CIVIL AND ARCHITECTURAL ENGR (CAE)

CAE 502
Acoustics and Lighting
General introduction to the aural and visual environment. Subjective and objective scales of measurement. Laws of psychophysics. Introduction to vibration. The hearing mechanism. Transfer of sound. Passive control of noise in buildings, transmission loss. Absorption and reverberation time. Active control of the aural environment. Visual perception. Photometry, brightness, luminance and illumination. Natural lighting of buildings. Artificial lighting.
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 503
Advanced Structural Analysis
Introduction to the mechanics of solids. Energy methods and the calculus of variations. Ritz/Galerkin approximation methods. Introductory discussions on elastic stability and plate analyses.
Prerequisite(s): CAE 411 with min. grade of C or MMAE 501* with min. grade of C or CAE 514* with min. grade of C or Graduate standing, An asterisk (*) designates a course which may be taken concurrently.
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 504
Seismic Retrofit and Earthquake Hazard Reduction
Selection of site-dependent earthquake for retrofit. Strength and ductility of aging structures. Cyclic behavior and modeling of structures under seismic loading. Performance-based retrofit criteria. Evaluating earthquake vulnerability of existing buildings and bridges. Upgrading lateral load-carrying systems. Conceptual basis for seismic isolation and energy-absorbing techniques and their applications in earthquake hazard reduction in existing bridges and buildings. Selection of retrofit methods. Case studies of seismic retrofit of typical buildings, bridges, and industrial facilities using strength upgrading, energy dissipation devices, and base isolation.
Prerequisite(s): CAE 529 with min. grade of C
Lecture: 4 **Lab:** 0 **Credits:** 4

CAE 505
Applications of Computational Fluid Dynamics in Engineering
The course introduces concepts of computational fluid dynamics (CFD) and focuses on engineering applications of CFD. Students will learn how to use CFD tools to model internal and external flows in a wide range of architectural, chemical, civil, and mechanical engineering applications. Projects offer students flexibility in selecting their applications. Example semester long projects include design of room air distribution systems, indoor and outdoor air quality, natural ventilation, heat transfer coefficient calculations, pipe flow, rotating reference frame, and more.
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 506
Building Envelope Rehabilitation
Repair and rehabilitation of existing building exterior envelopes. The course will include problem identification, investigative techniques, repair methods, preparation of remedial design documents and general management of rehabilitation projects. Types of constructions include buildings, exterior walls, facades, cladding, roofing, plazas, porches, fire escapes, and others.
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 508
Advanced Bridge Engineering
Specifications for bridge design and evaluation. Advanced bridge design and evaluation topics such as design load envelope, seismic load design, bridge condition rating, bridge load rating, and steel bridge fatigue evaluation. Bridge management systems. Life cycle analyses. Use of high performance materials in bridge engineering.
Prerequisite(s): CAE 408 with min. grade of C or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 510
Dynamics of Fire
Introduction to fire, physics and chemistry, and mass and heat transfer principles, fire fluid mechanic fundamentals, fundamentals and requirements of the burning of materials (gases, liquids, & solids), fire phenomena in enclosures such as pre-flashover and post-flashover.
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 511
Fire Protection of Buildings
Fundamentals of building design for fire and life safety. Emphasis on a systematic design approach. Basic considerations of building codes, fire loading, fire resistance, exit design, protective systems & other fire protection systems. For architects, and engineers not majoring in fire protection and safety engineering.
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 513
Building Science
Study of the physical interactions between buildings, people, and climate (i.e., temperature, humidity, wind, sun, rain, snow, etc.). Topics include: heat transfer, psychrometrics, thermal comfort, indoor air quality, ventilation, infiltration, solar insolation, heating and cooling load calculations, building energy efficiency, and building codes.
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 514
Mathematical Methods for Structural Engineering
Matrices, linear spaces and transformations, eigenvalue problems, and their application to civil engineering. First-order differential equations for structural dynamics. Calculus of variations and variational principles for dynamics and statics. Rayleigh-Ritz method, finite element approximations, Newmark-Beta method, Green's Function, and Duhamel Integral and their application to civil engineering.
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 515
Building Information Modeling Applications for Building Performance
Building Information Modeling (BIM) is at the core of building performance optimization and sustainability, making it possible to model performance while tracking construction of the building in sequence. This course builds essential knowledge of building performance optimization using BIM processes and provides the necessary background and skills to use BIM with building energy simulation software tools. Autodesk Revit with Insight will be used as the primary design authoring, manipulation, and analysis tool. Secondary Autodesk BIM tools such as Formit for building massing and orientation; recap for existing conditions capturing; Navisworks for interference checking and design collaboration; revit Live for Virtual Reality visualizations and presentations; and BIM 360 Ops for facility management and operation will also be used in class. Proven methods for using BIM to address essential building performance and sustainability issues will be presented using real-world examples, placing particular emphasis on using BIM for analysis of design alternatives for the life cycle of a building. Complete with coverage of sustainability, integrated design, and lean construction requirements, this is a valuable course for architects, architectural engineers, MEP engineers, facility managers, and other construction professionals involved in building performance modeling and optimization.
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 517
HVAC Systems Design
Study of the fundamental principles and engineering procedures for the design of heating, ventilating, and air conditioning systems; HVAC system characteristics; system and equipment selection; duct design and layout. Attention is given to energy conservation techniques and computer applications.
Prerequisite(s): CAE 331 or CAE 513
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 518
Advanced Reinforced Concrete
Advanced topics in behavior and mechanics of reinforced concrete members: ultimate flexural strength, development of reinforcement, moment-curvature analysis, non-linear deflections, two- way slabs, deep beams, torsion, columns with biaxial bending, slender columns, and numerical methods. Strong emphasis is placed on the underlying structural behavior and its influence on building codes and design standards.
Prerequisite(s): CAE 432* with min. grade of C or Graduate standing, An asterisk (*) designates a course which may be taken concurrently.
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 519
Structural Forensic Engineering
Introduction to structural forensic engineering as relates to civil and architectural engineering. Application of engineering principles to failure investigations including understanding the causes of failures, and safety issues at collapsed sites. Field investigations and data gathering including the use of sensor technology, sampling, and structural monitoring. Understanding the effects of the environment on the properties of common structural materials. Evaluation of distress conditions such as vibrations, cracks, metal fatigue, excessive deformation resulting from creep and inelasticity, thermal effects, fire damage, effects of extreme loading conditions, and localized failures. Preparation of forensic reports, presenting results of evaluations of failed structural systems and structural distress conditions, insurance/legal issues, responsibility of engineer and ethics issues. Review of case studies.
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 520
Buckling of Structures
Review of simple column buckling for various conditions. Basic considerations of stable and unstable equilibrium. Determination of buckling loads of columns with variable cross-section. Analysis of elastic stability of framed structures. Approximate solutions of more complicated problems by various numerical and energy methods. Analysis of lateral and torsional stability of beams and beam-columns. Stability in the inelastic range of columns. Buckling of plates and cylindrical shells.
Prerequisite(s): CAE 431 with min. grade of C and CAE 411 with min. grade of C
Lecture: 4 **Lab:** 0 **Credits:** 4

CAE 522
Structural Model Analysis
Theory of measurements, statistics, similitude, and model laws and the usefulness of structural models. Displacement and strain measurement techniques. Theory and practice of indirect model analysis. Theory and practice of direct model techniques including photo elasticity and Moire methods.
Prerequisite(s): CAE 503 with min. grade of C
Lecture: 2 **Lab:** 2 **Credits:** 4

CAE 523
Statistical Analysis of Engineering Data
Descriptive statistics and graphs, probability distribution, random sampling, independence, significance tests, design of experiments, regression, time series analysis, statistical process control, and introduction to multivariate analysis.
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 524
Building Enclosure Design
Design of building exteriors, including the control of heat flow, air and moisture penetration, building movements, and deterioration. Study of the principle of rain screen walls and of energy conserving designs. Analytical techniques and building codes are discussed through case studies and design projects.
Prerequisite(s): CAE 513 with min. grade of C
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 525
Advanced Steel Structures
Torsion and web openings. Behavior and design of rigid and semi rigid beam-to-column connections and base plates. Inelastic behavior of steel and composite members and systems under severe cyclic loading. Design of steel-concrete composite and hybrid systems. P-delta effect and design considerations for system stability. Design of special and ordinary moment- resisting frames. Design of concentrically and eccentrically braced frames. Design of bracing for stability. Plate girders. Fatigue and fracture.
Prerequisite(s): CAE 431* with min. grade of C or Graduate standing, An asterisk (*) designates a course which may be taken concurrently.
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 526
Energy Conservation in Buildings
Introduction to both theory and hands-on applications in building energy conservation and energy efficiency in buildings new and old. Analyzing energy consumption patterns in buildings. Understanding building rating systems and measures to design and operate energy efficient buildings. Use of building energy simulation tools to predict energy consumption of building energy end-uses. Calibration of building energy models. Energy retrofit strategies and parametric design. Visualize and analyze building performance data.
Prerequisite(s): CAE 331 or CAE 513
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 529
Dynamics of Structures
Fundamentals of free, forced, and transient undamped and viscously damped vibration of single and multi-degree of freedom structures. Time, frequency, and approximate methods of analysis. Application of numerical methods in time and frequency domain. Response spectra, modes, coupling and modal space. Response history and response spectrum analyses and an introduction to earthquake engineering.
Prerequisite(s): CAE 411 with min. grade of C or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 530
Finite Element Method of Analysis
Advanced and special topics in finite element analysis such as finite element-boundary element method, plates, and shell analysis using finite elements.
Prerequisite(s): CAE 411 with min. grade of C or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 532
Analysis of Plates and Shells
Exact and approximate stress analysis of elastic, isotropic plates of various shapes acted upon by forces in their plane, as well as transverse forces. Stability of plates with various edge conditions, orthotropic plates, elastically supported plates and simple cylinders. Approximate methods such as finite differences, finite elements and the methods of Ritz and Galerkin.
Prerequisite(s): CAE 503 with min. grade of C
Lecture: 4 **Lab:** 0 **Credits:** 4

CAE 533
Theory and Analysis of Thin Shells
Differential geometry of surfaces. Elastic theory of general shells with nonorthogonal curvilinear coordinates. Specialization to cylindrical shells, shells of revolution and translational shells. Exact and approximate solutions applied to the bending membrane theories of thin shells. Approximate methods including finite differences, finite elements and methods associated with Ritz, Galerkin, Puchler and Gaeckler.
Prerequisite(s): CAE 503 with min. grade of C
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 534
Computational Techniques in Finite Element Analysis
Survey of numerical methods as applied to FEM software. Database management, equation solvers, eigen value routines and schemes for direct integration (both implicit/explicit), all as employed in the development of a finite element program. Topics covered also include band and front minimizers, static and dynamic substructuring via super elements and sensitivity studies. Same as MAE 538.
Prerequisite(s): CAE 530* with min. grade of C or Graduate standing, An asterisk (*) designates a course which may be taken concurrently.
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 535
Nonlinear Finite Element Analysis
FEM as applied to nonlinear problems. Contact problems, the mechanics of large deformation, full and updated Lagrange formulations, review of plasticity, solution algorithms, Eulerian approaches, application to FEM to limit analysis. Same as MAE 539.
Prerequisite(s): CAE 442 with min. grade of C or MMAE 501 with min. grade of C or CAE 514 with min. grade of C
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 537
Homeland Security Concerns in Building Designs
Review of blast effects produced by solid phase weapons and their effects on structures and people. Estimation of the risk of a terrorist attack and the corresponding threat. Review of simplified methods for the analysis and design of structures to meet homeland security concerns and procedures to minimize casualties. Analysis of post event fires and how to prevent them. Review of security measures to minimize the effects of blast on buildings and people.
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 538
Control of Building Environmental Systems
Introduction to automatic control systems. Control issues related to energy conservation, indoor air quality and thermal comfort in buildings. Classification of HVAC control systems. Control systems hardware: selection & sizing of sensors, actuators & controllers. Practical HVAC control systems; elementary local loop and complete control systems. Case studies. Computer applications.
Prerequisite(s): CAE 331 or CAE 513 with min. grade of C or MMAE 322
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 539
Introduction to Geographic Information Systems
Geographic information system (GIS) technology allows users to combine tabular information with maps, creating powerful spatial databases which display and query information in new ways. This course will teach general GIS and GPS skills and concepts, useful to students and practitioners in a variety of disciplines. Students will complete a final GIS project relevant to their field of study. This hands-on class will use ESRI's ArcView and Spatial Analyst products, as well as Trimble GeoExplorer GPS units.
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 540
Asphalt and Concrete Mix Design
Types of asphalt and physical properties of asphalt. Types of mixes: dense graded, open graded, base courses, and maintenance mixes. Types of pavement structures and hot mix asphalt placement. Aggregate physical properties, tests, and blending. Maintenance and rehabilitation materials. Mixture design procedures, including Marshall and Hveem procedures, and weight-volume relationships. Evaluation of mixture properties, engineering property's importance to performance, resilient modulus, fatigue, and creep testing, and thermal cracking properties. Laboratory included.
Lecture: 2 **Lab:** 3 **Credits:** 3

CAE 541
Pavement Evaluation and Management
Pavement management systems (PMS) concepts, network definition, condition survey, pavement condition index (PCI), non-destructive deflection testing (NDT), measurement of roughness and skid resistance, micropaver PMS, PMS implementation, project and network-level management, maintenance alternatives, development of annual and long-range work plans.
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 543
Demand Models for Urban Transportation
Fundamental theory of supply and demand, transportation economics, network equilibrium, land use and transportation equilibrium. Demand models: trip generation, geographical distribution, mode split, route assignment, the direct-demand model and disaggregate-behavioral-demand models. Special properties of models. Relationships among models.
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 544
Urban Transportation Planning
Exploration of the goals of urban transportation. Program planning in relating transportation technology to social, economic, and environmental systems. Systems analysis in forecasting urban land use and travel demand and evaluating alternatives in transportation planning to reach a balance between demand and supply.
Lecture: 4 **Lab:** 0 **Credits:** 4

CAE 545
Traffic Operations and Flow Theory
Studies of space and time distribution of speed and other traffic characteristics in the transportation network. Macro, micro, and mesoscopic traffic flow theories. Simulation in traffic networks. Application of flow theories to traffic control and operations.
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 546
Public Transportation Systems
Operational and economic characteristics of urban systems. Transit planning process: demand for transit, transit routing, transit scheduling, network design. Improvements of existing systems and exploration of new technologies.
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 547
Advanced Traffic Engineering
Data collection, statistical analysis, and interpretation of traffic information. Advanced traffic engineering topics such as signaling, street-and-highway capacity analysis, and highway safety research.
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 548
Transportation Systems Management
Transportation as a system. Problems of traffic congestion, land use/transportation intersection; intersection control; freeway and arterial incident management; safety considerations; evaluation of strategies; case studies.
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 549
Transportation Economics, Development and Policy
Application of managerial, micro- and macroeconomic concepts to transportation systems. Investment and impact analysis. Transport policy as it relates to social, economic and environmental issues. Legislative actions affecting transport issues.
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 550
Applied Building Energy Modeling
This course introduces students to building energy modeling software and techniques that are widely used in industry applications. The course is practice-oriented and builds upon building energy modeling methods as they are practiced in engineering offices (using IES software). The course centers on the two most common types of energy models in practice: (1) models for LEED and code compliance, and (2) parametric models for evaluating energy conservation measures. During the first half of the course, students will learn modeling methods and assumptions to create an energy model of an actual building project for the LEED Energy and Atmosphere credit with all supporting documents required for LEED submission. In the second half of the course, students will learn to analyze energy conservation measures using parametric energy models. The course will also focus on advanced energy modeling topics, such as modeling HVAC systems and controls, passive techniques, composite fenestration, thermal bridges, thermal mass, and others. At the end of the course, students will have two complete energy models that they can use in their portfolio.
Prerequisite(s): CAE 331 or CAE 513
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 551
Prestressed Concrete
Fundamental behavior, mechanics, and design of prestressed concrete members and structures. Service loading, ultimate strength, computation of prestress losses, deformations, and precast concrete components. Exposure to relevant building code provisions, design standards, and industry recommended practice. The opportunity for students to compete in a prestressed concrete beam fabrication and design competition may also be offered.
Prerequisite(s): CAE 432
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 553
Measurement and Instrumentation in Architectural Engineering
Hands-on experience with energy and indoor environmental quality measurements in buildings including experimental design, data analysis, and experimental statistics. Measurements and techniques covered include: thermal performance (e.g., temperature, humidity, and heat flux); fluid flows and HVAC characteristics (e.g., velocity, pressure, and airflow rates); energy performance (e.g., current, voltage, and power draw); whole building diagnostics (e.g., envelope airtightness, ventilation performance, and duct leakage testing); and indoor air quality (e.g., tracer gas techniques, particle measurements, and gas measurements). Course combines lectures and field measurements in buildings on campus.
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 554
Building Commissioning
This course introduces students to the fundamentals and practice of building commissioning and prepares students for the Building Commissioning Professional (BCxP) Certification Exam. Building commissioning is an integrated process of quality assurance (QA), quality control (QC), and communications that is utilized to ensure that all of its systems, including mechanical, electrical, lighting, plumbing, fire protection, acoustical, and controls, perform interactively and according to the design intent. Building commissioning also ensures that building operators are prepared to operate and maintain its systems and equipment, which saves time, money, and energy, and improves the sustainability and resilience of buildings. This course is open to all majors with familiarity in buildings and their systems.
Prerequisite(s): CAE 331 or CAE 513
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 555
Transportation Systems Evaluation
Concepts and principles of transportation economic analysis, transportation costs and benefits, user and nonuser consequences, needs studies, finance and taxation, methods for evaluation of plans and projects, cost-efficiency, cost-effectiveness, environmental impact assessment, and economic development assessment.
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 556
Net Zero Energy Building Design I
An interdisciplinary project-based course in which students work in teams to design and provide full design documentation for a net zero energy building, meaning that it combines energy efficiency and renewable energy generation to consume only as much energy as can be produced onsite through renewable resources on an annual basis. Teams are expected to effectively and affordably integrate principles of building science, construction engineering and management, economic analysis, and architectural design in an integrated design process. Teams are required to submit full sets of plans, drawings, renderings, construction details, and analyses for energy efficiency, costs, affordability, environmental justice, equity, sustainability, and resiliency. The course aligns with a design competition, typically the Department of Energy's Solar Decathlon Design Challenge. The course prepares the next generation of architects, engineers, and construction managers with skills and expertise to start their careers and generate creative solutions for real-world net zero energy buildings. CAE 556 is the first course in a two-course series.
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 557
Net Zero Energy Building Design II
An interdisciplinary project-based course in which students work in teams to design and provide full design documentation for a net zero energy building, meaning that it combines energy efficiency and renewable energy generation to consume only as much energy as can be produced onsite through renewable resources on an annual basis. Teams are expected to effectively and affordably integrate principles of building science, construction engineering and management, economic analysis, and architectural design in an integrated design process. Teams are required to submit full sets of plans, drawings, renderings, construction details, and analyses for energy efficiency, costs, affordability, environmental justice, equity, sustainability, and resiliency. The course aligns with a design competition, typically the Department of Energy's Solar Decathlon Design Challenge. The course prepares the next generation of architects, engineers, and construction managers with skills and expertise to start their careers and generate creative solutions for real-world net zero energy buildings. CAE 557 is the second course in a two-course series.
Prerequisite(s): CAE 556 with min. grade of C
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 558
Urban Systems Engineering Design
CAE 558 is a project-based course where students will explore integrated designs of urban systems. Each project will apply the students' engineering disciplines (such as structures, transportation, building science, construction engineering and management, environmental engineering) in a comprehensive analysis that considers the economic, human, and environmental issues associated with the project.
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 559
Urban Systems Engineering Seminar
CAE 559 is an active seminar course that emphasizes current topics in urban systems engineering. Invited speakers will include researchers and representatives from current practice such as municipal and regional planners and consultants. Appropriate readings will be assigned in advance of each speaker to guide students in preparation for active discussion with each speaker. Each student will also write a term paper on an urban systems engineering tropic of their choice, connecting material from the assigned reading, the speakers, and additional references selected by the student.
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 560
Plastic Methods
Fundamental concepts of plasticity in the design of steel structures. Principle of plastic hinges. Upper and lower-bound theorems. Alternating plasticity and incremental collapse. Analysis and design of single story and multi-story framed structures.
Prerequisite(s): CAE 431* with min. grade of C and CAE 503* with min. grade of C, An asterisk (*) designates a course which may be taken concurrently.
Lecture: 4 **Lab:** 0 **Credits:** 4

CAE 561
Structural Reliability and Probabilistic Bases of Design
Fundamentals of probability theory and stochastic processes; statistical analysis of engineering data; probabilistic modeling of structural loads and material properties. Reliability analysis and design of structure, reliability-based design criteria. Evaluation of existing design codes. Safety analysis of structures under fatigue loads. Fault and event tree analysis.
Prerequisite(s): CAE 307 with min. grade of C or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 562
Engineering Behavior of Soil
Soil mineralogy and soil fabric, soil-water electrolyte system, dispersive clay, stress and strain analyses, elastic equilibrium in soil masses, plastic equilibrium in soil masses, in situ and laboratory stress paths, shear strength of sands and clays, thermal properties of soils, critical state soil mechanics principles, nonlinear pseudo elastic and elastoplastic constitutive models.
Lecture: 4 **Lab:** 0 **Credits:** 4

CAE 563
Advanced Soil Mechanics Laboratory
Advanced aspects of soil property measurement with application to design and analysis, system characteristics on soil sediment, pinhole test for identifying dispersive clays, consolidation, triaxial compression and triaxial extension with porewater measurement, cyclic triaxial test, permeability with back pressure, determination of critical void ratio.
Prerequisite(s): (CAE 323 with min. grade of C or Graduate standing) and CAE 562* with min. grade of C, An asterisk (*) designates a course which may be taken concurrently.
Lecture: 1 **Lab:** 3 **Credits:** 1

CAE 564
Design of Foundations, Embankments and Earth Structures
Consolidation phenomena, derivation of bearing capacity equations, beams and slabs on soils, piles and pile groups, compaction, earth pressure theories and pressure in embankment, slope stability analyses, retaining structures, embankment design, soil structure interaction during excavation, design of anchors for landslide stabilization and retaining structures and instrumentation.
Prerequisite(s): (CAE 323 with min. grade of C or Graduate standing) and CAE 457 with min. grade of C
Lecture: 4 **Lab:** 0 **Credits:** 4

CAE 565
Rock Mechanics and Tunneling
Rock classification for engineering purposes, mechanical behavior of rocks, in situ stresses in rock, stresses around underground openings, rock slope engineering, design of underground structures, design of deep support excavation and tunnels, primary and secondary linings of tunnels, mined shafts, instrumentation.
Prerequisite(s): CAE 457 with min. grade of C
Lecture: 4 **Lab:** 0 **Credits:** 4

CAE 566
Earthquake Engineering and Soil Dynamics
Earthquakes and their intensity, influence of group motion, review of I-DOF and M-DOF systems, wave propagation theories, vibration due to blast and shock waves, design earthquake motion, dynamic properties of soils, soil liquefaction, bearing capacity during earthquakes and design of machine foundations, isolation of foundations, pile foundation, and dynamic analysis, earth pressure during earthquakes on retaining structures and embankment.
Prerequisite(s): (CAE 323 with min. grade of C or Graduate standing) and CAE 420 with min. grade of C
Lecture: 4 **Lab:** 0 **Credits:** 4

CAE 568
Transportation Asset Management
Processes and techniques for managing the preservation and expansion of highway transportation facilities such as pavements, bridges, and traffic control and safety hardware; system usage concerning mobility, safety and security, energy consumption, and vehicle emissions; and economic development impacts. Five component management systems are first examined: pavements, bridges, traffic control and safety hardware, roadway maintenance, safety, and congestion. Finally, the methodology for overall transportation asset management is discussed. The primary emphasis is on data collection, database management, performance modeling, needs assessment, project evaluation, project selection, program development strategies, risk and uncertainty modeling, and institutional issues.
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 569
Construction Methods, Cost Estimating, and Project Budgeting
The role of program management and project budgeting in establishing a construction project, estimating in construction design and contract administration. Types of estimates, unit costs and production rates; job costs. Preparing bid for complete building project using manual methods and the CSI format; checking quantity take-off and cost estimating in selected divisions using a computer software package.
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 570
Legal Issues in Civil Engineering
This course introduces students to the legal aspects of engineering and construction, contract documents, and contract clauses. Upon completion of this course, students will be able to do the following: (1) identify the elements of contract formation; (2) interpret contract clauses; (3) explain the rights and duties of the parties involved in design and construction; and (4) evaluate changes and their root causes. Students will also be able to objectively identify and analyze legal liabilities and the expected professional standard of architects, engineers, and contractors.
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 571
Lean Construction and Control
This course introduces students to lean principles and the lean project delivery system (LPDS) applied to the construction industry. Lean construction and lean project delivery embrace concepts and techniques originally conceived in the automobile manufacturing industry and adopted by the construction industry. In the manufacturing sector, lean production has revolutionized product manufacturing, resulting in significant gains in plant productivity, reliability, and reductions in defects. Specific concepts that will be covered in this course include Plan-Do-Check-Act continuous improvement, A3 reporting, value stream mapping, pull systems and pull planning, kanban, 5S, standardization, and the Choosing by Advantages Decisionmaking System.
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 572
Construction Business Operations and Cost Accounting & Control
Teaches the company basics of preparing Design Proposals and Construction Bids. Explains the dual accounting systems of corporate accounting (GAP) and Earned Value (EV) accounting used in the construction industry. Review of basic accounting principles and techniques--purchasing, accounts payable, invoicing, accounts receivable, general ledger, payrolls and indirect costs. Job costing and budgeting. Recording and reporting procedures in construction projects--invoices, subcontractor applications for payment, labor time cards, unit completion reports, change orders. Cost coding systems for construction activities. Variance reporting procedures. Project closeout.
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 573
Construction Management with Building Information Modeling
Fundamentals and practical use of information technologies in the construction industry; basic concepts of building information modeling (BIM); review of software and technology available for BIM; practical use of BIM including design and clash detection; impact of BIM on construction management functions; construction scheduling and sequencing using BIM; cost estimating using BIM; facility management with BIM; integrated approach to navigate BIM as a multi-disciplinary design, analysis, construction, and facility management technology; class exercise to create a BIM model and to use it in scheduling, sequencing, cost estimating, management, and simulation of a construction project.
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 574
Economic Decision Analysis in Civil Engineering
Basic economic concepts including interest calculations, economic comparison of alternatives, replacement decisions, depreciation and depletion, tax considerations, and sensitivity analysis. Evaluation of public projects, the effect of inflation, decision making under risk and/or uncertainty, economic decision models. Case studies from the construction industry.
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 575
Systems Analysis in Civil Engineering
Management and system concepts, linear programming, graphical methods, Simplex, two-phase Simplex, the transportation problem, the assignment problem, integer programming, and sensitivity analysis. System modeling by activity networks; maximal-low flow, longest-path and shortest-path analyses, flow graphs, decision-tree analysis, stochastic-network modeling, queuing systems, and analysis of inventory systems. Case studies from the construction industry.
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 576
Applications of Unmanned Aerial Vehicles (UAVs or "Drones") for Construction Projects
This course will introduce knowledge on Unmanned Aerial Systems (UAS) for construction projects. UAS are systems, such as Unmanned Aerial Vehicles (UAVs) that require a level of autonomy with minimal or no intervention from project actors to navigate over job-site environments. Instruction and learning activities incorporate all steps of processing UAV information. Laboratory activities include the design of plans to collect, analyze, and draw conclusions from UAV data and the sharing of experimental results with peers and faculty. Students will have access to a university-provided UAV equipped with advanced software for image processing, high-definition video camera, data communication platforms, and positioning sensors to capture a physical environment and register telemetry data related to their projects.
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 577
Construction Equipment Management
Factors affecting the selection of construction equipment. Descriptions, operating methods, production rates, unit costs related to excavating equipment. Power shovels, draglines, clam shells, and trenching machines. Engineering fundamentals. Moving construction equipment, including trucks, wagons, scrapers, dozers, soil-stabilization and compaction equipment. Belt conveyors, compaction and drilling equipment, pile driving equipment, pumps and crushers.
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 578
Construction Claims Management
This course provides a basic explanation of construction contract claims by types such as delays, acceleration, and scope issues, the underlying legal theories of the contract construction and claims, elements required for each claims type defenses to the claim, prophylactic claims measures. The claims process within the contract and extra-contractual basis's for claims are examined. Resolution of claims by ADR techniques and the formal litigation process are explained. AIA, AGC, and federal claims provisions are described. In addition to construction contract claims other types of claims associated with construction projects are covered such as Surety bond claims and various insurance claims (CGL, Builder's Risk, workers comp, etc)
Prerequisite(s): CAE 473 with min. grade of C
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 579
Real Estate Fundamentals for Engineers and Architects
The objective of this course is to introduce civil engineering students to the real estate process. Students will learn techniques and methodologies for evaluating real estate investment opportunities using engineering economic analysis principles. Students will use Time Value of Money analysis for evaluating real estate transactions, including how to carry out calculations using formulas, financial calculators, and spreadsheets. This course will help civil engineering students learn financial skills that can be applied to professional and personal investment decisions.
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 580
Intelligent Transportation Systems
The concept of intelligent transportation systems (ITS) involves the use of rapidly emerging information and communication technologies in mitigating congestion and attendant problems. A substantial amount of research and development activities have taken place over the last few decades. This course will provide an introduction to the various aspects of ITS and will focus on ITS planning, technology, big data analysis, and evaluation. In addition, such topics as deployment, financing, and management are also discussed. The course will include guest lectures and possibly field visits.
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 581
Algorithms in Transportation
Modeling and analysis of transportation network problems through the design, analysis, and implementation of algorithms. Emphasis on the use of quantitative and qualitative methods of operations research to model system performance. Covers fundamental data structures, complexity analysis, memory management, recursive programs, application of graph theory, and network analysis to transportation problems, analytical formulations, and solution algorithms for origin-destination estimation, static and dynamic traffic assignments, and transportation resource allocation.
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 582
Structural Wind and Earthquake Engineering
Introduction to nature of wind, aerodynamic wind-loading and design. Strong ground motion phenomenon. Investigation of the response of structures to dynamic and pseudo dynamic wind, earthquake, shock waves and other deterministic and probabilistic loadings. Design criteria for buildings and nuclear power stations, special topics in lifeline earthquake engineering.
Prerequisite(s): CAE 529 with min. grade of C or Graduate standing
Lecture: 4 **Lab:** 0 **Credits:** 4

CAE 583
Performance-Based Structural and Seismic Design of Buildings and Bridges
This course covers performance-based structural and seismic design (PBSSD) for buildings and bridges. The course will begin with brief reviewing and critical discussion on conventional code-based seismic design followed by the development of the concept and applicability of this new alternative and advanced PBSSD. Computer methods in linear dynamic, nonlinear static, and dynamic analyses will be surveyed and discussed as primary tools in PBSSD. Ample case studies from real-world projects are carried out throughout the course. These case studies include the PBSSD of special structures, tall buildings, and those that building code-based design is not applicable.
Prerequisite(s): CAE 529 with min. grade of C or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 584
Stormwater Management
Basic principles of storm water management; hydrology and hydraulics of excess water; excess water management and design; sewer system design and management, storm water detention systems; flood plain system design; risk based design of drainage systems; practical and case study problems.
Prerequisite(s): CHE 301 or MMAE 313 or CAE 302 or CAE 209
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 586
Seismic Design of Building and Bridge Structures
The course covers six topics, as listed in the course outline, on seismic design of steel and R/C building structures and bridges. In addition to offer fundamentals and experiences in seismic design through design examples, it is also assumed that structural engineers who are preparing for their Structural Engineer License Exam might find extremely helpful.
Prerequisite(s): (CAE 431 with min. grade of C and CAE 432 with min. grade of C) or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 587
Commissioning of Construction Projects
This course provides students with the methods and process of Commissioning, a high-level engineering skill in construction projects of independently verifying that the design and the construction meets the Owner's bargained for quality. It enumerates tracking the processes of equipment approval, installation, individual equipment testing and manufacturer training, programming of digital controls, and operational tests in high and low states to verify that end product of the construction project meets the Owner's requirements. The Construction Standard Institute (CSI) of the United States and Canada MasterFormat is used as a guide to specific types of commissioning.
Corequisite(s): CAE 569
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 588
Computing, Informatics, and Advanced Information Technologies in Construction Engineering
The course covers concepts in computing, processing information and data, representation, and reasoning strategies to be applied in construction engineering tasks during the whole life cycle of a project. The course presents advanced information technologies used to manage project design and construction operations, including application methods and techniques. Topics allow the student to acquire a broad understanding of information, data, and knowledge within any construction process. The instructor will also include research-level topics of discussion concerning the use of state- of-the-art technologies within the civil and construction engineering practice, such as the Internet of Things (IoT), robotics, digital twins, ontologies, and technologies along the virtuality-reality continuum (e.g., augmented reality, mixed reality).
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 589
Groundwater Hydrology and Sampling
Groundwater geology and flow, response of ideal aquifer to pumping. Chemical properties and principles including source of contamination and estimation of saturated hydraulic conductivity. Principles of exploration and sampling, methods of subsurface explorations, groundwater observation techniques. Instructor permission required.
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 590
Geotechnical Landfill Design and Maintenance
Regulatory and legal issues, site selection and assessment, geotechnical-subsurface investigation, clay mineralogy and clay-water-electrolyte system, linear and leachate-control-systems design, stability of landfill slopes, cover design, construction and operation, final use and remediation design.
Prerequisite(s): CAE 323 with min. grade of C or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3

CAE 591
Research and Thesis for M.S. Degree
Research and Thesis for M.S. Degree.
Credit: Variable

CAE 594
Research Problems
Credit: Variable

CAE 595
Current Issues in the Construction Industry
The task organization and operation of Design and Construction projects is reviewed. Each student selects a major issue/problem they have experienced on their projects as a basis for a podcast interview with the Professor. The other students in the class will provide input by direct participation or by use of the discussion board for that podcast. At the end of the semester each student submits a paper on the strategic directions of the Construction Industry using all the podcasts and their experience as a basis. At least 3 years' experience in the U.S. Canadian design and construction industry where project organizations are task organizations are task organized from many different companies and parties using contracts. The student has worked with the processes of RFP/Bid preparation, monthly Pay Apps, and Change Orders (Mods).
Lecture: 1 **Lab:** 3 **Credits:** 3

CAE 597
Special Problems
Graduate course work in the problem subject matter. Subject matter will vary with the interests and background of students and instructor. Design or research problems may be assigned from the areas of architectural, construction, geotechnical, geoenvironmental, structural, or transportation engineering.
Credit: Variable

CAE 598
Special Topics
A special topic in civil or architectural engineering at the graduate level.
Credit: Variable

CAE 599
Graduate Workshop
Graduate workshop.
Lecture: 0 **Lab:** 0 **Credits:** 0

CAE 691
Research and Thesis for Ph.D. Degree
Research and Thesis for Ph.D. degree.
Credit: Variable

CAE 724
Introduction to Acoustics
This short course provides a brief introduction to the fundamentals of acoustics and the application to product noise prediction and reduction. The first part focuses on fundamentals of acoustics and noise generation. The second part of the course focuses on applied noise control.
Lecture: 2 **Lab:** 0 **Credits:** 2