Humanitarian Engineering and Science

Degrees
- Graduate Certificate in Humanitarian Engineering and Science

Program Description
The MS degrees in Humanitarian Engineering and Science (HES) are a professional MS (non-thesis) and a thesis-based MS. These degrees are targeted to recent graduates or mid-career professionals with a BS in science and engineering who are interested in careers, research opportunities, and/or acquiring skills that will help them work effectively with communities. The degrees include a core HES curriculum plus an approved track of related courses in a science or engineering discipline.

The HES graduate certificate is designed for professionals seeking to attend school part time or students who are seeking degrees in other departments at Mines but still desire graduate training in humanitarian engineering and science. It consists of four courses.

In both the master’s degrees and graduate certificates, a unique mix of social science, applied science, and engineering perspectives prepares students to apply knowledge about the earth to promote more sustainable and just uses of water, energy, and other earth resources and to understand and mitigate potential hazards.

To achieve the Master of Science (MS) degree, students may elect the non-thesis option based exclusively upon coursework and a practicum, or the thesis option. The thesis option is comprised of coursework in combination with individual research performed under the guidance of two faculty advisors and presented in a written thesis approved by the student’s committee. HES students have academic advisors from both the Engineering, Design & Society Department and their disciplinary track (Data Science, Environmental Engineering, Geological Engineering, Geophysics, Robotics or Interdisciplinary). The thesis-based MS usually takes two years to complete, while the non-thesis MS can often be completed in one year.

For more information on program curriculum please refer to the HES website: https://humanitarian.mines.edu/mshes/.

Primary Contact
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303-384-2329
rkrahenb@mines.edu

Graduate Certificate Program Requirements
The Humanitarian Engineering and Science (HES) certificate is an online or residential program designed for working professionals as well as graduate students who are enrolled in other degrees at Mines but wish to gain knowledge in humanitarian engineering and science. To obtain a graduate certificate, students must complete a minimum of 9 credits of the following courses. Students may not double-count courses from their undergraduate degrees. Students who have already taken one of the classes as undergraduates must find a suitable replacement, to be approved by the HES director. Students are encouraged to take 12 credits of coursework if possible, adding an elective from the approved HES electives list below.

Required HES certificate courses (9 credits):

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDNS515</td>
<td>Introduction to Science and Technology Studies</td>
<td>3.0</td>
</tr>
<tr>
<td>EDNS577</td>
<td>Advanced Engineering and Sustainable Community Development</td>
<td>3.0</td>
</tr>
<tr>
<td>EDNS579</td>
<td>Community-Based Research Methods</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Total Semester Hrs 9.0

Master of Science (MS) Program Requirements
The MS degrees in Humanitarian Engineering and Science (HES) are a professional MS (non-thesis) and a thesis-based MS. These degrees are targeted to recent graduates or mid-career professionals with a BS in science and engineering who are interested in careers, research opportunities, and/or acquiring skills that will help them work effectively with communities. The degrees include a core HES curriculum plus an approved track of related courses in a science or engineering discipline. A unique mix of social science, applied science, and engineering perspectives prepares students to apply knowledge about the earth to promote more sustainable and just uses of water, energy, and other earth resources and to understand and mitigate potential hazards.

Master of Science (non-thesis)
To obtain the 30 credits required for the MS (non-thesis), students must satisfy the following program requirements: (1) 12 credits of required HES courses, 2) 3 credits of elective HES courses approved by Engineering, Design & Society, and 3) 15 credits of courses approved by the affiliated department (see the six tracks detailed below).

HES MS (Non-Thesis) Core Courses (15 credits):

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDNS515</td>
<td>Introduction to Science and Technology Studies</td>
<td>3.0</td>
</tr>
<tr>
<td>EDNS577</td>
<td>Advanced Engineering and Sustainable Community Development</td>
<td>3.0</td>
</tr>
<tr>
<td>EDNS579</td>
<td>Community-Based Research Methods</td>
<td>3.0</td>
</tr>
<tr>
<td>EDNS580</td>
<td>Humanitarian Engineering and Science Capstone Practicum</td>
<td>3.0</td>
</tr>
<tr>
<td>ELECTIVE</td>
<td>An approved HES elective from the list below</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Total Semester Hrs 15.0

Approved HES Electives:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDNS590</td>
<td>Risks in Humanitarian Engineering and Science</td>
<td>3.0</td>
</tr>
<tr>
<td>CEEN501</td>
<td>Life Cycle Assessment</td>
<td>3.0</td>
</tr>
<tr>
<td>CEEN575</td>
<td>Hazardous Waste Site Remediation</td>
<td>3.0</td>
</tr>
<tr>
<td>CEEN593</td>
<td>Sustainable Engineering Design</td>
<td>3.0</td>
</tr>
<tr>
<td>CEEN556</td>
<td>Mining and the Environment</td>
<td>3.0</td>
</tr>
<tr>
<td>CEEN570</td>
<td>Water and Wastewater Treatment</td>
<td>3.0</td>
</tr>
<tr>
<td>CEEN573</td>
<td>Reclamation of Disturbed Lands</td>
<td>3.0</td>
</tr>
<tr>
<td>CEEN580</td>
<td>Chemical Fate and Transport in the Environment</td>
<td>3.0</td>
</tr>
<tr>
<td>CEEN581</td>
<td>Watershed Systems Modeling</td>
<td>3.0</td>
</tr>
</tbody>
</table>
Disciplinary Tracks

**Track 1: Geophysics (GPGN) (15 credits):**

Degree candidates should have an undergraduate degree in geophysics, physics, quantitative earth sciences and engineering, or equivalent coursework. In addition, candidates will need to complete necessary prerequisite courses for the graduate courses.

In addition to the core HES MS (non-thesis) curriculum (15 credits) detailed above, MS (non-thesis) students following the Geophysics track must take one required course (3 credits) and at least 12 credits of approved elective courses, as shown below. Courses not listed below that align with the student's practicum can be substituted in consultation with the degree advisor.

<table>
<thead>
<tr>
<th>Required Course</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPGN577</td>
<td>HUMANITARIAN GEOSCIENCE</td>
<td>3.0</td>
</tr>
</tbody>
</table>

At least four courses of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPGN520</td>
<td>ELECTRICAL AND ELECTROMAGNETIC EXPLORATION</td>
<td>3.0</td>
</tr>
<tr>
<td>GPGN570</td>
<td>APPLICATIONS OF SATELLITE REMOTE SENSING</td>
<td>3.0</td>
</tr>
<tr>
<td>GPGN574</td>
<td>ADVANCED HYDROGEOPHYSICS</td>
<td>3.0</td>
</tr>
<tr>
<td>GPGN590</td>
<td>INSTRUMENTAL DESIGN IN APPLIED GEOSCIENCES</td>
<td>3.0</td>
</tr>
</tbody>
</table>

**Track 2: Environmental Engineering (CEEN) (15 credits):**

A BS degree in a science or engineering discipline is required. Pre-requisites include two semesters of college calculus, one semester of college physics, two semesters of college chemistry, and one semester of college statistics.

In addition to the core HES MS (non-thesis) curriculum (15 credits) detailed above, MS (non-thesis) students following the Environmental Engineering track must take three required courses (9 credits) and at least two courses (6 credits) of approved elective courses, as shown below. Courses not listed below that align with the student's practicum can be substituted in consultation with the degree advisor.

**Required Courses:**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPGN577</td>
<td>HUMANITARIAN GEOSCIENCE</td>
<td>3.0</td>
</tr>
<tr>
<td>CEEN550</td>
<td>PRINCIPLES OF ENVIRONMENTAL CHEMISTRY</td>
<td>3.0</td>
</tr>
<tr>
<td>CEEN580</td>
<td>CHEMICAL FATE AND TRANSPORT IN THE ENVIRONMENT</td>
<td>3.0</td>
</tr>
</tbody>
</table>

At least two courses of the following:

**Environmental Microbiology**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEEN560</td>
<td>MOLECULAR MICROBIAL ECOLOGY AND THE ENVIRONMENT</td>
<td>3.0</td>
</tr>
<tr>
<td>CEEN562</td>
<td>ENVIRONMENTAL GEOMICROBIOLOGY</td>
<td>3.0</td>
</tr>
<tr>
<td>CEEN566</td>
<td>MICROBIAL PROCESSES, ANALYSIS AND MODELING</td>
<td>3.0</td>
</tr>
</tbody>
</table>

**Treatment**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEEN570</td>
<td>WATER AND WASTEWATER TREATMENT</td>
<td>3.0</td>
</tr>
<tr>
<td>CEEN575</td>
<td>HAZARDOUS WASTE SITE REMEDIATION</td>
<td>3.0</td>
</tr>
<tr>
<td>MNGN556</td>
<td>MINE WATER AND ENVIRONMENT</td>
<td>3.0</td>
</tr>
</tbody>
</table>

**Hydrology**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEEN555</td>
<td>LIMNOLOGY</td>
<td>3.0</td>
</tr>
<tr>
<td>CEEN581</td>
<td>WATERSHED SYSTEMS MODELING</td>
<td>3.0</td>
</tr>
<tr>
<td>GEGN582</td>
<td>INTEGRATED SURFACE WATER HYDROLOGY</td>
<td>3.0</td>
</tr>
<tr>
<td>GEGN584</td>
<td>FIELD METHODS IN HYDROLOGY</td>
<td>3.0</td>
</tr>
</tbody>
</table>

**Track 3: Geological Engineering (GEGN) (15 credits):**

Degree candidates should have an undergraduate degree in engineering or the equivalent coursework. In addition, candidates will need to complete necessary prerequisite courses for the graduate courses, including engineering geology, groundwater engineering, soil mechanics, and rock mechanics.

In addition to the core HES MS (non-thesis) curriculum (15 credits) detailed above, MS (non-thesis) students following the Geological Engineering track must take two required courses (6 credits) and at least three courses (9 credits) of approved elective courses, as shown below.

**Required Courses:**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEGN532</td>
<td>GEOLOGICAL DATA ANALYSIS</td>
<td>3.0</td>
</tr>
<tr>
<td>GPGN577</td>
<td>HUMANITARIAN GEOSCIENCE</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Candidates must also take at least three of the following courses. The student and the instructor will work together to develop humanitarian themes in the project assignments within each course.

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEGN563</td>
<td>APPLIED NUMERICAL MODELLING FOR GEOMECHANICS</td>
<td>3.0</td>
</tr>
<tr>
<td>GEGN570</td>
<td>CASE Histories in Geological Engineering and Hydrogeology</td>
<td>3.0</td>
</tr>
<tr>
<td>GEGN573</td>
<td>GEOLOGICAL ENGINEERING SITE INVESTIGATION</td>
<td>3.0</td>
</tr>
<tr>
<td>GEGN575</td>
<td>APPLICATIONS OF GEOGRAPHIC INFORMATION SYSTEMS</td>
<td>3.0</td>
</tr>
<tr>
<td>GEGN580</td>
<td>APPLIED REMOTE SENSING FOR GEOENGINEERING AND GEOSCIENCES</td>
<td>3.0</td>
</tr>
<tr>
<td>GEGN671</td>
<td>LANDSLIDES: INVESTIGATION, ANALYSIS &amp; MITIGATION</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Below is a table of course requirements and credits for each track:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEEN595</td>
<td>ANALYSIS OF ENVIRONMENTAL IMPACT</td>
<td>3.0</td>
</tr>
<tr>
<td>EBGN553</td>
<td>PROJECT MANAGEMENT</td>
<td>3.0</td>
</tr>
<tr>
<td>HASS525</td>
<td>ENVIRONMENTAL COMMUNICATION</td>
<td>3.0</td>
</tr>
<tr>
<td>HASS526</td>
<td>INTERCULTURAL COMMUNICATION</td>
<td>3.0</td>
</tr>
<tr>
<td>HASS527</td>
<td>RISK COMMUNICATION</td>
<td>3.0</td>
</tr>
<tr>
<td>HASS565</td>
<td>SCIENCE, TECHNOLOGY, AND SOCIETY</td>
<td>3.0</td>
</tr>
<tr>
<td>HASS568</td>
<td>ENVIRONMENTAL JUSTICE</td>
<td>3.0</td>
</tr>
<tr>
<td>HASS590</td>
<td>ENERGY AND SOCIETY</td>
<td>3.0</td>
</tr>
<tr>
<td>MNGN503</td>
<td>MINING TECHNOLOGY FOR SUSTAINABLE DEVELOPMENT</td>
<td>3.0</td>
</tr>
<tr>
<td>MNGN510</td>
<td>FUNDAMENTALS OF MINING AND MINERAL RESOURCE DEVELOPMENT</td>
<td>3.0</td>
</tr>
<tr>
<td>MNGN565</td>
<td>MINE RISK MANAGEMENT</td>
<td>3.0</td>
</tr>
<tr>
<td>MNGN567</td>
<td>SUSTAINABLE DEVELOPMENT AND EARTH RESOURCES</td>
<td>3.0</td>
</tr>
<tr>
<td>MNGN571</td>
<td>ENERGY, NATURAL RESOURCES, AND SOCIETY</td>
<td>3.0</td>
</tr>
<tr>
<td>PEGN530</td>
<td>ENVIRONMENTAL LAW AND SUSTAINABILITY</td>
<td>3.0</td>
</tr>
</tbody>
</table>
GEGN673  ADVANCED GEOLOGICAL ENGINEERING DESIGN 3.0

**TRACK 4: Humanitarian Robotics (15 CREDITS):**
Degree candidates should have an undergraduate degree in computer science, mechanical or electrical engineering, or robotics, or equivalent coursework. In addition, candidates will need to complete necessary prerequisite courses for the graduate courses.

In addition to the Core HES MS (non-thesis) curriculum (15 credits) detailed above, MS (non-thesis) students following the Humanitarian Robotics track must take three required course (9 credits) and at least 6 credits of approved elective courses, as shown below. Courses not listed below that align with the student's practicum can be substituted in consultation with the degree advisor.

**Required Courses:**
- CSCI532  ROBOT ETHICS 3.0
- CSCI536  HUMAN-ROBOT INTERACTION 3.0
- CSCI573  ROBOT PROGRAMMING AND PERCEPTION 3.0

At least two courses from the following:
- CSCI507  INTRODUCTION TO COMPUTER VISION 3.0
- CSCI534  ROBOT PLANNING AND MANIPULATION 3.0
- CSCI575  ADVANCED MACHINE LEARNING 3.0
- EENG517  THEORY AND DESIGN OF ADVANCED CONTROL SYSTEMS 3.0
- EENG519  ESTIMATION THEORY AND KALMAN FILTERING 3.0
- MEGN540  MECHATRONICS 3.0
- MEGN544  ROBOT MECHANICS: KINEMATICS, DYNAMICS, AND CONTROL 3.0
- MEGN545  ADVANCED ROBOT CONTROL 3.0

**TRACK 5: Data Science (DSCI) (15 CREDITS):**
Degree candidates should have an undergraduate degree in computer science, mathematics, or data science or equivalent coursework. In addition, candidates will need to complete necessary prerequisite courses for the graduate courses.

In addition to the core HES MS (non-thesis) curriculum (15 credits) detailed above, MS (non-thesis) students following the Data Science track must take four required courses (12 credits) and at least 3 credits of approved elective courses, as shown below. In addition to earning the HES MS (non-thesis) degree, they will also earn the Data Science Statistical Learning Graduate Certificate.

**Required Courses**
- DSCI503  ADVANCED DATA SCIENCE 3.0
- DSCI530  STATISTICAL METHODS I 3.0
- DSCI560  INTRODUCTION TO KEY STATISTICAL LEARNING METHODS I 3.0
- DSCI561  INTRODUCTION TO KEY STATISTICAL LEARNING METHODS II 3.0

At least one course of the following:
- MATH532  SPATIAL STATISTICS 3.0
- MATH533  TIME SERIES AND ITS APPLICATIONS NaN
- MATH536  ADVANCED STATISTICAL MODELING 3.0
- MATH537  MULTIVARIATE ANALYSIS 3.0
- MATH582  STATISTICS PRACTICUM 3.0

**TRACK 6: Interdisciplinary (15 CREDITS):**
In addition to the core HES MS (non-thesis) curriculum (15 credits) detailed above, MS (non-thesis) students following the Interdisciplinary track will work with their advisor to choose an additional 15 credits that best match their intellectual interests. As with our other tracks, at least 12 of these credits need to be engineering or applied science courses. Students seeking this track are required to identify their desired focus area when applying and identify possible courses upon matriculation. They will then work with their advisor to ensure that the student meets the course prerequisites and that the courses are offered on an appropriate timetable according to their anticipated graduation date.

**Master of Science (thesis):**
To obtain the 30 credits required for the MS (thesis), students must satisfy the following program requirements: 1) 9 credits of required HES core courses, 2) 3 credits of elective HES classes approved by Engineering, Design and Society, 3) 12 credits of approved Disciplinary Track classes, and 4) 6 credits of MS thesis research on a thesis topic approved by HES faculty in the Engineering, Design, and Society Division and the affiliated disciplinary track.

**HES MS (thesis) Core Courses (12 credits):**
- EDNS515  INTRODUCTION TO SCIENCE AND TECHNOLOGY STUDIES 3.0
- EDNS577  ADVANCED ENGINEERING AND SUSTAINABLE COMMUNITY DEVELOPMENT 3.0
- EDNS579  COMMUNITY-BASED RESEARCH METHODS 3.0
- ELECTIVE 3 credits of approved HES electives from list below 3.0

**Approved HES Electives:**
- EDNS590  RISKS IN HUMANITARIAN ENGINEERING AND SCIENCE 3.0
- CEEN501  LIFE CYCLE ASSESSMENT 3.0
- CEEN575  HAZARDOUS WASTE SITE REMEDIATION 3.0
- CEEN593  SUSTAINABLE ENGINEERING DESIGN 3.0
- CEEN556  MINING AND THE ENVIRONMENT 3.0
- CEEN570  WATER AND WASTEWATER TREATMENT 3.0
- CEEN573  RECLAMATION OF DISTURBED LANDS 3.0
- CEEN580  CHEMICAL FATE AND TRANSPORT IN THE ENVIRONMENT 3.0
- CEEN581  WATERSHED SYSTEMS MODELING 3.0
- CEEN595  ANALYSIS OF ENVIRONMENTAL IMPACT 3.0
- EGN553  PROJECT MANAGEMENT 3.0
- HASS525  ENVIRONMENTAL COMMUNICATION 3.0
- HASS526  INTERCULTURAL COMMUNICATION 3.0
- HASS527  RISK COMMUNICATION 3.0
- HASS565  SCIENCE, TECHNOLOGY, AND SOCIETY 3.0
- HASS568  ENVIRONMENTAL JUSTICE 3.0
- HASS590  ENERGY AND SOCIETY 3.0
Disciplinary Tracks

Track 1: Geophysics (GPGN) Courses and Thesis (18 credits):
Degree candidates should have an undergraduate degree in geophysics, physics, quantitative earth sciences, or engineering or equivalent coursework. In addition, candidates will need to complete necessary prerequisite courses for the graduate courses.

In addition to the core HES MS (thesis) curriculum (12 credits) detailed above, MS (thesis) students following the Geophysics track must take one required course (3 credits), at least 9 credits of approved elective courses, and 6 credits of independent thesis research, as shown below.

Courses not listed below that align with the student’s thesis can be substituted in consultation with the degree advisor.

Required Course:

GPGN577  HUMANITARIAN GEOSCIENCE  3.0

At least three courses of the following:

GPGN520  ELECTRICAL AND ELECTROMAGNETIC EXPLORATION  3.0
GPGN570  APPLICATIONS OF SATELLITE REMOTE SENSING  3.0
GPGN574  ADVANCED HYDROGEOPHYSICS  3.0
GPGN590  INSTRUMENTAL DESIGN IN APPLIED GEO SCIENCES  3.0
GEGN532  GEOLOGICAL DATA ANALYSIS  3.0

And:

GPGN707  GRADUATE THESIS / DISSERTATION RESEARCH CREDIT  6.0

Track 2: Environmental Engineering (CEEN) (18 credits):
A BS degree in a science or engineering discipline is required. Prerequisites include two semesters of college calculus, one semester of college physics, two semesters of college chemistry, and one semester of college statistics.

In addition to the Core HES MS (thesis) curriculum (12 credits) detailed above, MS (thesis) students following the Environmental Engineering track must take two required courses (6 credits), at least two courses (6 credits) of approved elective courses, and 6 credits of independent thesis research, as shown below. Courses not listed below that align with the student’s thesis can be substituted in consultation with the degree advisor.

Required Course:

GPGN577  HUMANITARIAN GEOSCIENCE  3.0

At least three courses of the following:

CEEN550  PRINCIPLES OF ENVIRONMENTAL CHEMISTRY  3.0
CEEN580  CHEMICAL FATE AND TRANSPORT IN THE ENVIRONMENT  3.0

Environmental Microbiology

CEEN560  MOLECULAR MICROBIAL ECOLOGY AND THE ENVIRONMENT  3.0
CEEN562  ENVIRONMENTAL GEOMICROBIOLOGY  3.0
CEEN566  MICROBIAL PROCESSES, ANALYSIS AND MODELING  3.0

Treatment

CEEN570  WATER AND WASTEWATER TREATMENT  3.0
CEEN575  HAZARDOUS WASTE SITE REMEDIATION  3.0
MNGN556  MINE WATER AND ENVIRONMENT  3.0

Hydrology

CEEN555  LIMNOLOGY  3.0
CEEN581  WATERSHED SYSTEMS MODELING  3.0
GEGN582  INTEGRATED SURFACE WATER HYDROLOGY  3.0
GEGN584  FIELD METHODS IN HYDROLOGY  3.0

And

CEEN707  GRADUATE THESIS / DISSERTATION RESEARCH CREDIT  6.0

Track 3: Geological Engineering (GEGN) (18 credits):
Degree candidates should have an undergraduate degree in engineering or the equivalent coursework. In addition, candidates will need to complete necessary prerequisite courses for the graduate courses, including engineering geology, groundwater engineering, soil mechanics, and rock mechanics.

In addition to the Core HES MS (thesis) curriculum (12 credits) detailed above, MS (thesis) students following the Geological Engineering track must take two required courses (6 credits), at least two courses (6 credits) of approved elective courses, and 6 credits of independent thesis research, as shown below.

Required Course:

GEGN532  GEOLOGICAL DATA ANALYSIS  3.0
GPGN577  HUMANITARIAN GEOSCIENCE  3.0

At least two of the following courses:

GEGN563  APPLIED NUMERICAL MODELLING FOR GEOMECHANICS  3.0
GEGN570  CASE HISTORIES IN GEOLOGICAL ENGINEERING AND HYDROGEOLOGY  3.0
GEGN573  GEOLOGICAL ENGINEERING SITE INVESTIGATION  3.0
GEGN575  APPLICATIONS OF GEOGRAPHIC INFORMATION SYSTEMS  3.0
GEGN580  APPLIED REMOTE SENSING FOR GEOENGINEERING AND GEOSCIENCES  3.0
GEGN671  LANDSLIDES: INVESTIGATION, ANALYSIS & MITIGATION  3.0
Track 4: Humanitarian Robotics (18 CREDITS):

Degree candidates should have an undergraduate degree in computer science, mechanical or electrical engineering, or robotics or equivalent coursework. In addition, candidates will need to complete necessary prerequisite courses for the graduate courses.

In addition to the core HES MS (thesis) curriculum (12 credits) detailed above, MS (thesis) students following the Humanitarian Robotics track must take three required course (9 credits), at least 3 credits of approved elective courses, and 6 credits of independent thesis research, as shown below. Courses not listed below that align with the student’s thesis can be substituted in consultation with the degree advisor.

Required Courses:
- **CSCI532** ROBOT ETHICS 3.0
- **CSCI536** HUMAN-ROBOT INTERACTION 3.0
- **CSCI573** ROBOT PROGRAMMING AND PERCEPTION 3.0
- At least one course from the following:
  - **CSCI507** INTRODUCTION TO COMPUTER VISION 3.0
  - **CSCI534** ROBOT PLANNING AND MANIPULATION 3.0
  - **CSCI575** ADVANCED MACHINE LEARNING 3.0
  - **EENG517** THEORY AND DESIGN OF ADVANCED CONTROL SYSTEMS 3.0
  - **EENG519** ESTIMATION THEORY AND KALMAN FILTERING 3.0
  - **MEGN540** MECHATRONICS 3.0
  - **MEGN544** ROBOT MECHANICS: KINEMATICS, DYNAMICS, AND CONTROL 3.0
  - **MEGN545** ADVANCED ROBOT CONTROL 3.0

And:
- **CSCI707** GRADUATE THESIS / DISSERTATION RESEARCH CREDIT 6.0

Track 5: Data Science (DSCI) (18 CREDITS):

Degree candidates should have an undergraduate degree in computer science, mathematics, or data science or equivalent coursework. In addition, candidates will need to complete necessary prerequisite courses for the graduate courses.

In addition to the core HES MS (thesis) curriculum (12 credits) detailed above, MS (thesis) students following the Data Science track must take four required courses (12 credits) and 6 credits of independent thesis research, as shown below. In addition to earning the HES MS (thesis) degree, they will also earn the Data Science Statistical Learning Graduate Certificate.

Required Courses
- **DSCI503** ADVANCED DATA SCIENCE 3.0
- **DSCI530** STATISTICAL METHODS I 3.0
- **DSCI560** INTRODUCTION TO KEY STATISTICAL LEARNING METHODS I 3.0
- **DSCI561** INTRODUCTION TO KEY STATISTICAL LEARNING METHODS II 3.0
- **MATH707** GRADUATE THESIS / DISSERTATION RESEARCH CREDIT 6.0

Track 6: Interdisciplinary (18 CREDITS):

In addition to the core HES MS (thesis) curriculum (12 credits) detailed above, MS (thesis) students following the Interdisciplinary track will work with their advisor to choose an additional 12 elective credits that best match their intellectual interests and take 6 credits of independent thesis research. The 12 elective credits need to be engineering or applied science courses. Students seeking this track are required to identify their desired focus area when applying and identify possible courses upon matriculation. They will then work with their advisor to ensure that the student meets the course prerequisites and that the courses are offered on an appropriate timetable according to their anticipated graduation date.

Mines’ Combined Undergraduate/Graduate Degree Program

Students enrolled in Mines’ combined undergraduate/graduate program may double count up to 6 credits of graduate coursework to fulfill requirements of both their undergraduate and graduate degree programs. These courses must have been passed with B- or better, not be substitutes for required coursework, and meet all other university, department, and program requirements for graduate credit.

Students are advised to consult with their undergraduate and graduate advisors for appropriate courses to double count upon admission to the combined program.

EDNS479. COMMUNITY-BASED RESEARCH. 3.0 Semester Hrs.

Engineers and applied scientists face challenges that are profoundly socio-technical in nature, and communities are increasingly calling for greater participation in the decisions that affect them. Understanding the diverse perspectives of communities and being able to establish positive working relationships with their members is therefore crucial to the socially responsible practice of engineering and applied science. This course provides students with the conceptual and methodological tools to conduct community-based research. Students will learn ethnographic field methods and participatory research strategies, and critically assess the strengths and limitations of these through a final original research project. Prerequisite: HASS100 or graduate student standing. Co-requisite: HASS200 or graduate student standing.
EDNS515. INTRODUCTION TO SCIENCE AND TECHNOLOGY STUDIES. 3.0 Semester Hrs.
This course engages scholarship on the inextricable link between science, engineering and the various social contexts within which scientists and engineers work. We begin by critically reflecting on the question, What are science and engineering for? We then explore key conceptual domains in the social scientific study of science and engineering, including knowledge, agency, and expertise. We will learn from a diverse set of social scientific experts who study and collaborate with scientists and engineers. Students will leave the course with a better understanding of how social scientific inquiry can aid in understanding, and practicing, science and engineering. They will also have a clearer articulation of their individual professional commitments and how those fit with more traditional understandings of science and engineering.

Course Learning Outcomes

• By the end of this course, students will have demonstrated the ability to:
  • Frame and translate complex ambiguous problems into actionable opportunities for innovation
  • Conduct effective, objective and ongoing beneficiary discovery in efficient ways
  • Combine tools and methods to quickly test assumptions and secure beneficiary acceptance
  • Develop creative approaches to navigate real and perceived constraints
  • Leverage mentor and stakeholder support through credible communication based on research
  • Launch innovative solutions with the advocacy of beneficiaries and stakeholders
  • Create value by solving complex problems that straddle technical and social domains
  • Launch innovative solutions with the advocacy of beneficiaries and stakeholders

EDNS544. INNOV8X. 3.0 Semester Hrs.
Innov8x introduces concepts and tools to accelerate the design, validation and adoption of innovations in support of creative problem solving. Using an entrepreneurial mindset, we learn how to identify and frame problems that beneficiaries and stakeholders face. We attempt to design and test practical solutions to those problems in collaboration with those who experience the problems. We apply beneficiary discovery, prototyping, business model design (social, economic and environmental), constrained creativity, efficient experimentation, and rapid iteration. While resolving challenges involves technical solutions, an important aspect of this course is directly engaging beneficiaries and stakeholders in social contexts to develop solutions with strong impact potential. Innov8x is grounded in collaborative creativity theory at the intersection of organizational behavior (social psychology), design principles, entrepreneurship and innovation management.

EDNS577. ADVANCED ENGINEERING AND SUSTAINABLE COMMUNITY DEVELOPMENT. 3.0 Semester Hrs.
Analyzes the relationship between engineering and sustainable community development (SCD) from historical, political, ethical, cultural, and practical perspectives. Students will study and analyze different dimensions of sustainability, development, and “helping”, and the role that engineering might play in each. Will include critical explorations of strengths and limitations of dominant methods in engineering problem solving, design and research for working in SCD. Through case-studies, students will analyze and evaluate projects in SCD and develop criteria for their evaluation. 3 hours lecture and discussion; 3 semester hours.

Course Learning Outcomes

• By the end of this course, students will have demonstrated the ability to:
  • During this course students will learn to:

EDNS579. COMMUNITY-BASED RESEARCH METHODS. 3.0 Semester Hrs.
Engineers and applied scientists face challenges that are profoundly sociotechnical in nature, and communities are increasingly calling for greater participation in the decisions that affect them. Understanding the diverse perspectives of communities and being able to establish positive working relationships with their members is therefore crucial to the socially responsible practice of engineering and applied science. This course provides graduate students with the conceptual and methodological tools to conduct community-based research. Graduate students will learn ethnographic field methods and participatory research strategies, and critically assess the strengths and limitations of these through a final original research project related to their ongoing independent research or practicums.

Course Learning Outcomes

• Identify successful practices for humanitarian projects in real settings (ABET a,h,j) • Determine different ways in which previous humanitarian projects could have been improved to yield more successful technical and social results (ABET a,b,h,j) • Determine effective engineering methods for different humanitarian applications (ABET b,c,h,j) • Work in teams to design, execute and evaluate a project with stakeholders (ABET a,b,c,d,e,j,k) • Gain experience in engaging and communicating with community members and stakeholders (ABET c,d,f,h,i,j,k) • Develop stronger professional communication skills through written assignments, group projects, discussions, presentations, and community engagement (ABET g,f,h,i,j,k)
EDNS590. RISKS IN HUMANITARIAN ENGINEERING AND SCIENCE.
3.0 Semester Hrs.
(I) This course provides students with opportunities to consider the risks related to humanitarian projects or any projects that effect and involve people. These risks might include things that different scientific and engineering disciplines typically consider, as well as those that may be pertinent to project stakeholder perspectives. Guided by social scientific insights related to risk, students in this class will gain new tools for defining problems in ways that are relevant and appropriate for multiple contexts. Students will read, discuss, and analyze material together and to undertake independent research to deepen their understandings of chosen topics. 3 semester hours.

Course Learning Outcomes

• Analyze humanitarian science and engineering projects using established evaluation criteria (ABET a,h,j)
• Identify the most successful practices for humanitarian science and engineering (ABET a,h,j)
• Determine different ways in which previous engineering or scientific projects could have been improved to yield more successful technical and social results (ABET a,b,h,j)
• Gain conceptual tools for and experience in engaging and communicating with community members and stakeholders (ABET c,d,f,h,i,j,k)
• Develop stronger professional communication skills through written assignments, group projects, discussions, presentations, and community engagement (ABET g,f,h,i,j,k)

EDNS598. SPECIAL TOPICS IN ENGINEERING DESIGN & SOCIETY.
6.0 Semester Hrs.
(I, II, S) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once, but no more than twice for the same course content. Prerequisite: none. Variable credit: 0 to 6 credit hours. Repeatable for credit under different titles.

EDNS599. INDEPENDENT STUDY. 0.5-6 Semester Hr.
Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Variable credit: 0.5 to 6 credit hours. Repeatable for credit under different topics/experience and maximums vary by department. Contact the Department for credit limits toward the degree. Independent Study form must be completed and submitted to the Registrar.

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