

Hydrologic Science and Engineering

Degrees Offered

- Master of Science (Hydrology), non-thesis
- Master of Science (Hydrology), thesis
- Doctor of Philosophy (Hydrology)

Program Description

Hydrologic Science and Engineering (HSE) is comprised of faculty from several different Mines departments and offers interdisciplinary graduate degrees in hydrology.

The program offers programs of study in fundamental hydrologic science and applied hydrology with engineering applications. Our program encompasses groundwater hydrology, surface-water hydrology, vadose-zone hydrology, watershed hydrology, contaminant transport and fate, contaminant remediation, hydrogeophysics, and water policy/law.

HSE requires a core study of formal graduate courses for all degrees. Programs of study are interdisciplinary in nature, and coursework is obtained from multiple departments at Mines and is approved for each student by the student's advisor and thesis committee.

To achieve the Master of Science (MS) degree, students may elect the non-thesis option based exclusively upon coursework and an independent study project or a designated design course, or the Thesis option. The thesis option is comprised of coursework in combination with individual laboratory, modeling, and/or field research performed under the guidance of a faculty advisor and presented in a written thesis approved by the student's committee.

To achieve the Doctor of Philosophy (PhD) degree, students are expected to complete a combination of coursework and novel, original research, under the guidance of a faculty advisor and doctoral committee, which culminates in a significant scholarly contribution to a specialized field in hydrologic sciences or engineering. Full-time enrollment is expected and leads to the greatest success, although part-time enrollment may be allowed under special circumstances. All doctoral students must complete the full-time, on-campus residency requirements.

Currently, students will apply to the Hydrology program through the Graduate School and be assigned to the HSE participating department of the student's HSE advisor. Participating units include: Chemistry and Geochemistry, Civil and Environmental Engineering (CEE), Geology and Geological Engineering (GE), Geophysical Engineering, Humanities, Arts, and Social Sciences (HASS), Mechanical Engineering (ME), Mining Engineering (MN), and Petroleum Engineering (PE).

For more information on program curriculum please refer to the HSE website at hydrology.mines.edu.

Program Requirements

MS non-thesis: 30 credits total, including a design course or independent study. (See a list of design courses below)

MS thesis: 30 credits total, consisting of 24 credits of coursework and 6 credits of thesis credit. Students must also write and orally defend a research thesis.

PhD: 72 total credits, consisting of coursework (at least 36 hours), and research (at least 24 hours). Students must also successfully complete qualifying examinations, write and defend a dissertation proposal, write and defend a doctoral dissertation, and are expected to submit the dissertation work for publication in scholarly journals.

Thesis and Dissertation Committee Requirements

Students must meet the general requirements listed in the graduate bulletin section *Graduate Degrees and Requirements*. In addition, the student's advisor or co-advisor must be an HSE faculty member. For MS thesis students, at least two committee members must be members of the HSE faculty. For doctoral students, at least two faculty on the committee must be a member of the HSE faculty. For PhD committee the required at-large member must be from a Mines department outside the student's home department, and where applicable, outside the students minor department.

Prerequisites

- Baccalaureate degree in a science or engineering discipline
- College calculus: two semesters required
- Differential equations: one semester required
- College physics: one semester required
- College chemistry: two semesters required
- College statistics: one semester required
- Fluid mechanics

Note that some prerequisites may be completed in the first few semesters of the graduate program if approved by the HSE director/program manager. Contact Rachel McDonald for questions at rmcdonald@mines.edu.

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.

Required Curriculum

Students will work with their academic advisors and graduate thesis committees to establish plans of study that best fit their individual interests and goals. Each student will develop and submit a plan of study to their advisor during the first semester of enrollment. Doctoral students may transfer in credits from an earned MS graduate program according to requirements listed in the Graduate Degrees and Requirements section of the graduate bulletin, and after approval by the student's thesis committee.

Core Curriculum

Curriculum areas of emphasis consist of core courses, and electives. Core courses cover four areas of knowledge: Groundwater, Surface Water, Chemistry, and Contaminant Fate and Transport. Students can

elect to take 9 or 12 credits of core curriculum depending on selected option below. Courses that meet core requirements include the following:

Option #1 (9 credit hrs.)

GEGN566	GROUNDWATER ENGINEERING	3.0
GEGN582	INTEGRATED SURFACE WATER HYDROLOGY	3.0
CEEN/GEGN587	HYDROCHEMICAL AND TRANSPORT PROCESSES	3.0

Option #2 (12 credit hrs.)

GEGN566	GROUNDWATER ENGINEERING	3.0
GEGN582	INTEGRATED SURFACE WATER HYDROLOGY	3.0
CEEN550	PRINCIPLES OF ENVIRONMENTAL CHEMISTRY	3.0

AND Choose one of the following:

CEEN584	SUBSURFACE CONTAMINANT TRANSPORT	3.0
CEEN580	CHEMICAL FATE AND TRANSPORT IN THE ENVIRONMENT	3.0

Students who have completed coursework for a previous degree that satisfies one of these requirements can get core curriculum requirements waived with the appropriate Waiver form and approval of advisor.

In addition, a fluid mechanics class is required for students to complete the HSE degree programs. If a student has previously taken a fluid mechanics course (for example as part of an undergraduate degree) then this requirement is met; if a student has not previously taken a fluid mechanics course this requirement can be satisfied by taking: GEGN/CEEN 585 – Fluid Mechanics for Hydrology.

Areas of Specialization

Students may choose to complete an area of specialization within the MS in Hydrology degrees by taking additional defined courses. These areas of specialization are: Hydrogeophysics, Hydrobiogeochemistry, and Hydrology, Policy, and Management. The area of specialization will appear on the transcripts of students who register for and complete the required coursework. Courses required for these areas of specialization are:

1. Hydrogeophysics:

GPGN574	ADVANCED HYDROGEOPHYSICS	3.0
GPGN533	GEOPHYSICAL DATA INTEGRATION & GEOSTATISTICS	3.0
GPGN570	APPLICATIONS OF SATELLITE REMOTE SENSING	3.0
or GPGN520	ELECTRICAL AND ELECTROMAGNETIC EXPLORATION	

2. Hydrobiogeochemistry

Students choose three of the following courses with at least one from each of microbiology-focused and geochemistry focused courses.

Students with a Hydrobiogeochemistry area of specialization are encouraged to enroll in CEEN550 and a separate Contaminant Fate and Transport course (CEEN580 or CEEN584) to satisfy the HSE core, leaving GEGN586 and CEEN551 as the geochemistry focused courses.

Microbiology Focus:

CEEN562	ENVIRONMENTAL GEOMICROBIOLOGY	3.0
CEEN560	MOLECULAR MICROBIAL ECOLOGY AND THE ENVIRONMENT	3.0

Geochemistry Focus:

CEEN550	PRINCIPLES OF ENVIRONMENTAL CHEMISTRY	3.0
GEGN586	NUMERICAL MODELING OF GEOCHEMICAL SYSTEMS	3.0
CEEN551	ENVIRONMENTAL ORGANIC CHEMISTRY	3.0

3. Hydrology, Policy, and Management

Students pursuing the Hydrology, Policy, and Management specialty track will choose two of the following three courses focused on water policy and management.

EBGN537	ECONOMICS OF WATER	3.0
HASS588	GLOBAL WATER POLITICS AND POLICY	3.0
HASS584	US WATER POLITICS AND POLICY	3.0

In addition, students will choose a third course from a broader list that also includes courses in complementary areas of communication, economics, law, philosophy, and policy. Current course options are listed below. Because course options are continually expanding, additional complementary courses (beyond those listed here) may be approved on an ad hoc basis by the coordinator of the Hydrology, Policy, and Management track and the HSE program director in response to individual student requests.

EBGN537	ECONOMICS OF WATER	3.0
EBGN570	ENVIRONMENTAL ECONOMICS	3.0
HASS521	ENVIRONMENTAL PHILOSOPHY	3.0
HASS523	ADVANCED SCIENCE COMMUNICATION	3.0
HASS525	ENVIRONMENTAL COMMUNICATION	3.0
HASS560	GEPOLITICS OF NATURAL RESOURCES	3.0
HASS565	SCIENCE, TECHNOLOGY, AND SOCIETY	3.0
HASS568	ENVIRONMENTAL JUSTICE	3.0
HASS588	GLOBAL WATER POLITICS AND POLICY	3.0
HASS584	US WATER POLITICS AND POLICY	3.0
HASS593	NATURAL RESOURCES & ENERGY POLICY: THEORIES AND PRACTICE	3.0
MNGN571	ENERGY, NATURAL RESOURCES, AND SOCIETY	3.0
PEGN530	ENVIRONMENTAL LAW AND SUSTAINABILITY	3.0

A grade of B- or better is required in all core classes for graduation.

Design Courses

For non-thesis MS students, the following is a list of **Design Courses** that may be completed in lieu of an Independent Study:

CEEN515	HILLSLOPE HYDROLOGY AND STABILITY	3.0
CEEN581	WATERSHED SYSTEMS MODELING	3.0
CEEN575	HAZARDOUS WASTE SITE REMEDIATION	3.0
CEEN584	SUBSURFACE CONTAMINANT TRANSPORT	3.0
GEGN532	GEOLOGICAL DATA ANALYSIS	3.0
GEGN575	APPLICATIONS OF GEOGRAPHIC INFORMATION SYSTEMS	3.0
GEGN583	MATHEMATICAL MODELING OF GROUNDWATER SYSTEMS	3.0
GEGN584	FIELD METHODS IN HYDROLOGY	3.0

GEGN586	NUMERICAL MODELING OF GEOCHEMICAL SYSTEMS	3.0
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Elective courses may be chosen from the approved list below or as approved by your advisor or thesis committee.

CEEN511	UNSATURATED SOIL MECHANICS	3.0
CEEN512	SOIL BEHAVIOR	3.0
CEEN515	HILLSLOPE HYDROLOGY AND STABILITY	3.0
CEEN560	MOLECULAR MICROBIAL ECOLOGY AND THE ENVIRONMENT	3.0
CEEN562	ENVIRONMENTAL GEOMICROBIOLOGY	3.0
CEEN570	WATER AND WASTEWATER TREATMENT	3.0
CEEN571	ADVANCED WATER TREATMENT ENGINEERING AND WATER REUSE	3.0
CEEN575	HAZARDOUS WASTE SITE REMEDIATION	3.0
CEEN581	WATERSHED SYSTEMS MODELING	3.0
GEGN532	GEOLOGICAL DATA ANALYSIS	3.0
GEGN573	GEOLOGICAL ENGINEERING SITE INVESTIGATION	3.0
GEGN575	APPLICATIONS OF GEOGRAPHIC INFORMATION SYSTEMS	3.0
GEGN581	ANALYTICAL HYDROLOGY	3.0
GEGN584	FIELD METHODS IN HYDROLOGY	3.0
GEGN586	NUMERICAL MODELING OF GEOCHEMICAL SYSTEMS	3.0
GEOL540	ISOTOPE GEOCHEMISTRY AND GEOCHRONOLOGY	3.0
MATH530	INTRODUCTION TO STATISTICAL METHODS	3.0
MATH531	THEORY OF LINEAR MODELS	3.0
MATH532	SPATIAL STATISTICS	3.0
EBGN510	NATURAL RESOURCE ECONOMICS	3.0
HASS588	GLOBAL WATER POLITICS AND POLICY	3.0
GEGN585	FLUID MECHANICS FOR HYDROLOGY	2.0

Directors

Jonathan (Josh) Sharp, HSE Director, Professor, Civil & Environmental Engineering

David Benson, HSE Associate Director, Professor, Geology & Geological Engineering

Department of Chemistry

James Ranville, Professor

Bettina Voelker, Professor

Department of Civil & Environmental Engineering

Eric Anderson, Associate Professor

Christopher Higgins, Professor

Terri Hogue, Dean of Earth & Society Programs

Tissa Illangasekare, Professor and AMAX Distinguished Chair

Ning Lu, Professor

Junko Munakata Marr, Professor and Department Head CEE

John McCray, Professor

John Spear, Professor

Department of Economics and Business

Steven M. Smith, Assistant Professor

Department of Geology and Geological Engineering

Adrienne Marshall, Assistant Professor, Geology and Geological Engineering

Reed Maxwell, Professor

Danica Roth, Assistant Professor

Paul Santi, Professor

Kamini Singha, Professor

Alexis Sitchler, Associate Professor

Wendy Zhou, Professor

Department of Geophysics

John Bradford, Vice President for Global Initiatives

Brandon Dugan, Professor and Baker Hughes Chair in Petrophysics & Borehole Geophysics and Associate Department Head GP

Matthew Siegfried, Assistant Professor

Department of Humanities, Arts and Social Sciences

Hussein Amery, Professor

Adrienne Kroepsch, Assistant Professor

Department of Mechanical Engineering

Nils Tilton, Associate Professor

Department of Mining Engineering

Rennie Kaunda, Assistant Professor

Department of Petroleum Engineering

Yu-Shu Wu, Professor