# Civil Engineering (CV_ENG)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Description</th>
<th>Credit Hours</th>
<th>Prerequisites/Co-requisites</th>
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<tbody>
<tr>
<td>CV_ENG 1001: Experimental Course</td>
<td>For freshman-level students. Content and number of credit hours to be listed in Schedule of Courses.</td>
<td>1-99</td>
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<tr>
<td>CV_ENG 2001: Experimental Course</td>
<td>For sophomore-level students. Content and number of credit hours to be listed in Schedule of Courses.</td>
<td>1-99</td>
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<tr>
<td>CV_ENG 2080: Introduction to Dynamics</td>
<td>Basic fundamentals of particle and rigid body dynamics; energy and momentum methods.</td>
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<tr>
<td>CV_ENG 3010: Decision Methods for Civil Engineering Design</td>
<td>Essential features of civil engineering including the design process, design teams, experimental and computational tools, engineering economy, communication skills, and ethical considerations.</td>
<td>3</td>
<td>ENGINR 1200</td>
<td></td>
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<tr>
<td>CV_ENG 3010W: Decision Methods for Civil Engineering Design - Writing Intensive</td>
<td>Essential features of civil engineering including the design process, design teams, experimental and computational tools, engineering economy, communication skills, and ethical considerations.</td>
<td>3</td>
<td>ENGLISH 1000</td>
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<tr>
<td>CV_ENG 3050: Introduction to Geographic Information Systems GIS</td>
<td>(same as GEOG 3040) Introduces theory, concepts and techniques related to the creation, manipulation, processing, and basic analysis of spatial data using GIS. Data management, current data models, GIS applications and course topics are reinforced through hands-on computer laboratory exercises.</td>
<td>3</td>
<td>ENGINR 1200</td>
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<tr>
<td>CV_ENG 3100: Fundamentals of Transportation Engineering</td>
<td>Covers fundamentals of transportation engineering including geometric design, traffic engineering, pavements, and planning.</td>
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<td>CV_ENG 3010</td>
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<tr>
<td>CV_ENG 3100: Fundamentals of Transportation Engineering</td>
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<td>4</td>
<td>ENGLISH 1000</td>
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<tr>
<td>CV_ENG 3101: Experimental Course</td>
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<td>1-99</td>
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<td>CV_ENG 3102: Experimental Course</td>
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<td>CV_ENG 3103: Experimental Course</td>
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<td>1-99</td>
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<tr>
<td>CV_ENG 3200: Fundamentals of Environmental Engineering</td>
<td>Fundamentals of water quality engineering and water resources, water and wastewater treatment, solid and hazardous and radioactive waste management, air pollution, environmental regulation, and environmental ethics.</td>
<td>4</td>
<td>CV_ENG 3010</td>
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<td>CV_ENG 3201: Experimental Course</td>
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<td>CV_ENG 3202: Experimental Course</td>
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<td>CV_ENG 3203: Experimental Course</td>
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<tr>
<td>CV_ENG 3250: Pollutant Fate and Transport</td>
<td>(same as ENV_SC 3250). Introduction to concepts governing pollutant fate and transport in the environment, including pollutant interactions within and migration through environmental systems, as well as analytical techniques and tools necessary to quantify conditions and movement.</td>
<td>3</td>
<td>ENV_SC 1100 or SOIL 2100 or CV_ENG 3200; and CHEM 1320; or instructor's permission</td>
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<tr>
<td>CV_ENG 3300: Structural Analysis I</td>
<td>Analysis of statically determinate beams, frames; shear and moment diagrams; influence line diagrams; beam deflections. Analysis of statically indeterminate structures; moment distribution; energy methods. Introduction to matrix analysis.</td>
<td>4</td>
<td>ENGINR 1200 and ENGINR 2200</td>
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<tr>
<td>CV_ENG 3300H: Structural Analysis I - Honors</td>
<td>Analysis of statically determinate beams, frames; shear and moment diagrams; influence line diagrams; beam deflections. Analysis of statically indeterminate structures; moment distribution; energy methods. Introduction to matrix analysis.</td>
<td>4</td>
<td>ENGINR 1200 and ENGINR 2200. Honors Eligibility required</td>
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<tr>
<td>CV_ENG 3312: Reinforced Concrete Design</td>
<td>Basic principles of reinforced concrete design. Design of beams for flexure and shear; design of short and slender columns. Prerequisites: CV_ENG 3300;</td>
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<tr>
<td>CV_ENG 3312: Reinforced Concrete Design</td>
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<tr>
<td>CV_ENG 3313: Structural Steel Design</td>
<td>Basic principles of structural steel design. Design of beams, axially loaded members, columns, and bolted and welded connections.</td>
<td>3</td>
<td>CV_ENG 3300 and CV_ENG 3600</td>
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<tr>
<td>CV_ENG 3400: Fundamentals of Geotechnical Engineering</td>
<td>Detailed study of physical and mechanical properties of soil governing its behavior as an engineering material.</td>
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<tr>
<td>CV_ENG 3400: Fundamentals of Geotechnical Engineering</td>
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<tr>
<td>CV_ENG 3500: Introduction to Geographic Information Systems GIS</td>
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</table>
CV_ENG 3600: Civil Engineering Materials
Introduces composition, structure, properties, behavior, and selection of civil engineering materials.

Credit Hours: 4
Prerequisites or Corequisites: CV_ENG 3010
Prerequisites: grade of C- or better in ENGINR 2200 or instructor's consent

CV_ENG 3700: Fluid Mechanics
Statics and dynamics of fluids, principles of continuity, momentum and energy, pipe flow.

Credit Hours: 3
Prerequisites: grade of C- or better PHYSCS 2750

CV_ENG 3702: Hydrology
Fundamental concepts of hydrology in engineering; quantitative estimation of stream-flow magnitude and frequency; and open channel flow considerations from stream-flow. Fluid Mechanics lab with lab reports.

Credit Hours: 4
Prerequisites: grade of C- or better MATH 2300 and CV_ENG 3200 and CV_ENG 3700

CV_ENG 4001: Topics in Civil Engineering
Study of current and new technical developments in civil engineering.

Credit Hour: 1-3
Prerequisites: instructor's consent

CV_ENG 4006: Computational Methods in Civil Engineering (cross-leveled with CV_ENG 7006). Use of numerical methods for solution of engineering problems involving roots of equations, simultaneous equations, curve fitting, integration, optimization, differentiation, and differential equations. The numerical methods are demonstrated through computer implementation and application to engineering design problems.

Credit Hours: 3
Prerequisites: MATH 2300
Corequisites: MATH 4100


Credit Hours: 3
Prerequisites: grade of C- or better in CV_ENG 3100


Credit Hours: 3
Prerequisites: grade of C- or better in ENGINR 2200

CV_ENG 4105: Asphalt Materials and Mixture Design (cross-leveled with CV_ENG 7105). This course consists of a combination of interactive classroom lectures and discussions, group activities, hands-on laboratory exercises, laboratory demonstrations, and field trips (live and/or recorded) to observe asphalt binder and mixture design, production, and control. Upon completion of the course, the student will be able to: (1) select, specify, and design an asphalt paving mixture for specific climatic and traffic conditions using the SUPERPAVE mixture design system; (2) understand the sources, types, and manufacturing aspects of asphalt binders and aggregates; (3) understand the key elements of asphalt mixture construction, process control, and acceptance; (4) perform key SUPERPAVE laboratory tests for asphalt binders, aggregates, and mixtures and master the analysis and interpretation of data collected; (5) understand contemporary concepts and approaches in sustainable asphalt mixture design and construction; (6) understand and mathematically describe fundamental properties of asphalt binders and mixtures, which is a critical step in mastering mixture/pavement design, evaluation, and rehabilitation, and; (7) understand and describe the key types and uses of special asphalt binder and mixture products, including emulsions, cutbacks, polymer-modified binders, warm-mix asphalt, other additives, and mixtures containing recycled asphalt pavement (RAP) and recycled asphalt shingles (RAS). Graded on A-F only.

Credit Hours: 3
Prerequisites or Corequisites: CV_ENG 3600

CV_ENG 4106: Intelligent Transportation Systems (cross-leveled with CV_ENG 7106). This is an introductory course in Intelligent Transportation Systems (ITS). Topics include the theory of transportation networks and systems optimization, current implementations of ITS, and practical issues and implications of ITS.

Credit Hours: 3
Prerequisites: grade of C- or better in CV_ENG 3100

CV_ENG 4110: Transportation Simulation (cross-leveled with CV_ENG 7110). Theory and application of simulation in transportation engineering.

Credit Hours: 3
Prerequisites: grade of C- or better in CV_ENG 3100

CV_ENG 4008: Risk and Reliability for Civil Engineers (cross-leveled with CV_ENG 7008). This course focuses on how to use probability and statistics to quantify uncertainties and consider risks when making civil engineering decisions and designing civil engineering systems.

Credit Hours: 3
Prerequisites: grade of C- or better in CV_ENG 3010 or other introductory probability/statistics course

CV_ENG 4085: Problems in Civil and Environmental Engineering
Directed investigation of civil engineering.

Credit Hour: 2-4
Prerequisites: instructor's consent
CV_ENG 4120: Airport Engineering
(cross-leveled with CV_ENG 7120). Airport systems planning, design, and management.

Credit Hours: 3
Prerequisites: grade of C- or better in CV_ENG 3100

CV_ENG 4125: Transportation Legal Issues
(cross-leveled with CV_ENG 7125). This course discusses some of the legal issues that transportation engineers encounter throughout the course of their careers.

Credit Hours: 3
Prerequisites: CV_ENG 3100

CV_ENG 4130: Transportation Safety
(cross-leveled with CV_ENG 7130). This course is an introduction to transportation safety. The focus will be on surface transportation. The student is expected to analyze safety data and to devise engineering solutions to safety problems.

Credit Hours: 3
Prerequisites: CV_ENG 3100

CV_ENG 4145: Civil and Environmental Engineering Legal Issues
(cross-leveled with CV_ENG 7145). Discussion of legal issues facing civil engineers including right of way, risk and liability, environment, financing public works, contracting and ethics.

Credit Hours: 3
Prerequisites: CV_ENG 3100

CV_ENG 4155: Transportation Geography
(same as GEOG 4850; cross-leveled with CV_ENG 7155; GEOG 7850). Introduction to fundamental concepts and modes of analysis in transportation geography. Focus on descriptive, explanatory, as well as normative approaches. Topics reviewed include spatial organization, transportation economics, spatial interaction, network analysis, location/ allocation, and urban transportation planning.

Credit Hours: 3

CV_ENG 4175: The Geospatial Science in National Security
(Same as GEOG 4130; cross-leveled with CV_ENG 4175, GEOG 7130). This course explores the critical contribution of the geospatial sciences in the collection processing, visualization and analysis of geospatial information related to national security. May be repeated for credit.

Credit Hours: 3
Prerequisites: instructor's consent
Recommended: junior standing

CV_ENG 4185: Location Analysis/Site Selection
(same as GEOG 4740; cross-leveled with CV_ENG 7185; GEOG 7740). An overview of location analysis in regional planning and spatial decision support, this course focuses on the use of Geographic Information Science (GIS) and location analysis methods in addressing regional service needs. Maybe be repeated for credit.

Credit Hours: 3

CV_ENG 4190: Infrastructure Project Development
(cross-leveled with CV_ENG 7190). Students will learn how the key elements of major civil engineering infrastructure projects fit together. The course will focus on the horizontal integration of: financing - planning - environment - right of way - design - construction - operations - maintenance. Engineering is important but so are a lot of other things. Graded on A-F basis only. Prerequisites: junior standing

Credit Hours: 3

CV_ENG 4220: Hazardous Waste Management
(same as CH_ENG 4220; cross-leveled with CV_ENG 7220, CH_ENG 7220). Engineering principles involved in handling, collection, transportation, processing and disposal of hazardous wastes, waste minimization, legislation on hazardous wastes and groundwater contamination.

Credit Hours: 3

CV_ENG 4230: Introduction to Water Quality
(cross-leveled with CV_ENG 7230). Methods for determining and characterizing water quality, effects of pollution on streams and lakes, and an introduction to engineered systems for the distribution, collection and treatment of water and wastewater.

Credit Hours: 3
Prerequisites: junior standing

CV_ENG 4232: Water and Wastewater Treatment Facilities
(cross-leveled with CV_ENG 7232). Physical, chemical, and biochemical processes for treating drinking water supplies and wastewaters (domestic and industrial), with emphasis on planning and design of such facilities.

Credit Hours: 3
Prerequisites: CV_ENG 4230 or CV_ENG 7230 or instructor's consent

CV_ENG 4240: Water Quality Analysis
(cross-leveled with CV_ENG 7240). Chemical, physical and biological methods for analysis of streams, lakes, wastewaters and water supplies and their use in water quality management.

Credit Hours: 3
Prerequisites: grade of C- or better in CV_ENG 4230 or instructor's consent

CV_ENG 4245: Environmental Chemistry for Engineers
(cross-leveled with CV_ENG 7245). This course will cover the fundamentals of environmental chemistry. Physical, equilibrium, organic and colloid chemistry topics will be presented from an environmental perspective with a focus on their relevant engineering applications.

Credit Hours: 3
Prerequisites: CHEM 1320 or CV_ENG 3200

CV_ENG 4250: Environmental Regulatory Compliance
(cross-leveled with CV_ENG 7250). Systems of water law; provisions of major federal environmental laws and regulations; development of regulations at the federal, state, and local levels; regulatory frameworks; permits; and enforcement.

Credit Hours: 3
CV_ENG 4270: Environmental Engineering Microbiology
(cross-leveled with CV_ENG 7270). Theory and application of fundamental principles of microbiology, ecology, and aquatic biology of the microorganisms of importance to sanitary engineers.

Credit Hours: 3
Prerequisites: senior standing or instructor's consent

CV_ENG 4286: Environmental Sustainability
(cross-leveled with CV_ENG 7286). This course will present an introduction to sustainability in engineering, tools for assessing sustainability and principles of sustainable design practices. Topics include climate change, energy and renewable resources, limits to growth, risk assessment, life cycle assessments, water and energy footprints, green buildings, and the water-food-energy-nexus. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: CV_ENG 3200

CV_ENG 4290: Wastewater Treatment and Process Design
(cross-leveled with CV_ENG 7290). Selection and use of wastewater and sludge treatment processes, disposal methods, sustainable wastewater treatment including anaerobic treatment of wastewater reuse.

Credit Hours: 3
Prerequisites: grade of C- or better in CV_ENG 3200. Instructor's consent required

CV_ENG 4300: Advanced Structural Steel Design
(cross-leveled with CV_ENG 7300). Design of steel structures and bridges. Topics include composite beams, plate girder design, and moment resistant connections.

Credit Hours: 3
Prerequisites: grade of C- or better in CV_ENG 3312 and CV_ENG 3313

CV_ENG 4302: Prestressed/Advanced Reinforced Concrete

Credit Hours: 3
Prerequisites or Corequisites: CV_ENG 3312

CV_ENG 4320: Energy Methods in Mechanics
(cross-leveled with CV_ENG 7320). Variational mechanics including practical examples. Topics include calculus of variation of boundary value problems, energy methods such as Ritz and Galerkin methods, approximate solutions methods such as the finite element and finite difference, and eigenvalue problems.

Credit Hours: 3
Prerequisites: senior or graduate standing required

CV_ENG 4330: Structural System Design
(cross-leveled with CV_ENG 7330). Design of buildings in steel and reinforced concrete, including estimation of loads and design of gravity and lateral force resisting systems.

Credit Hours: 3
Prerequisites: grade of C- or better in CV_ENG 3312 and CV_ENG 3313

CV_ENG 4350: Matrix Methods of Structural Analysis
(cross-leveled with CV_ENG 7350). An introduction to the fundamentals of stiffness and flexibility methods for analysis of truss and frame structures. Application of the STRUDL and NASTRAN programs to three dimensional structures.

Credit Hours: 3
Prerequisites: senior standing or instructor's consent

CV_ENG 4360: Bridge Engineering

Credit Hours: 3
Prerequisites: grade of C- or better in CV_ENG 3312 and CV_ENG 3313

CV_ENG 4404: Geotechnical Earthquake Engineering
(cross-leveled with CV_ENG 7404). This course provides an introduction to geotechnical aspects of earthquake engineering. Topics include: basic seismology, seismic hazard analysis, dynamic soil properties, site response analysis and soil liquefaction.

Credit Hours: 3
Prerequisites: grade of C- or better in CV_ENG 3400 or instructor's consent

CV_ENG 4406: Geotechnics of Landfill Design
(cross-leveled with CV_ENG 7406). This course will focus on geotechnical and construction aspects in the analysis, design and construction of waste containment facilities (landfills) including expansions of existing facilities.

Credit Hours: 3
Prerequisites: instructor's consent

CV_ENG 4410: Foundation Engineering
(cross-leveled with CV_ENG 7410). Subsurface exploration. Design of basic foundation structures, shallow foundations, retaining walls, deep foundations.

Credit Hours: 3
Prerequisites: grade of C- or better in CV_ENG 3400

CV_ENG 4412: Applied Geotechnical Engineering
(cross-leveled with CV_ENG 7412). Study of concepts, theories, and design procedures for modern earthwork engineering including: compaction and densification of soils and soil improvement, seepage and drainage, slope stability and performance, and earth retaining structures.

Credit Hours: 3
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Prerequisites: grade of C- or better in CV_ENG 3400

CV_ENG 4500: Introduction to Construction Management
(cross-leveled with CV_ENG 7500). Structure of the construction industry; construction drawings and specifications; estimating and bidding; construction contracts, bonds and insurance; planning and scheduling of construction operations; project management; computer techniques.
Credit Hours: 3
Prerequisites: junior standing

CV_ENG 4600: Advanced Mechanics of Materials
(same as MAE 4600; cross-leveled with CV_ENG 7600 and MAE 7600). Analysis of more complicated problems in stresses, strains.
Credit Hours: 3
Prerequisites: C- or better in ENGINR 2200, MAE 3200 and Junior standing

CV_ENG 4610: Sensors and Experimental Stress Analysis
(cross-leveled with CV_ENG 7610). Sensors and instrumentation for stress analysis, mechanical measurement and health monitoring of civil structures. Application and design of data acquisition systems, basic digital signal processing. Electronics and instrumentation circuits.
Credit Hours: 3
Prerequisites: grade of C- or better in ENGINR 2200 and PHYSCS 2760

CV_ENG 4660: Vibration Analysis
(same as MAE 4660; cross-leveled with CV_ENG 7660, MAE 7660). Vibration theory and its application to mechanical systems. Topics include free and forced vibration analysis of single- and multi-degree of freedom systems.
Credit Hours: 3
Prerequisites: C- or better in MATH 4100 and MAE 2600

CV_ENG 4692: Introduction to Structural Dynamics
(cross-leveled with CV_ENG 7692). Theory of structural response to dynamic loads. Computation of dynamic response of structures to dynamic loads like blast and earthquake. Modal analysis and single degree of freedom methods will be covered.
Credit Hours: 3
Prerequisites: grade of C- or better in CV_ENG 3300

CV_ENG 4720: Watershed Modeling Using GIS
(same as BIOL_EN 4350). Watershed evaluation using AVSWAT for hydrology, sediment yield, water quality; includes USLE, MUSLE, WEPP, Procedures for model calibration/sensitivity data analysis.
Credit Hours: 3
Prerequisites: BIOL_EN 2180 or CV_ENG 3200

CV_ENG 4730: Hydraulic Design
(cross-leveled with CV_ENG 7730). Design of hydraulic infrastructure utilizing principles of both pressure conduits and open channels. Hand calculations and use of commercial design software for water distribution (quantity and quality), stormwater collection and sanitary sewer systems, and detention basins. Graded on A-F basis only.
Credit Hours: 3
Prerequisites: CV_ENG 3700 or equivalent

CV_ENG 4740: Irrigation and Drainage Engineering
(same as BIOL_EN 4250; cross-leveled with CV_ENG 7740). Soil, water, plant relationships. Water supplies and design of surface, sprinkler and drip irrigation systems. Surface and tile drainage.
Credit Hours: 3
Prerequisites: CV_ENG 3700 or MAE 3400 or BIOL_EN 2180

CV_ENG 4980: Civil Engineering Systems Design
Design of civil engineering systems.
Credit Hours: 3
Prerequisites: senior standing in Civil Engineering at the University of Missouri-Columbia or written consent of Chairman

CV_ENG 4980W: Civil Engineering Systems Design - Writing Intensive
Design of civil engineering systems.
Credit Hours: 3
Prerequisites: senior standing in Civil Engineering at the University of Missouri-Columbia or written consent of Chairman

CV_ENG 4990: Undergraduate Research in Civil and Environmental Engineering
Independent investigation or project in Civil Engineering. May be repeated to 6 hours. Enrollment limited to seniors in Civil and Environmental Engineering.
Credit Hour: 1-4
Prerequisites: instructor's consent

CV_ENG 4995: Research in Civil and Environmental Engineering-Undergraduate Honors
Independent project, supervised by the honors advisor, to be presented as a formal written report.
Credit Hour: 1-3
Prerequisites: Civil Engineering students only
Recommended: participation in the Civil and Environmental Engineering Departmental Honors Program
### CV_ENG 7001: Topics in Civil Engineering
Study of current and new technical developments in civil engineering.

**Credit Hours:** 1-3  
**Prerequisites:** instructor's consent

### CV_ENG 7002: Analysis of Civil Engineering Decisions
Formulates and analyzes probabilistic models of civil engineering systems and their environment. Elementary theory of decision making under uncertainty. Application to selected civil engineering problems.

**Credit Hours:** 3

### CV_ENG 7003: Optimization of Civil Engineering Systems
Automated design techniques such as linear, nonlinear, and dynamic programming; gradient and random searching. Civil engineering applications emphasized throughout.

**Credit Hours:** 3

### CV_ENG 7004: Engineering Administration
Cash flow analysis, financial analysis, managerial accounting and cost control, budgeting, organizational structure and behavior.

**Credit Hours:** 3  
**Prerequisites:** MATH 1300 or MATH 1500, or instructor's consent

### CV_ENG 7006: Computational Methods in Civil Engineering
Use of numerical methods for solution of engineering problems involving roots of equations, simultaneous equations, curve fitting, integration, optimization, differentiation, and differential equations. The numerical methods are demonstrated through computer implementation and application to engineering design problems.

**Credit Hours:** 3  
**Prerequisites:** MATH 2300  
**Corequisites:** MATH 4100

### CV_ENG 7007: Quality Management in Civil Engineering
Quantitative and qualitative quality planning and analysis concepts, including statistical tools and total quality management techniques, control, measurement and assessment. Graded on A-F basis only.

**Credit Hours:** 3

### CV_ENG 7008: Risk and Reliability for Civil Engineers
This course focuses on how to use probability and statistics to quantify uncertainties and consider risks when making civil engineering decisions and designing civil engineering systems.

**Credit Hours:** 3  
**Prerequisites:** grade of C- or better in CV_ENG 3010 or other introductory probability/statistics course

### CV_ENG 7009: Advanced Surveying
Celestial observations for determination of position; state coordinate systems, precise surveys, introduction to geodetic surveys, principles of photogrammetry. Theory of optical surveying instruments.

**Credit Hours:** 3  
**Prerequisites:** MATH 1500

### CV_ENG 7010: Property Boundary Location
Principles of real property ownership, deeds, property boundary surveying, legal principles of original and retracement surveys Missouri statutes and regulations affecting surveying, GLO corner restoration and re-establishment.

**Credit Hours:** 3  
**Prerequisites:** ENGINR 1500 and CV_ENG 2090

### CV_ENG 7020: Traffic Engineering
(cross-leveled with CV_ENG 4100). Characteristics and studies associated with highway traffic. Capacity analysis and evaluation of freeways, rural highways, and urban streets. Traffic signal control and coordination.

**Credit Hours:** 3  
**Prerequisites:** grade of C- or better in CV_ENG 3100

### CV_ENG 7040: Pavement Materials and Design

**Credit Hours:** 3  
**Prerequisites:** grade of C- or better in ENGINR 2200

### CV_ENG 7060: Asphalt Materials and Mixture Design
(cross-leveled with CV_ENG 4105). This course consists of a combination of interactive classroom lectures and discussions, group activities, hands-on laboratory exercises, laboratory demonstrations, and field trips (live and/or recorded) to observe asphalt binder and mixture design, production, and control. Upon completion of the course, the student will be able to: (1) select, specify, and design an asphalt paving mixture for specific climatic and traffic conditions using the SUPERPAVE mixture design system; (2) understand the sources, types, and manufacturing aspects of asphalt binders and aggregates; (3) understand the key elements of asphalt mixture construction, process control, and acceptance; (4) perform key SUPERPAVE laboratory tests for asphalt binders, aggregates, and mixtures and master the analysis and interpretation of data collected; (5) understand contemporary concepts and approaches in sustainable asphalt mixture design and construction; (6) understand and mathematically describe fundamental properties of asphalt binders and mixtures, which is a critical step in mastering mixture/pavement design, evaluation, and rehabilitation, and; (7) understand and describe the key types and uses of special asphalt binder and mixture products, including emulsions, cutbacks, polymer-modified binders, warm-mix asphalt, other additives, and mixtures containing recycled asphalt pavement (RAP) and recycled asphalt shingles (RAS). Graded on A-F only.

**Credit Hours:** 3  
**Prerequisites or Corequisites:** CV_ENG 3600

### CV_ENG 7080: Advanced Surveying
(cross-leveled with CV_ENG 4080). This is an introductory course in Intelligent Transportation Systems (ITS). Topics include the
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theory of transportation networks and systems optimization, current implementations of ITS, and its practical issues and implications of ITS.

Credit Hours: 3
Prerequisites: grade of C- or better in CV_ENG 3100

CV_ENG 7109: Urban Development and Planning
Introduction to planning processes; procedures and forces that shape urbanization.

Credit Hours: 3

CV_ENG 7110: Transportation Simulation
(cross-leveled with CV_ENG 7110). Theory and application of simulation in transportation engineering.

Credit Hours: 3
Prerequisites: C- or better in CV_ENG 3100

CV_ENG 7120: Airport Engineering
(cross-leveled with CV_ENG 4120). Airport systems planning, design, and management.

Credit Hours: 3
Prerequisites: grade of C- or better in CV_ENG 3100

CV_ENG 7125: Transportation Legal Issues
(cross-leveled with CV_ENG 4125). This course discusses some of the legal issues that transportation engineers encounter throughout the course of their careers.

Credit Hours: 3
Prerequisites: CV_ENG 3100

CV_ENG 7130: Transportation Safety
(cross-leveled with CV_ENG 4130). This course is an introduction to transportation safety. The focus will be on surface transportation. The student is expected to analyze safety data and to devise engineering solutions to safety problems.

Credit Hours: 3
Prerequisites: CV_ENG 3100

CV_ENG 7145: Civil and Environmental Engineering Legal Issues
(cross-leveled with CV_ENG 4125). Discussion of legal issues facing civil engineers including right of way, risk and liability, environment, financing public works, contracting and ethics.

Credit Hours: 3
Prerequisites: CV_ENG 3100

CV_ENG 7155: Transportation Geography
(same as GEOG 7850; cross-leveled with CV_ENG 4155, GEOG 4850). Introduction to fundamental concepts and modes of analysis in transportation geography. Focus on descriptive, explanatory, as well as normative approaches. Topics reviewed include spatial organization, transportation economics, spatial interaction, network analysis, location/allocation, and urban transportation planning.

Credit Hours: 3

CV_ENG 7165: Geographic Information Systems I
Introduces concepts of computer analysis of geographic data and emphasizes the techniques for handling geographic data. Application of computer-based GIS systems in coursework.

Credit Hours: 3
Prerequisites: instructor's consent; GEOG 2840

CV_ENG 7175: The Geospatial Sciences in National Security
(Same as GEOG 7130; cross-leveled with CV_ENG 4175, GEOG 4130). This course explores the critical contribution of the geospatial sciences in the collection, processing, visualization and analysis of geospatial information related to national security. May be repeated for credit.

Credit Hours: 3
Prerequisites: instructor's consent

CV_ENG 7185: Location Analysis/Site Selection
(same as GEOG 7740; cross-leveled with CV_ENG 4185, GEOG 4740). An overview of location analysis in regional planning and spatial decision support, this course focuses on the use of Geographic Information Science (GIS) and location analysis methods in addressing regional service needs. May be repeated for credit.

Credit Hours: 3

CV_ENG 7190: Infrastructure Project Development
(cross-leveled with CV_ENG 4190). Students will learn how the key elements of major civil engineering infrastructure projects fit together. The course will focus on the horizontal integration of: financing - planning - environment - right of way - design - construction - operations - maintenance. Engineering is important but so are a lot of other things. Graded on A-F basis only.

Credit Hours: 3

CV_ENG 7200: Remote Sensing of the Environment
(cross-leveled with CV_ENG 4200). Principles, characteristics and applications of remote sensing in engineering, geosciences, agriculture and environmental projects. Topics: basic concepts, photographic, thermal multispectral and microwave systems, satellite remote sensing and digital image processing.

Credit Hours: 3

CV_ENG 7220: Hazardous Waste Management
(same as CH_ENG 7220; cross-leveled with CV_ENG 4220, CH_ENG 4220). Engineering principles involved in handling, collection, transportation, processing and disposal of hazardous wastes, waste minimization, legislation on hazardous wastes and groundwater contamination.

Credit Hours: 3

CV_ENG 7230: Introduction to Water Quality
(cross-leveled with CV_ENG 4230). Methods for determining and characterizing water quality, effects of pollution on streams and lakes, and an introduction to engineered systems for the distribution, collection and treatment of water and wastewater.

Credit Hours: 3
**CV_ENG 7232: Water and Wastewater Treatment Facilities**
(cross-leveled with CV_ENG 4232). Physical, chemical, and biochemical processes for treating drinking water supplies and wastewaters (domestic and industrial), with emphasis on planning and design of such facilities.

**Credit Hours:** 3  
**Prerequisites:** CV_ENG 4230 or CV_ENG 7230 or instructor's consent

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**CV_ENG 7240: Water Quality Analysis**
(cross-leveled with CV_ENG 4240). Chemical, physical and biological methods for analysis of streams, lakes, wastewaters and water supplies and their use in water quality management.

**Credit Hours:** 3  
**Prerequisites:** C- or better in CV_ENG 4230 or instructor's consent

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**CV_ENG 7245: Environmental Chemistry for Engineers**
(cross-leveled with CV_ENG 4245). This course will cover the fundamentals of environmental chemistry. Physical, equilibrium, organic and colloid chemistry topics will be presented from an environmental perspective with a focus on their relevant engineering applications. Graded on A-F basis only.

**Credit Hours:** 3

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**CV_ENG 7250: Environmental Regulatory Compliance**
(cross-leveled with CV_ENG 4250). Systems of water law; provisions of major federal environmental laws and regulations; development or regulations at the federal, state, and local levels; regulatory frameworks; permits; and enforcement.

**Credit Hours:** 3

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**CV_ENG 7260: Environmental Public Policy**
(cross-leveled with CV_ENG 4260). Engineering and economic aspects of environmental policy. Basic understanding of environmental statutes and case law. Graded on A-F basis.

**Credit Hours:** 3

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**CV_ENG 7270: Environmental Engineering Microbiology**
(cross-leveled with CV_ENG 4270). Theory and application of fundamental principles of microbiology, ecology, and aquatic biology of the microorganisms of importance to sanitary engineers.

**Credit Hours:** 3

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**CV_ENG 7286: Environmental Sustainability**
(cross-leveled with CV_ENG 4286). This course will present an introduction to sustainability in engineering, tools for assessing sustainability and principles of sustainable design practices. Topics include climate change, energy and renewable resources, limits to growth, risk assessment, life cycle assessments, water and energy footprints, green buildings, and the water-food-energy-nexus. Graded on A-F basis only.

**Credit Hours:** 3  
**Prerequisites:** CV_ENG 3200

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**CV_ENG 7290: Wastewater Treatment and Process Design**
(cross-leveled with CV_ENG 4290). Selection and use of wastewater and sludge treatment processes, disposal methods, leading to rational design of overall wastewater treatment systems. Sustainable wastewater treatment including advanced processes in nutrient removal, anaerobic treatment for wastewater reuse. Graded on A-F basis only.

**Credit Hours:** 3

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**CV_ENG 7300: Advanced Structural Steel Design**
(cross-leveled with CV_ENG 4300). Design of steel structures and bridges. Topics include composite beams, plate girder design, and moment resistant connections.

**Credit Hours:** 3  
**Prerequisites:** grade of C- or better in CV_ENG 3313

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**CV_ENG 7302: Prestressed/Advanced Reinforced Concrete**

**Credit Hours:** 3  
**Corequisites:** CV_ENG 3312

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**CV_ENG 7310: Structural Design and Analysis**

**Credit Hours:** 3  
**Prerequisites:** grade of C- or better in CV_ENG 4300

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**CV_ENG 7320: Energy Methods in Mechanics**
(cross-leveled with CV_ENG 4320). Variational mechanics including practical examples. Topics include calculus of variation of boundary value problems, energy methods such as Ritz and Galerkin methods, approximate solutions methods such as the finite element and finite difference, and eigenvalue problems.

**Credit Hours:** 3

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**CV_ENG 7330: Structural System Design**
(cross-leveled with CV_ENG 4330). Design of buildings in steel and reinforced concrete, including estimation of loads and design of gravity and lateral force resisting systems.

**Credit Hours:** 3  
**Prerequisites:** grade of C- or better in CV_ENG 3312 and CV_ENG 3313

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**CV_ENG 7350: Matrix Methods of Structural Analysis**
(cross-leveled with CV_ENG 4350). An introduction to the fundamentals of stiffness and flexibility methods for analysis of truss and frame structures. Application of the STRUDL and NASTRAN programs to three dimensional structures.

**Credit Hours:** 3  
**Prerequisites:** grade of C- or better in CV_ENG 3300
CV_ENG 7360: Bridge Engineering

Credit Hours: 3
Prerequisites: Grade of C- or better in CV_ENG 3312 and CV_ENG 3313

CV_ENG 7404: Geotechnical Earthquake Engineering
(cross-leveled with CV_ENG 4404). This course will provide an introduction to topics relating to geotechnical aspects of earthquake engineering. Topics to be covered include: basic seismology, seismic hazard analysis, dynamic soil properties, site response analysis and soil properties, site response analysis and soil liquefaction. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: Grade of C- or better in CV_ENG 3400 or instructor's consent

CV_ENG 7410: Foundation Engineering
(cross-leveled with CV_ENG 4410). Subsurface exploration. Design of basic foundation structures: shallow foundations, retaining walls, deep foundations.

Credit Hours: 3
Prerequisites: Grade of C- or better in CV_ENG 3400

CV_ENG 7412: Applied Geotechnical Engineering
(cross-leveled with CV_ENG 4412). Study of concepts, theories, and design procedures for modern earthwork engineering including: compaction and densification of soils and soil improvement, seepage and drainage, slope stability and performance, and earth retaining structures.

Credit Hours: 3
Prerequisites: grade or C- or better in CV_ENG 3400

CV_ENG 7500: Introduction to Construction Management
(cross-leveled with CV_ENG 4500). Structure of the construction industry; construction drawings and specifications; estimating and bidding; construction contracts, bonds and insurance; planning and scheduling of construction operations; project management; computer techniques.

Credit Hours: 3

CV_ENG 7510: Construction Methods and Equipment
Selection and use of construction equipment, planning construction operations, equipment economics and operations analyses.

Credit Hours: 3
Prerequisites: MATH 1300 or MATH 1500, or instructor's consent

CV_ENG 7600: Advanced Mechanics of Materials
(same as MAE 7600; cross-leveled with CV_ENG 4600 and MAE 4600). Analysis of more complicated problems in stresses, strains.

Credit Hours: 3
Prerequisites: C- or better in ENGINR 2200, MAE 3200

CV_ENG 7610: Sensors and Experimental Stress Analysis
(cross-leveled with CV_ENG 4610). Sensors and instrumentation for stress analysis, mechanical measurement and health monitoring of civil structures. Application and design of data acquisition systems, digital signals and basic digital signal processing. Electronics and instrumentation circuits.

Credit Hours: 3
Prerequisites: Grade of C- or better in ENGINR 2200 and PHYSCS 2760

CV_ENG 7660: Vibration Analysis
(same as MAE 7660; cross-leveled with CV_ENG 4660, MAE 4660). Vibration theory with application to mechanical systems.

Credit Hours: 3
Prerequisites: C- or better in MATH 4100 and MAE 2600

CV_ENG 7700: Hydraulics of Open Channels
Gradually varied flow and theory of the hydraulic jump. Slowly varied flow involving storage; rating curves.

Credit Hours: 3
Prerequisites: Graduate standing and Grade of C- or better in CV_ENG 3400

CV_ENG 7702: Pipeline Engineering
Theoretical and practical aspects of pipeline engineering including pipeline transport of natural gas and various solids such as coal, sand and solid wastes.

Credit Hours: 3
Prerequisites: CV_ENG 3700 and MAE 3400

CV_ENG 7703: Applied Hydrology
Modern methods of applied hydrologic analysis and synthesis of hydrologic records.

Credit Hours: 3
Prerequisites: grade of C- or better in CV_ENG 3700 and CV_ENG 3702, or instructor's consent

CV_ENG 7710: Soil and Water Conservation Engineering
(same as BIOL_EN 7150; cross-leveled with CV_ENG 4710, BIOL_EN 4150). Urban and rural run-off and erosion analysis. Design and layout of erosion control structures.

Credit Hours: 3
Prerequisites: BIOL_EN 3200 or CV_ENG 3200 or instructor's consent
CV_ENG 7720: Watershed Modeling Using GIS
(same as BIOL_EN 7350). Watershed evaluation using AVSWAT for hydrology, sediment yield, water quality; includes USLE, MUSLE, WEPP. Procedures for model calibration/sensitivity data analysis.

Credit Hours: 3
Prerequisites: BIOL_EN 2180 or CV_ENG 3200 or instructor's consent

CV_ENG 7730: Hydraulic Design
(cross-leveled with CV_ENG 4730). Design of hydraulic infrastructure utilizing principles of both pressure conduits and open channels. Hand calculations and use of commercial design software for water distribution (quantity and quality), stormwater collection and sanitary sewer systems, and detention basins. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: CV_ENG 3700 or equivalent

CV_ENG 7740: Irrigation and Drainage Engineering
(same as BIOL_EN 7250; cross-leveled with CV_ENG 4740). Soil, water, plant relationships. Water supplies and design of surface, sprinkler and drip irrigation systems. Surface and tile drainage.

Credit Hours: 3
Prerequisites: CV_ENG 3700 or MAE 3400 or BIOL_EN 2180

CV_ENG 7792: Analysis of Water-Resource Systems
(cross-leveled with CV_ENG 4792). Applies hydrology, hydraulic and sanitary engineering, and economics to water-resource design problems considering man and his environment. Uses methods of systems analysis.

Credit Hours: 3
Prerequisites: instructor's consent

CV_ENG 8001: Advanced Topics in Civil Engineering
New and current technical developments in civil engineering.

Credit Hour: 1-3
Prerequisites: CV_ENG 4006 or equivalent

CV_ENG 8002: Directed Reading In Civil Engineering
Faculty supervised readings course.

Credit Hour: 1-3

CV_ENG 8085: Problems in Civil Engineering
Supervised investigation in civil engineering to be presented in the form of a report.

Credit Hour: 1-6

CV_ENG 8100: Transportation Planning and Models
Regional and metropolitan transportation studies; land use, traffic generation, distribution and assignment models.

Credit Hours: 3
Prerequisites: CV_ENG 4002 or CV_ENG 4003

CV_ENG 8106: Advanced Intelligent Transportation Systems
This course is intended to be an introductory course in Intelligent Transportation Systems (ITS). This course includes the background of ITS, current implementations, sample deployments, and practical issues and implications.

Credit Hours: 3

CV_ENG 8110: Theory of Traffic Flow
Scientific approach to study of traffic phenomena with emphasis on applications. Deterministic and stochastic models of traffic flow; optimization of intersection controls; computer simulation of traffic problems.

Credit Hours: 3
Prerequisites: CV_ENG 4002 or instructor's consent

CV_ENG 8140: Highway Transportation
Economics of transportation on highways. Comparison of vehicle operation costs. Project studies of highway problems in general.

Credit Hours: 3
Prerequisites: CV_ENG 4103 or equivalent

CV_ENG 8150: Transportation Networks
This course presents techniques used in equilibrium analysis of transportation networks. The details of traffic assignment algorithms will be discussed along with theory and practical algorithms.

Credit Hours: 3

CV_ENG 8160: Advanced Research Methods in Transportation Engineering
This course will cover advanced research methods used in transportation. A special focus will be on the state-of-art approaches in traffic engineering. Mathematical and analytical models will be reviewed in detail. This is a reading intensive course where students are expected to review research articles on various topics. The methods used in the articles and a critical review of the article findings will be discussed in an interactive manner in the class. Graded on A-F basis only.

Credit Hours: 3

CV_ENG 8187: Seminar in Transportation Engineering
Review of research in progress in the area of transportation engineering.

Credit Hour: 1

CV_ENG 8200: Water Quality Modeling
Derivation and application of models for describing oxygen budget, nutrient exchange, and biological productivity in streams, lakes and estuaries.

Credit Hours: 3
Prerequisites: CV_ENG 7230
CV_ENG 8215: Environmental Transport Phenomena
Fundamental processes that control the transport of constituents substances in fluids, and the implications of these processes for a variety of important applications in natural and engineered systems.
Credit Hours: 3

CV_ENG 8220: Advanced Hazardous Waste Treatment Processes
Course includes some introductory materials about hazardous waste regulations followed by advanced treatment methods such as air stripping, soil-vapor extraction, chemical oxidation, membrane processes, in-situ and ex-situ biotreatment methods, solidification and thermal processes.
Credit Hours: 3
Prerequisites: CV_ENG 4220

CV_ENG 8225: Aquatic Chemistry
Principles of chemical thermodynamics and equilibrium applied to processes in natural water and water and wastewater treatment systems. Emphasis on quantitative analyses of acid/base, complexation/dissociation, precipitation/dissolution, and reduction/oxidation reactions. Graded on A-F basis only.
Credit Hours: 3

CV_ENG 8230: Unit Process Laboratory
Studies chemical and physical relationships as applied to unit processes of water and wastewater.
Credit Hours: 3

CV_ENG 8240: Physiochemical Treatment Processes
Fundamental principles, analysis and modeling of physical and chemical processes for water and wastewater treatment.
Credit Hours: 3

CV_ENG 8245: Particles in the Environment
This course is an introduction to interfacial and colloid science, with an emphasis on aqueous systems of natural colloids and engineered nanomaterials. Graded on A-F basis only.
Credit Hours: 3

CV_ENG 8250: Biochemical Treatment Processes
Biochemical principles, kinetic models and energy considerations in the design of biological wastewater treatment processes.
Credit Hours: 3

CV_ENG 8250: Environmental Biotechnology
Major biochemical reactions relevant to environmental engineering. Theory and application of fundamental principles of attached and suspended microbial growth and process engineering for sanitary engineering and biodegradation.
Credit Hours: 3
Prerequisites: CV_ENG 8250 or instructor's consent

CV_ENG 8270: Design of Water and Wastewater Treatment Facilities
Development of design criteria and their application to the design of water and wastewater treatment facilities.
Credit Hours: 3

CV_ENG 8287: Seminar in Environmental Engineering
Review of research in progress in the area of environmental engineering.
Credit Hour: 1

CV_ENG 8295: Environmental Regulatory Policy
Discussion of the various policy aspects of environmental regulation: economic and non-economic impacts of degradation; risk assessment and management; distribution of environmental risks; regulatory tools; federal vs. state; disclosure; enforcement. Relation to environmental laws. Graded on A-F basis only.
Credit Hours: 3
Prerequisites: CV_ENG 4250 or CV_ENG 7250 or equivalent

CV_ENG 8312: Advanced Structural Analysis
Credit Hours: 3

CV_ENG 8320: Continuum Mechanics
(same as MAE 8320). Introductory course in the mechanics of continuous media. Basic concepts of stress, strain, constitutive relationships; conservation laws are treated using Cartesian tensor notation. Examples from both solid and fluid mechanics investigated.
Credit Hours: 3
Prerequisites: CV_ENG 3700, MATH 7100, ENGINR 2200
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Description</th>
<th>Credit Hours</th>
<th>Prerequisites</th>
</tr>
</thead>
<tbody>
<tr>
<td>CV_ENG 8340: Theory of Plates and Shells</td>
<td>(same as MAE 8340). Rectangular and circular plates. Variational methods in the analysis of plates and shells. Plates of unusual shape. Shear deformation effects. Large deformation analysis. Analysis of cylindrical shells.</td>
<td>3</td>
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<tr>
<td>CV_ENG 8342: Space Mechanics</td>
<td>Rigid body dynamics analysis of satellites, space vehicles. Trajectories, time of flight optimization.</td>
<td>3</td>
<td>MAE 3600 or equivalent, and MATH 4100</td>
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<tr>
<td>CV_ENG 8360: Theory of Plasticity</td>
<td>(same as MAE 8360). Plastic yield conditions and stress-strain relations. Behavior of elastic-perfectly plastic members. Plain strain in plastic members.</td>
<td>3</td>
<td>CV_ENG 8330 or instructor's consent</td>
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</tr>
<tr>
<td>CV_ENG 8372: Reinforced Concrete Theory and Design</td>
<td>Advanced design of reinforced concrete structures; review of standard codes and specifications and their influence.</td>
<td>3</td>
<td>CV_ENG 4350 or equivalent</td>
<td></td>
</tr>
<tr>
<td>CV_ENG 8380: Nonlinear Mechanical Analysis</td>
<td>Analysis of behavior of nonlinear mechanical systems. Nonlinear phenomena of importance in mechanical design.</td>
<td>3</td>
<td>MAE 3600 or equivalent and MATH 4100</td>
<td></td>
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<tr>
<td>CV_ENG 8387: Seminar in Structural Engineering</td>
<td>Review of research in progress in the area of structural engineering.</td>
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<tr>
<td>CV_ENG 8392: Dynamics of Structures</td>
<td>(same as MAE 8392). Study of the dynamic behavior of structures. Analysis of equivalent lumped parameter systems for the design of structures in a dynamic environment.</td>
<td>3</td>
<td>MAE 2600 and MATH 4100 or MATH 7100</td>
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<tr>
<td>CV_ENG 8402: Advanced Shear Strength of Soils</td>
<td>Theoretical soil mechanics as applied to solution of specific engineering problems.</td>
<td>3</td>
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<tr>
<td>CV_ENG 8403: Consolidation and Settlement</td>
<td>Settlement of soil. Theory of Consolidation, consolidation testing, settlements of earth fills and embankments, stress distribution in soils, elastic settlement, bearing capacity of shallow foundations, shallow foundations design.</td>
<td>3</td>
<td>CV_ENG 3400</td>
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</tr>
<tr>
<td>CV_ENG 8404: Seepage in Soils</td>
<td>General principles that govern flow of water through soils and specific procedures for analysis and design of filtration and drainage media in geotechnical and geoenvironmental applications.</td>
<td>3</td>
<td>CV_ENG 3400 or instructor's consent</td>
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<tr>
<td>CV_ENG 8407: Soil Behavior</td>
<td>Detailed study of composition, fabric, and geotechnical and hydrologic properties of soils that consist partly or wholly of clay. Emphasizes physico-chemical factors governing volume change and shear strength. Expansive clay behavior is examined in detail.</td>
<td>3</td>
<td>CV_ENG 3400 and instructor's consent</td>
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</tr>
<tr>
<td>CV_ENG 8408: Soil Dynamics</td>
<td>Cover topics relating to the response of soils to dynamic loading. Topics to be covered include: lab and field methods, cyclic soil models, foundation vibrations, and wave propagation through soil. Graded on A-F basis only.</td>
<td>3</td>
<td>CV_ENG 3400 and instructor's consent</td>
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</tr>
<tr>
<td>CV_ENG 8410: Advanced Foundation Engineering</td>
<td>Foundation design beyond simple spread footings, special footings and beams on an elastic foundations, mat foundations, pile foundations -</td>
<td>3</td>
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<td></td>
</tr>
</tbody>
</table>
Civil Engineering (CV_ENG)

static capacity, lateral loads, buckling, dynamic analysis load tests, pile groups, drilled piers.

Credit Hours: 3
Prerequisites: CV_ENG 4410

CV_ENG 8412: Stability and Performance of Earth Slopes
Principles, mechanics and procedures for analyzing the stability of earth slopes and landfills under short-term, long-term, rapid drawdown, and earthquake conditions.

Credit Hours: 3
Prerequisites: CV_ENG 3400 or instructor's consent

CV_ENG 8413: Design and Analysis of Earth Retaining Structures
General principals and specific procedures for analysis and design of earth retention systems including consideration of soil-structure interaction.

Credit Hours: 3
Prerequisites: CV_ENG 3400 or instructor's consent

CV_ENG 8487: Seminar in Geotechnical Engineering
Review of research in progress in the area of geotechnical engineering.

Credit Hour: 1

CV_ENG 8610: Materials and Measurement
About 25% of the course is devoted to the physical measurement of strain, force, displacement and motion. Remainder of course is devoted to advanced study of the behavior of steel and concrete with emphasis on brittle fracture in steel.

Credit Hours: 3
Prerequisites: CV_ENG 3600 or equivalent

CV_ENG 8620: Advanced Dynamics
(same as MAE 8620). Fundamental principles of advanced rigid body dynamics with applications. Special mathematical techniques including Lagrangian and Hamiltonian methods.

Credit Hours: 3
Prerequisites: CV_ENG 2080 and MATH 4100

CV_ENG 8630: Vibrations of Distributed Parameter Systems
(same as MAE 8630). Vibration analysis of strings, cables, bars, rods, shafts, beams, membranes, plates, circular rings, frames; free and forced oscillation; miscellaneous loading; various boundary conditions; effect of damping; energy methods; method of difference equations.

Credit Hours: 3
Prerequisites: CV_ENG 4660

CV_ENG 8720: Hydrotechnical Practicum
Application of advanced analysis and design techniques to practical problems in hydrotechnical engineering. Collaborative group investigations that may include experimental and computer aided studies. No more than 6 practicum hours may be applied toward the MS degree. Graded on A-F basis only.

Credit Hour: 2-4
Prerequisites: graduate standing in Civil Engineering

CV_ENG 8990: Research-Masters Thesis in Civil & Environmental Engineering
Independent investigation in the field of civil engineering to be presented in the form of a thesis. Graded on a S/U basis only.

Credit Hour: 1-99

CV_ENG 9990: Research-Doctoral Dissertation Civil & Environmental Engineering
Independent investigation in the field of civil engineering to be presented in the form of a thesis. Graded on a S/U basis only.

Credit Hour: 1-99