Underground Construction and Tunnel Engineering

Degrees Offered

- Master of Science (Underground Construction and Tunnel Engineering), Thesis
- Master of Science (Underground Construction and Tunnel Engineering), Non-Thesis
- Doctor of Philosophy (Underground Construction and Tunnel Engineering)

Program Description

Underground Construction and Tunnel Engineering (UCTE) is an interdisciplinary field primarily involving civil engineering, geological engineering and mining engineering, and secondarily involving mechanical engineering, electrical engineering, geophysics, geology and others. UCTE deals with the design, construction, rehabilitation and management of underground space including caverns, shafts and tunnels for commercial, transportation, water and wastewater use. UCTE is a challenging field involving complex soil and rock behavior, groundwater conditions, excavation methods, construction materials, structural design flow, heterogeneity, and very low tolerance for deformation due to existing infrastructure in urban environments. Students pursuing a graduate degree in UCTE will gain a strong and interdisciplinary foundation in these topics.

The graduate degree program in UCTE is offered jointly by the Departments of Civil & Environmental Engineering (CEE), Geology & Geological Engineering (GEGN), and Mining Engineering (MN). UCTE faculty from each department are collectively responsible for the operations of the program. Participating students reside in one of these departments, typically the home department of their advisor.

Program coursework is selected from multiple departments at Mines (primarily CEE, GEGN, MN) and is approved for each student by the student’s advisor and graduate committee. To achieve the MS degree, students may elect the non-thesis option based upon coursework and an independent study report tied to a required internship. Students may alternatively select the thesis option comprised of coursework and a research project performed under the guidance of a UCTE faculty advisor and presented in a written report approved by the student’s thesis committee.

PhD students are expected to complete a combination of coursework and novel, original research under the guidance of a UCTE faculty advisor and doctoral committee, which culminates in a significant scholarly contribution to a specialized field in UCTE. Full-time enrollment is encouraged and leads to the greatest success, although part-time enrollment is permissible for working professionals. All graduate students must complete the full-time, on-campus residency requirements described in the general section of the Graduate Catalog.

Program Requirements

**MS Non-Thesis Option:**

- Coursework - 27.0 credit hours

**PhD Option:**

- Coursework (beyond BS degree) - 42.0 credit hours
- Independent Study* - 3.0 credit hours
- Research (minimum) - 24.0 credit hours
- UCTE Seminar - 0.0 credit hours

**Total Hours - 72.0**

*Where possible, MS non-thesis students should complete a practically-focused independent study in partnership with an industry partner; this may include student participation in an industry internship on a UCTE project.

**MS Thesis Option:**

- Coursework - 24.0 credit hours
- Research (minimum) - 6.0 credit hours
- UCTE Seminar - 0.0 credit hours

**Total Hours - 30.0**

MS Thesis students must write and successfully defend a thesis report of their research. Ideally, MS thesis research should be industry-focused and should provide value to industry UCTE practice.

**PhD Option:**

- Coursework (beyond BS degree) - 42.0 credit hours
- Independent Study* - 3.0 credit hours
- Research (minimum) - 24.0 credit hours
- UCTE Seminar - 0.0 credit hours

**Total Hours - 72.0**

PhD students must also successfully complete qualifying examinations, write and defend a dissertation proposal, and write and defend a doctoral dissertation. PhD research is aimed at fundamentally advancing the state of the art in UCTE. PhD students are expected to submit the dissertation work for publication in scholarly journals and disseminate findings throughout industry periodicals.

*PhD students are expected to complete an internship of approximately 3 months in duration (with a design firm, contractor, owner, equipment manufacturer, etc., and preferably on a UCTE job site). If an internship is not available or if the student has sufficient industry experience (determined by advisor and committee), the student may complete an industry-focused research project via independent study with a UCTE faculty member and industry partner culminating with a written report and presentation.

**Mines’ Combined Undergraduate/Graduate Degree Program**

Students enrolled in Mines’ combined undergraduate/graduate program (meaning uninterrupted registration from the time the student earns a Mines undergraduate degree to the time the student begins a Mines graduate degree) may double count up to six hours of credits which were used in fulfilling the requirements of their undergraduate degree at Mines, towards their graduate program. Any courses that count towards the graduate degree requirements as either “Required Coursework” or “Elective Coursework”, as defined below, may be used for the purposes of double counting at the discretion of the advisor (MS Non-Thesis) or thesis committee (MS Thesis or PhD). These courses must have been passed with a “B-“ or better and meet all other University, Department, Division, and Program requirements for graduate credit.
Required Coursework

The following 18 credit hours are required for the MS. (thesis and non-thesis) and PhD degrees.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEGN468</td>
<td>ENGINEERING GEOLOGY AND GEOTECHNICS</td>
<td>4.0</td>
</tr>
<tr>
<td>GEGN561</td>
<td>UNDERGROUND CONSTRUCTION ENGINEERING LABORATORY 1</td>
<td>0.5</td>
</tr>
<tr>
<td>GEGN562</td>
<td>UNDERGROUND CONSTRUCTION ENGINEERING LABORATORY 2</td>
<td>0.5</td>
</tr>
<tr>
<td>CEEN523</td>
<td>UNDERGROUND CONSTRUCTION ENGINEERING IN SOFT GROUND</td>
<td>4.0</td>
</tr>
<tr>
<td>MNGN504</td>
<td>UNDERGROUND CONSTRUCTION ENGINEERING IN HARD ROCK</td>
<td>3.0</td>
</tr>
<tr>
<td>CEEN512</td>
<td>SOIL BEHAVIOR</td>
<td>3.0</td>
</tr>
<tr>
<td>MNGN509</td>
<td>CONSTRUCTION ENGINEERING AND MANAGEMENT</td>
<td>3.0</td>
</tr>
</tbody>
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All MS. and PhD students are required to attend the UCTE seminar series (0 h); no registration is required.

MS. non-thesis and PhD students must complete a practically-focused project (separate from the thesis in the case of the PhD degree), registering as an independent study in the home department of the faculty advisor (CEEN599, GEGN599, or MNGN599). This requirement may be waived for students with sufficient UC&T industry experience.

Elective Coursework

The following courses may be taken as electives to complete the MS. and PhD course requirements. Students may petition for other courses not listed below to count towards the elective requirement. In addition, MS. or PhD students may petition one of the required courses for a required course if one of the required courses is not offered during the student's course of study or if a student has sufficient background in one of the required course topics. All petitions must be made to the student's advisor and thesis committee.

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>CEEN415</td>
<td>FOUNDATION ENGINEERING</td>
<td>3.0</td>
</tr>
<tr>
<td>CEEN506</td>
<td>FINITE ELEMENT METHODS FOR ENGINEERS</td>
<td>3.0</td>
</tr>
<tr>
<td>CEEN510</td>
<td>ADVANCED SOIL MECHANICS</td>
<td>3.0</td>
</tr>
<tr>
<td>CEEN541</td>
<td>DESIGN OF REINFORCED CONCRETE STRUCTURES II</td>
<td>3.0</td>
</tr>
<tr>
<td>CEEN599</td>
<td>INDEPENDENT STUDY</td>
<td>0.5-6</td>
</tr>
<tr>
<td>GEGN466</td>
<td>GROUNDWATER ENGINEERING</td>
<td>3.0</td>
</tr>
<tr>
<td>GEGN563</td>
<td>APPLIED NUMERICAL MODELLING FOR GEOMECHANICS</td>
<td>3.0</td>
</tr>
<tr>
<td>GEGN573</td>
<td>GEOLOGICAL ENGINEERING SITE INVESTIGATION</td>
<td>3.0</td>
</tr>
<tr>
<td>GEGN581</td>
<td>ANALYTICAL HYDROLOGY</td>
<td>3.0</td>
</tr>
<tr>
<td>GEGN672</td>
<td>ADVANCED GEOTECHNICS</td>
<td>3.0</td>
</tr>
<tr>
<td>GEGN673</td>
<td>ADVANCED GEOLOGICAL ENGINEERING DESIGN</td>
<td>3.0</td>
</tr>
<tr>
<td>GEGN599</td>
<td>INDEPENDENT STUDY IN ENGINEERING GEOLOGY OR ENGINEERING HYDROGEOLOGY</td>
<td>0.5-6</td>
</tr>
<tr>
<td>MNGN424</td>
<td>MINE VENTILATION</td>
<td>3.0</td>
</tr>
<tr>
<td>MNGN506</td>
<td>DESIGN AND SUPPORT OF UNDERGROUND EXCAVATIONS</td>
<td>3.0</td>
</tr>
<tr>
<td>MNGN507</td>
<td>ADVANCED DRILLING AND BLASTING</td>
<td>3.0</td>
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MNGN524     ADVANCED MINE VENTILATION 3.0
MNGN590     MECHANICAL EXCAVATION IN MINING 3.0
MNGN599     INDEPENDENT STUDY 0.5-6

Thesis Committee Requirements

Students must meet the general committee requirements listed in the graduate bulletin. In addition, the student’s advisor or co-advisor must be a UCTE faculty member. In the case that a student is co-advised, the co-advisor will serve as an additional committee member above and beyond the minimum committee requirements.

The committee for PhD students enrolled in the UCTE degree program shall be composed of a minimum of four (4) faculty members:

- The student’s advisor
- Two core UCTE faculty members representing two of three core UCTE departments (Civil Engineering, Geological Engineering, Mining Engineering)
- An “external” committee member, who has no connection to the student or their research (this member should not come from any of the three core UCTE departments, other than in exceptional circumstances); this member will chair the committee and must be a permanent CSM faculty member

Additional committee members may be added as appropriate, including off-campus representatives from industry and academia.

Given the interdisciplinary nature of the UCTE degree program, no more than two (2) of the four PhD committee members can be from the same department.

Qualifying Exam Procedure

Students enrolled in the UCTE PhD program are expected to have passed a qualifying exam by the end of their first year of study. This qualifying exam will be administered by a sub-committee of UCTE faculty. If a UCTE faculty member is serving on this sub-committee for the qualifying exam of a student they are advising, they will act as a non-voting member for that exam.

The intention of the qualifying exam is to evaluate the student’s capacity to undertake PhD-level research; this includes their ability to think critically, to apply core UCTE concepts to abstract problems, and to develop methods to test scientific hypotheses. The format of the exam will include a written component and an oral exam, approximately two hours in length. Prior to their oral exam, the student will be assigned two tasks:

- The student will be provided a research topic which has some relevance to their research, but is not directly related. The student will be required to submit an 8-10 page literature review on this topic to their committee twenty-four (24) hours prior to their oral exam. During the oral exam, the student will be asked questions related to their literature review.
- The student will be provided with four (4) questions which will represent a significant portion of their oral exam. These questions will be designed to assess the student’s ability to consider analysis, design, and research questions critically. The core UCTE curriculum will serve as foundational knowledge for these questions. As the student’s response will be oral (no written response to the questions will be submitted), the questions will require students to suggest problem solving approaches rather than to directly implement
them. Based on the student’s response to each question, follow-up questions will be asked.

If the student fails their first qualifying exam, they may be given an opportunity to attempt a second qualifying exam at the discretion of the committee who administered their first exam. If the student fails their second qualifying exam, they will not be admitted to PhD candidacy.

**Prerequisites**

Students will enter the UCTE programs with a variety of backgrounds. Because the UCTE degrees are engineering degrees, the required prerequisite courses for the UCTE programs include basic engineering coursework, and specifically: (1) Strength of Materials or Mechanics of Materials, and (2) Fluid Mechanics. These prerequisite courses may be completed during the first semester of the graduate program if approved by the UCTE program faculty. It is permissible for students to take graduate level courses without having completed the corresponding undergraduate courses to address areas where key competencies are lacking, such as in soil mechanics, rock mechanics, structural analysis or groundwater engineering. However, students may choose to complete undergraduate courses in these topics prior to or concurrently during enrollment in the required graduate program courses. With the exception of the 400-level coursework allowed by the graduate catalog, undergraduate level coursework to address any prerequisite deficiencies does not count towards the requirements of the MS. or PhD degrees. Students should consult with UCTE faculty for guidance in this matter.

**Director**

Gabriel Walton, UCTE Director

**Department of Civil & Environmental Engineering**

Marte Gutierrez, J.R. Paden Distinguished Chair & Professor

Reza Hedayat, Assistant Professor

Panos Kiousis, Associate Professor

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Shiling Pei, Assistant Professor

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