4600 or CIVL 4650. Reliability-based methods of structural analysis including review of probability and statistics, reliability analysis methods, development of design codes, load and resistance models, system reliability, and practical applications. May count either CIVL 5720 or CIVL 6720/6726.

**CIVL 5810 PAVEMENT DESIGN AND CONSTRUCTION (3)** LEC. 3. Pr. CIVL 3820 and CIVL 3310 and CIVL 3510. General concepts, traffic factors, material characterization, layer thickness selection, earthwork, base and sub-base construction, surface course construction, quality control/assurance. May count either CIVL 5810 or CIVL 6810/CIVL 6816.

**CIVL 5820 DESIGN AND PRODUCTION OF ASPHALT PAVING MIXTURES (3)** LEC. 2. LAB. 3. Pr. CIVL 3820. Selection and optimization of component materials based on physical properties, specification criteria, performance expectations, and costs. Production and quality assurance. May count either CIVL 5820 or CIVL 6820.

**CIVL 5970 CIVIL ENGINEERING SPECIAL TOPICS (3)** LEC. 3. Special topics of an advanced undergraduate nature pertinent to civil engineering. Specific prerequisites will be announced for each course offering. Credit will not be given for both CIVL 5970 and CIVL 6970. Course may be repeated for a maximum of 6 credit hours.

**CIVL 6110 OPEN CHANNEL HYDRAULICS (3)** LEC. 3. Pr. CIVL 3110. Application of continuity, energy, and momentum analyses to problems of open channel flow. Topics include rapidly and gradually varied flow, unsteady flow, flood routing, computational methods, design concepts and applications. Credit will not be given for both CIVL 5110 and CIVL 6110/CIVL 6116.

**CIVL 6120 HYDROLOGIC ANALYSIS AND MODELING (3)** LEC. 3. Pr. CIVL 3110 and STAT 3110. Departmental approval. Hydrologic cycle, hydrologic frequency analysis, precipitation, infiltration, runoff hydrograph, flood routing, urban hydrology, watershed hydrologic modeling, and computer modeling applications.

**CIVL 6130 HYDRAULIC DESIGN OF PRESSURIZED SYSTEMS (3)** LEC. 3. Pr. CIVL 3110. Pressurized flow applications; pump-pipeline design optimization; multiple reservoir operation; flow measurement/control systems; distribution manifolds; fundamentals of unsteady flows. Departmental approval. May count either CIVL 5130 or CIVL 6130.

**CIVL 6150 GROUNDWATER HYDRAULICS (3)** LEC. 3. Pr. CIVL 3110. Mechanics of groundwater flow, definitions, conservation of mass, Darcy's law, confined and unconfined flow, steady and transient flow, groundwater transport. May count either CIVL 5150 or CIVL 6150/CIVL 6156.

**CIVL 6160 STORMWATER MANAGEMENT AND MODELING (3)** LEC. 3. Introduction of current stormwater management practices (e.g., lower impact development and green infrastructures) and polices, rainfall analysis with different inter-event dry period, flood analysis, stormwater runoff hydrograph modeling (rainfall loss, overland flow hydrograph, unit hydrograph theory, and hydrograph routing), stormwater quality modeling (pollutant buildup, washoff, and transport), peak discharge control using detention ponds, and various best management practices for stormwater volume and quality control. Approval by the instructor (e.g., undergraduate hydraulics).

**CIVL 6170 NUMERICAL SOLUTIONS FOR HYDRO-ENVIRONMENTAL APPLICATIONS (3)** LEC. 3. Pr. CIVL 3110 and CIVL 3230. Theoretical and numerical solutions of various problems in water resources and environmental engineering using computational tools. Development of simple codes and spreadsheet-based tools for the description and prediction of flows, contaminant spreading, and other relevant processes in natural and built systems. May count either CIVL 5170 or CIVL 6170/6176.

**CIVL 6210 CHEMICAL PRINCIPLES OF ENVIRONMENTAL ENGINEERING (3)** LEC. 3. Pr. CIVL 3230. Fundamentals of aquatic chemistry as applied to environmental engineering: chemical thermodynamics, acid/ base equilibrium, solution/dissolution chemistry, redox equilibrium, and chemical kinetics. Departmental approval. Credit will not be given for both CIVL 5210 and CIVL 6210/CIVL 6216.

**CIVL 6230 ENVIRONMENTAL HEALTH ENGINEERING (3)** LEC. 3. Application of engineering methodology in environmental health; communicable disease control, insect and rodent control, solid and hazardous wastes, noise, radiological health, legal and administrative considerations, etc. Departmental approval. Credit will not be given for both CIVL 5230 and CIVL 6230/CIVL 6236.

**CIVL 6240 AIR POLLUTION (3)** LEC. 3. Nature, sources and effects of air pollutants; effects of atmospheric conditions on dispersion; dispersion modeling theory and design of control devices; legal/administrative control. Departmental approval. Credit will not be given for both CIVL 5240 and CIVL 6240/CIVL 6246.

**CIVL 6250 BIOLOGICAL PRINCIPLES OF ENVIRONMENTAL ENGINEERING (3)** LEC. 3. Pr. CIVL 3230. Fundamentals of aquatic biology and microbiology as applied to environmental engineering: microbial growth, microbial metabolism, microbial population dynamics, wastewater treatment microbiology, environmental impacts, toxicity testing, and biomonitoring. Departmental approval. Credit will not be given for both CIVL 5250 and CIVL 6250/CIVL 6256.

**CIVL 6260 SURFACE WATER QUALITY MODELING (3)** LEC. 3. Water uses and water quality goals, objectives, and criteria of natural aquatic systems. Principles of surface water quality modeling and waste load allocation. Physical, chemical, biological, and hydrological considerations relating to the fate and transport of pollutants in water environment

**CIVL 6330 LANDFILLS (3)** LEC. 3. Pr. CIVL 3310. Landfill siting design, construction and operational practices; regulations, terminology, closure regulations and procedures. Credit will not be given for both CIVL 5330 and CIVL 6330/CIVL 6336.

**CIVL 6340 GEOSYNTHETICS AND SOIL IMPROVEMENT (3)** LEC. 3. Pr. CIVL 3310. Use of geosynthetics in civil engineering design: reinforcement, retaining walls, filtration, slopes, roads and erosion control. Evaluation and testing of geosynthetics. Improvement of soil properties for civil engineering design: principles and practice of densification, grouting, reinforcement, stone columns, soil nailing. Credit will not be given for both CIVL 5340 and CIVL 6340/CIVL 6346.

**CIVL 6350 EARTH RETAINING STRUCTURES (3)** LEC. 3. Pr. CIVL 3310. Analysis and design of earth retaining structures. Shear strength; earth pressure theory; gravity, mechanically stabilized, flexible sheet, and anchored structures. May count either CIVL 5350 or CIVL 6350/CIVL 6356.

**CIVL 6410 GEOGRAPHIC INFORMATION SYSTEMS IN CIVIL ENGINEERING (3)** LEC. 3. Pr. CIVL 2010. Departmental approval. Basic principles and the development of geographic information systems and practical experiences in the field of civil engineering. Credit will not be given for both CIVL 5410 and CIVL 6410.

**CIVL 6420 CONSTRUCTION PROJECT SCHEDULING AND CONTROL (3)** LEC. 3. Pr. CIVL 3410 and CIVL 4420. Principles related to planning, scheduling and control of civil engineering projects. Deterministic and probabilistic methods of scheduling, resource usage optimization. May count either CIVL 5420 or CIVL 6420.

**CIVL 6430 CONSTRUCTION SAFETY (3)** LEC. 3. Pr. CIVL 3410. Departmental approval. Various causes of construction accidents and adopted strategies preventing worksite injuries and illnesses are investigated. Emphasis on OSHA standards, insurance, and health and safety hazards. Credit will not be given for both CIVL 5430 and CIVL 6430/CIVL 6436.

**CIVL 6440 CONSTRUCTION EQUIPMENT AND METHODS (3)** LEC. 3. Pr. CIVL 3410. Selection of equipment for heavy construction operations, production rates, owning and operating costs, fleet management. May count either CIVL 5440 or CIVL 6440/CIVL 6446.

**CIVL 6450 EROSION AND SEDIMENT CONTROL TECHNOLOGIES IN CONSTRUCTION (3)** LEC. 3. Pr. CIVL 3410. Process of erosion, sediment transport, and sedimentation along with strategies adopted to prevent and manage erosion on construction sites. May count either CIVL 5450 or CIVL 6450.

**CIVL 6460 PROJECT ESTIMATING (3)** LEC. 3. Pr. CIVL 3410. Conceptual and definitive estimates, overhead and profit determination; claim change order pricing. May count either CIVL 5460 or CIVL 6460.

**CIVL 6480 LEGAL ASPECTS OF CIVIL ENGINEERING PRACTICE (3)** LEC. 3. Pr. CIVL 3410. Covered is the law of contracts, agency, association, property, and labor law, studied generally and in the context that the practicing civil engineer encounters them. Departmental approval. May count either CIVL 5480 or CIVL 6480/CIVL 6486.

**CIVL 6500 TRAFFIC ENGINEERING ANALYSIS (3)** LEC. 3. Pr. CIVL 3510. Capacity analysis of rural and suburban highways, 2-lane highways, freeways, weaving sections, ramps and intersections. May count either CIVL 5500 or CIVL 6500/CIVL 6506.

**CIVL 6510 TRAFFIC CONTROL SYSTEMS DESIGN (3)** LEC. 3. Pr. CIVL 3510 and STAT 3010. Fundamental design concepts for highway traffic control systems. Control requirements and warrants: hardware operation and equipment selection; development and implementation of timing plans for isolated intersections and intersection networks. May count either CIVL 5510 or CIVL 6510/CIVL 6516.

**CIVL 6560 PLANNING FOR MULTIMODAL TRANSPORTATION SYSTEMS (3)** LEC. 3. Pr. CIVL 3510 and STAT 3010. The planning process for urban and regional transportation development. Topics include planning objectives and data requirements; planning inventories; modeling of trip-making behavior, development and evaluation of alternate plans; multimodal applications, including railway operations. Departmental approval. May count either CIVL 5560.

**CIVL 6580 INTELLIGENT TRANSPORTATION SYSTEMS (3)** LEC. 3. Pr. CIVL 3510. Introduction to intelligent transportation systems, covering applications of information and communications technologies to transportation, with emphasis on operations of traffic management and traveler information systems. Departmental approval. May count either CIVL 5580 or CIVL 6580/CIVL 6586.

**CIVL 6600 ADVANCED REINFORCED CONCRETE DESIGN (3)** LEC. 3. Pr. CIVL 4600. Analysis and design of continuous beams and one-way slabs, bond and development length, torsion, slenderness effects in columns, two-way slabs, footings, and retaining walls. May count either CIVL 5600 or CIVL 6600/CIVL 6606.

**CIVL 6620 PRESTRESSED CONCRETE DESIGN (3)** LEC. 3. Pr. CIVL 4600. Properties and behavior of pre-stressed concrete, pre-stressing systems and end anchorages, analysis and design of beams for flexure and shear, camber and deflection, cable layout, pre-stressed concrete slabs. May count either CIVL 5620 or CIVL 6620/CIVL 6626.

**CIVL 6630 ADVANCED CONCRETE MATERIALS (3)** LEC. 3. Pr. CIVL 3820. Comprehensive coverage of concrete materials. Topics include cement and aggregate properties; concrete microstructure; mechanical properties; supplementary cementing materials, chemical admixtures; durability issues; special concretes. May count either CIVL 5630 or CIVL 6630/CIVL 6636.

**CIVL 6640 STRUCTURAL MASONRY DESIGN (3)** LEC. 3. Pr. CIVL 4600. Properties of masonry component materials; behavior and design of unreinforced and reinforced masonry assemblages and structures. May count either CIVL 5640 or CIVL 6640/CIVL 6646.

**CIVL 6650 ADVANCED STEEL DESIGN (3)** LEC. 3. Pr. CIVL 4650. Composite construction, open web joists, torsion, plate girders, plastic analysis and design, highway bridges, computer applications. May count either CIVL 5650 or CIVL 6650/CIVL 6656.

**CIVL 6660 BRIDGE ENGINEERING (3)** LEC. 3. Pr. CIVL 4600 and CIVL 4650. The modern approach to design, evaluation, and rehabilitation of bridges, including design of abutments, piers, concrete deck slabs, non-composite and composite steel girders, and prestressed concrete girders. May count either CIVL 5660 or CIVL 6660/6666

**CIVL 6670 ADVANCED STRUCTURAL ANALYSIS (3)** LEC. 3. Pr. CIVL 3610. Analysis of continuous beams and frames by slope-deflection method. Analysis of beams, trusses, grids, and frames by direct stiffness method. Buckling of planar frames. Use of structural analysis software. May count either CIVL 5650 or CIVL 6650/CIVL 6656.

**CIVL 6690 TIMBER DESIGN (3)** LEC. 3. Pr. CIVL 3610. Properties and behavior of timber and plywood; design of timber beams, columns, floor and wall assemblies and wood formwork; timber trusses and laminated arches. May count either CIVL 5690 or CIVL 6690/CIVL 6696.

**CIVL 6700 DESIGN FOR LATERAL LOADS (3)** LEC. 3. Pr. CIVL 3610 and (CIVL 4600 or CIVL 4650). Wind meteorology and loadings, effects of wind loadings, building code wind pressures and load provisions, fundamentals of structural vibrations, earthquake characteristics and loadings, building code earthquake provisions, building lateral load resisting systems. May count either CIVL 5700 or CIVL 6700/CIVL 6706.

**CIVL 6710 STRUCTURAL REPAIR (3)** LEC. 3. Pr. CIVL 4600. Evaluation of causes of distress; condition; repair materials; methods of repair; protection methods; and structural strengthening in structural concrete applications. May count either CIVL 5710 or CIVL 6710/CIVL 6716.

**CIVL 6720 RELIABILITY OF STRUCTURES (3)** LEC. 3. Pr. CIVL 4600 or CIVL 4650. Reliability-based methods of structural analysis including review of probability and statistics, reliability analysis methods, development of design codes, load and resistance models, system reliability, and practical applications. May count either CIVL 5720 or CIVL 6720/6726.

**CIVL 6810 PAVEMENT DESIGN AND CONSTRUCTION (3)** LEC. 3. Pr. CIVL 3820 and CIVL 3310 and CIVL 3510. General concepts, traffic factors, material characterization, layer thickness selection, earthwork, base and sub-base construction, surface course construction quality control/assurance. May count either CIVL 5810 or CIVL 6810/CIVL 6816.

**CIVL 6820 DESIGN AND PRODUCTION OF ASPHALT PAVING MIXTURES (3)** LEC. 2. LAB. 3. Pr. CIVL 3820. Selection and optimization of component materials based on physical properties, specification criteria, performance expectations, and costs. Production and quality assurance. May count either CIVL 5820, CIVL 6820 or CIVL 6826.

**CIVL 6970 CIVIL ENGINEERING SPECIAL TOPICS (3)** LEC. 3. Departmental approval. Special topics of an advanced undergraduate nature pertinent to civil engineering. Specific prerequisites will be announced for each course offering. Credit will not be given for both CIVL 5970 and CIVL 6970. Course may be repeated for a maximum of 6 credit hours.

**CIVL 7120 HYDROLOGIC MODELING (3)** LEC. 3. Pr. (CIVL 6110 or CIVL 6116). Principles and practice of hydrologic modeling, introduction to hydrologic information systems, computer modeling of storm run-off, floodplain hydraulics and bridge hydraulics. Computer applications.

**CIVL 7130 SOCIAL-ECOLOGICAL-ENGINEERED SYSTEMS (3)** LEC. 3. This course explores foundational scholarship on the Social-Ecological Systems (SES) approach to understanding complex environmental problems with emphasis on the role of engineering in human interactions with natural systems. Students are expected to apply SES concepts and theories to analyses in their own areas of research. Note: This class is intended to be cross-listed with ESSI 7300.

**CIVL 7140 ECOHYDROLOGY (3)** LEC. 3. Pr. P/C CIVL 6120 or P/C CIVL 6126 or P/C GEOL 6100 or P/C FORY 7550. This course covers current theory, methods, and issues in ecohydrology. Topics include the soil-plant-atmosphere continuum; stochastic modeling of soil moisture; vadose zone hydrology; theory, measurement, and modeling of evapotranspiration; ecological competition in water-limited systems; and current issues and research topics.

**CIVL 7170 NUMERICAL METHODS IN HYDRAULICS AND HYDROLOGY (3)** LEC. 3. Pr. CIVL 3230. Numerical approximations of ordinary and partial differential equations representing problems common to civil engineering including groundwater flow, soil consolidation, and mass transport. The formulation and computational solution of diffusion and equilibrium problems are emphasized. Computer programming is required.

**CIVL 7220 WATER AND WASTEWATER OPERATIONS AND PROCESSES I (3)** LEC. 3. Pr. CIVL 3230. Departmental approval. Coreq. CIVL 6210. Physical and chemical principles applied to water and wastewater treatment. Advanced mathematical and modeling concepts.

**CIVL 7230 WATER AND WASTEWATER OPERATIONS AND PROCESSES II (3)** LEC. 3. Pr. CIVL 7220 or CIVL 7226. Departmental approval. Rigorous analysis of unit operations and processes used in modern water and wastewater treatment systems. Mixing, coagulation, sedimentation, filtration, and chemical precipitation.

**CIVL 7250 BIOLOGICAL WASTEWATER TREATMENT (3)** LEC. 3. Pr. CIVL 6250 or CIVL 6256. Departmental approval. Development and application of the theories of biological waste treatment.

**CIVL 7270 ADVANCED NUMERICAL METHODS FOR SOLVING ENVIRONMENTAL ENGINEERING PROBLEMS (3)** LEC. 3. Pr. CIVL 3010. Departmental approval. Basic concepts of finite element (FE) analysis. Development of FE computer codes for solving environmental engineering problems. FE grid generation and visualization methods.

**CIVL 7280 SURFACE WATER QUALITY MODELING (3)** LEC. 3. Pr. CIVL 3230. Departmental approval. Physical, chemical, biological and hydrological considerations relating to the degradation and self-purification of streams, lakes, and estuaries. Water uses and water quality goals, objectives and criteria. Principles of water quality modeling and waste load allocation.

**CIVL 7310 FOUNDATION ENGINEERING (3)** LEC. 3. Pr. CIVL 3310 and CIVL 4600. Analysis, design and construction of shallow and deep foundation systems.

**CIVL 7330 SOIL PROPERTIES (3)** LEC. 3. Pr. CIVL 3310. Soil behavior, shear strength, compressibility, hydraulic conductivity, and measurement of soil properties.

**CIVL 7340 SOIL DYNAMICS (3)** LEC. 3. Pr. CIVL 3310. Soil behavior during dynamic loads, wave propagation, dynamically loaded foundations, geotechnical earthquake engineering.

**CIVL 7360 EARTH SLOPES AND DAMS (3)** LEC. 3. Pr. CIVL 3310. Departmental approval. Engineering design of earth slopes, slope stability, cut slopes, embankments, settlement. Dam siting, stability, flownets, seepage analysis.

**CIVL 7390 IN SITU TESTING OF SOILS (3)** LEC. 3. Pr. CIVL 4310. In situ tests used in geotechnical engineering: test procedures, interpretation of results, and designing from in situ geotechnical data.

**CIVL 7420 CONSTRUCTION ENGINEERING PROJECT PLANNING AND CONTROL (3)** LEC. 3. Pr. CIVL 4420. Departmental approval. This course covers the processes needed to develop and use project plans and budgets for construction projects. These tools will be used to create different schedules needed for construction planning and monitoring and be able to adjust a project's projection to maximize performance throughout the project lifecycle. This will include the scheduling methods to predict desired outcomes and performance measures to actively gauge project performance.

**CIVL 7440 CONSTRUCTION EQUIPMENT PRODUCTIVITY AND ENGINEERING ECONOMICS (3)** LEC. 3. Pr. CIVL 4420. Departmental approval. This course will encompass the methods needed to select, use, and manage the proper construction equipment to accomplish different project tasks. This will include using engineering fundamentals to understand the production and efficiency capabilities of equipment and the economic and scheduling impact this will have on the construction project.

**CIVL 7460 PRECONSTRUCTION ENGINEERING PROJECT PLANNING (3)** LEC. 3. Pr. CIVL 4420. Departmental approval. Construction success starts with the planning process known commonly as Preconstruction. During this phase potential construction projects are considered, studied, planned, designed, scheduled, and budgeted. Project owners often rely on consultants such as construction managers to help evaluate a project idea, the factors associated with the idea becoming a reality, and overseeing the steps from project idea to project construction. The proposed course provides students with the tools needed to be able to oversee project planning and owner assistance to usher the project to completion.

**CIVL 7470 ADVANCED ENGINEERING PROJECT MANAGEMENT (3)** LEC. 3. Pr. CIVL 4420. Departmental approval. Construction management requires cutting edge methods to coordinate project activities from project inception through project closeout to meet project needs and maintain competitive balance. Project oversight from pre-construction planning, scheduling, and estimating management require constant management and control while sound decision methods are used for best management methods. The proposed course provides students with the tools needed to be able to meet project requirements and result in successful project completion.

**CIVL 7540 TRANSPORTATION SAFETY (3)** LEC. 3. Pr. CIVL 6500 or CIVL 6506. Departmental approval. Transportation safety problems and the engineer's role in developing and administering safety programs. Topics include hazardous location identification; analysis of accident data; development and evaluation of accident countermeasures and safety programs.

**CIVL 7610 STRUCTURAL DYNAMICS I (3)** LEC. 3. Pr. CIVL 6670 or CIVL 6676. Single-degree-of-freedom systems, numerical solution techniques, response spectrum, multi-degree-of-freedom systems, eigenproblem solution, mode superposition analysis.

**CIVL 7630 ADVANCED STRESS ANALYSIS (3)** LEC. 3. Pr. CIVL 3610. Hooke's 1-D, 2-D, 3-D stress-strain relations and applications, stress and strain transformations and Mohr's circle, material properties and failure theories, biaxial bending, unsymmetrical bending, composite material members, shear center, torsional stress, stress concentrations, beams on elastic foundations.

**CIVL 7640 STABILITY OF STRUCTURES (3)** LEC. 3. Coreq. CIVL 6670. Introduction to stability and failure of compression members, rigid bar buckling, elastic and inelastic buckling of columns, approximate methods of buckling analysis, beam-columns, buckling of frames, torsional buckling, lateral torsional buckling of beams.

**CIVL 7660 FINITE ELEMENT METHODS IN STRUCTURAL MECHANICS (3)** LEC. 3. Pr. CIVL 6670 or CIVL 6676. Departmental approval. Introduction to finite element analysis; variational principles. 1D, 2D and 3D element formulation; nonlinear (geometric and constitutive) formulations and solutions; eigenvalue problems.

**CIVL 7670 NUMERICAL TECHNIQUES IN STRUCTURAL ANALYSIS (3)** LEC. 3. Basic concepts of non-linear analyses, formulation of the continuum mechanics incremental equations, total and updated Lagrangian formulations, finite elements for non-linear analyses, non-linear solution strategies.

**CIVL 7680 FATIGUE AND FRACTURE MECHANICS (3)** LEC. 3. Pr. CIVL 4650. Departmental approval. Linear-elastic and elastic-plastic fracture mechanics, fatigue, yield criteria, applications to highway structures.

**CIVL 7720 EARTHQUAKE ENGINEERING (3)** LEC. 3. Pr. (CIVL 7610 or CIVL 7616) and (CIVL 5670 or CIVL 6670 or CIVL 6676). Principles of earthquakes and earthquake engineering; Analysis and design of steel and reinforced concrete buildings for earthquakes. May count either CIVL 7720 or CIVL 7726.

**CIVL 7820 ADVANCED PAVEMENT DESIGN AND REHABILITATION (3)** LEC. 3. Pr. CIVL 7810 or CIVL 7816. Pavement management concepts, life cycle costs analysis, design and rehabilitation alternatives, serviceability concepts, empirical thickness selection models, reliability.

**CIVL 7840 PAVEMENT MANAGEMENT AND REHABILITATION (3)** LEC. 3. Pr. CIVL 3820. Departmental approval. Topics include: network and project level management, pavement distress surveys, non-destructive testing for condition measurements, flexible and rigid pavement maintenance and rehabilitation practices.

**CIVL 7860 PAVEMENT CONSTRUCTION (3)** LEC. 3. Pr. CIVL 3820. Operation, quality control and specifications of component construction processes for asphalt and concrete paving; and overview of major rehabilitation strategies.

**CIVL 7870 ADVANCED CHARACTERIZATION OF PAVEMENT MATERIALS (3)** LEC. 2. LAB. 3. Pr. CIVL 3820. This course introduces theories and procedures for determining fundamental properties of asphalt materials for advanced material evaluation and pavement design.

**CIVL 7950 GRADUATE SEMINAR (1)** SEM. 1. SU. Course may be repeated for a maximum of 6 credit hours.

**CIVL 7970 SPECIAL TOPICS IN CIVIL ENGINEERING (1-3)** DSL. Individual student or group endeavor under direct faculty supervision involving special topics of an advanced nature in civil engineering. Course may be repeated for a maximum of 9 credit hours.

**CIVL 7980 ENGINEERING PROJECT (1-10)** LEC. 1-10. Directed study on an engineering project or research supervised by an individual graduate faculty member. Course may be repeated for a maximum of 10 credit hours.

**CIVL 7990 RESEARCH AND THESIS (1-10)** MST. Departmental approval. Credit to be arranged. Course may be repeated for a maximum of 10 credit hours.

**CIVL 8990 RESEARCH AND DISSERTATION (1-10)** DSL/DSR. Departmental approval. Credit to be arranged. Course may be repeated with change in topics.