ENGG*3220 Groundwater Engineering

01

Winter 2024
Section(s): 01

School of Engineering
Credit Weight: 0.50
Version 1.00 - January 04, 2024

---

1 Course Details

1.1 Calendar Description

This course introduces water resources engineering and environmental engineering students to the fundamentals of groundwater systems. Emphasis is placed on quantitative analyses required for groundwater resource extraction and quality protection of the saturated zone. Laboratories emphasize problem solving, use of commercial software and practical groundwater engineering investigation.

Pre-Requisites:	ENGG*2230
Restrictions:	Non-BENG students may take a maximum of 4.00 ENGG credits.

1.2 Course Description

This is an introductory course in groundwater engineering, an important area of practice for water resource and environmental engineers. The main goals of the course are: (1) to teach students fundamental concepts in applied quantitative hydrogeology; and (2) to provide understanding of practical engineering tools and approaches for analysis including field and lab work.

1.3 Timetable

Lectures:

Tuesday, Thursday		11:30AM - 12:50PM	MCKN, Room 233

Laboratory:

Friday	Sec 01	8:30AM - 10:20AM	*Soils Lab:* THRN 1107

			Seminar Room: MCKN 314 *Computer Lab:* THRN 2336
Wednesday	Sec 02	1:30PM - 3:20PM	*Soils Lab:* THRN 1107 *Seminar Room:* MCKN 308 *Computer Lab:* THRN 2336

Should the instructor, laboratory technician or GTA be ill and/or need to self-isolate, classes or labs (as appropriate) will be held online for that period. Should the University or Province of Ontario close face to face instruction moving forward, the lectures and labs, as appropriate, will be held online.

1.4 Final Exam

Thursday, **April 11, 2024: 08:30-10:30**, Room TBA on WebAdvisor.

The exam will be written in person (face to face).

---

2 Instructional Support

2.1 Instructional Support Team

Instructor: Jana Levison Ph.D., P.Eng.
Email: jlevison@uoguelph.ca
Office: RICH 3505

Lab Technician: Ryan Smith
Email: rsmith17@uoguelph.ca
Telephone: +1-519-824-4120 x53278
Office: THRN 1114

2.2 Teaching Assistants

Teaching Assistant (GTA): Elli Pattrick
Email: epattric@uoguelph.ca
Office Hours: Students can speak with the GTA during weekly labs.

---

3 Learning Resources

3.1 Required Resources

Course Website (Website)
https://courselink.uoguelph.ca

Course material, news, announcements, and grades will be regularly posted to the ENGG*3220 CourseLink site. You are responsible for checking the site regularly.

Applied Hydrogeology (Textbook)
https://bookstore.uoguelph.ca/p-21667-applied-hydrogeology.aspx
C.W. Fetter and D. Kreamer, **5th edition**, Waveland Press, Inc. **You need to purchase this textbook.**

*This is a **new** edition of the textbook that became available at the end of 2021.*

Alternatively you can purchase or rent an eTextbook copy here: https://www.vitalsource.com/en-ca/products/applied-hydrogeology-c-w-fetter-david-kreamer-v9781478648000

Groundwater (Textbook)
https://gw-project.org/books/groundwater/
A. Freeze and J.A. Cherry, Prentice Hall, 1979. A pdf version of this textbook is available at the above link (through The Groundwater Project).

3.2 Recommended Resources

Recommended Resources (Textbook)
There are various groundwater textbooks and resources available at the library, should you wish to do additional reading.

The Groundwater Project has numerous groundwater eTextbooks available (for free!) on focused topics. It is highly recommended that you use these wonderful resources for supplemental reading and learning. https://gw-project.org/books/

3.3 Additional Resources

Lecture Information (Notes)
The lecture slides are posted on CourseLink. Additional information is added to these slides during the lectures.

Lab Information (Lab Manual)
The handouts for all the lab sessions are within the labs section of CourseLink.

Exams (Other)
Any pertinent resources will be posted on CourseLink.

Miscellaneous Information (Other)
Additional resources (e.g., links to pertinent web pages) can be found on CourseLink.

3.4 Other Important Dates

Tuesday, January 9, 2024: first class

Monday, February 19, 2024: Winter Break begins (NO CLASSES SCHEDULED THIS WEEK)

Friday, March 29, 2024: holiday - Good Friday (no lab -> rescheduled to Monday, April 8)

Monday, April 8, 2024: last day of classes

Please refer to the undergraduate calendar for the semester scheduled dates.

3.4 Relationships with other Courses & Labs

Previous Courses:

ENGG*2230: Fundamentals of gravity and pressure driven flow.

Follow-on Courses:

ENGG*4240: Groundwater remediation technologies

---

4 Learning Outcomes

4.1 Course Learning Outcomes

By the end of this course, you should be able to:

1. Understand principals of and apply equations governing groundwater flow.
2. Conduct and interpret parameter estimation tests and analyses.
3. Apply fundamental knowledge to the design of groundwater resource extraction systems.
4. Understand and apply contaminant transport principals for porous media subsurface systems.
5. Use common software tools to aid quantitative analysis (e.g., interpretation of aquifer tests).

4.2 Engineers Canada - Graduate Attributes (2018)

Successfully completing this course will contribute to the following:

#	Outcome	Learning Outcome
1	Knowledge Base	1, 2, 3, 4
1.4	Recall, describe and apply program-specific engineering principles and concepts	1, 2, 3, 4
2	Problem Analysis	2, 3
2.1	Formulate a problem statement in engineering and non-engineering	2, 3

#	Outcome	Learning Outcome
	terminology	
2.2	Identify, organize and justify appropriate information, including assumptions	2, 3
2.3	Construct a conceptual framework and select an appropriate solution approach	2, 3
2.4	Execute an engineering solution	2, 3
5	Use of Engineering Tools	3, 5
5.1	Select appropriate engineering tools from various alternatives	5
5.2	Demonstrate proficiency in the application of selected engineering tools	3, 5
8	Professionalism	3
8.1	Demonstrate an understanding of what it means to be a professional engineer and distinguish between legislated and non-legislated professions	3
9	Impact of Engineering on Society and the Environment	3, 4
9.1	Analyze the safety, social, environmental, and legal aspects of engineering activity	3, 4

5 Teaching and Learning Activities

5.1 Lecture

Weeks 1 to 3

Topics: Principles of and equations governing groundwater flow

References: Fetter and Kreamer: Ch. 2, 3, 4

- Review of: aquifers, aquitards, hydraulic conductivity, intrinsic permeability, transmissivity, porosity, specific yield, storativity, hydraulic head, hydraulic gradient, recharge
- Homogeneity/heterogeneity and isotropy/anisotropy
- Darcy's law and its applicability
- Determining groundwater recharge from baseflow
- Derivation of 3D flow equations for confined and unconfined porous media aquifers
- Solutions of 3D flow equations for confined and unconfined porous media aquifers

- Boundary conditions
- Dupuit assumptions
- Review of flow nets

Weeks 4 to 6

Topics: Flow to wells, parameter estimation tests and aquifer properties

References: Fetter and Kreamer: Ch. 5, 6

- Radial flow
- Drawdown caused by a pumping well
- Determining aquifer parameters from time-drawdown data (pumping tests)
- Scale and representative elementary volume
- Slug tests
- Software for aquifer test analysis
- Unsaturated zone properties in a recharge context

Weeks 6 to 8

Topics: Groundwater resource extraction (for water supply and site dewatering)

References: Fetter and Kreamer: Ch. 5, 11, 7, 8

- Aquifer-test design (timing, wells/piezometer design)
- Well interference
- Well drilling, construction, maintenance and related legislation
- Sustainable yield
- Introduction to considerations for fractured bedrock systems
- Regional flow systems and geology of groundwater occurrence

Mon, Feb 19 - Fri, Feb 23

Topics: Winter Study Break

Tue, Feb 27

Topics: Midterm exam (in class)

Weeks 8 to 9

Topics: Introduction to subsurface contaminant transport

References: Fetter and Kreamer: Ch. 10

- Mass transport in porous media systems (advection, diffusion, mechanical dispersion, hydrodynamic dispersion, retardation, degradation)
- Point and non-point sources of groundwater contamination
- Groundwater monitoring (sampling, multilevel installations)
- Introduction to tracer experiments and environmental tracers (e.g., isotopes)
- Case history: Walkerton Tragedy
- Case histories: contaminated sites (e.g., Love Canal; Hinkley)

Week 10

Topics: Source water protection in a groundwater context (may be discussed partially during week 9)

References: Fetter and Kreamer: Ch. 11

- Delineating wellhead protection areas and related policy
- Groundwater under the direct influence of surface water (GUDI)
- Recharge and discharge areas
- Water budgets (from a groundwater perspective)
- Case histories/research examples: e.g. development of the City of Guelph water supply system

Weeks 11 to 12

Topics: Introduction to groundwater modelling

References: Fetter and Kreamer: Ch. 13

- Review of finite difference method
- Boundary conditions for numerical models
- Excel models
- Case histories: application of commercial groundwater models for flow and contaminant transport

5.2 Lab

Week 1 (Lab 1)

Topics: **Introduction** to the 3220 labs and safety training (meet the

GTA, Lab Technician and your lab section members; sign up for lab groups)

References: Laboratory Technician: Ryan
GTA: Elli

Location: Soils Lab

Due: Friday of Week 2 by 5 pm (not graded)

Week 2 (Lab 2)

Topics: **Calculation lab:** baseflow, Darcy's law, groundwater flow

References: GTA: Ceilidh

Location: Seminar Room

Due: Friday of Week 3 by 5 pm (not graded)

Week 3 (Lab 3 or 4)

Topics: **Within your lab section, you will be split two groups this week and next week (according to the group you signed up for during Week 1/Lab 1).** Half of you (Group A) will do Lab 3 with Ryan (in the Soils Lab), and half of you (Group B) will do Lab 4 with Elli (in your Seminar Room).

Lab 3, Water Lab: investigation of flow, pumping and contaminant transport using a physical aquifer model (porous media)

Lab 4, Calculation lab: groundwater flow equations and flow nets, pumping test analysis

References: Lab 3: Ryan (Laboratory Technician)
Lab 4: Elli (GTA)

Location: Lab 3 in Soils Lab and Lab 4 in Seminar Room

Due: Friday of Week 4 by 5 pm (Lab 3 graded; Lab 4 not graded)

Week 4 (Lab 4 or Lab 3)

Topics: Opposite of what you did during Week 3 (see above description).

References: See above

Location: See above

Due: Friday of Week 5 by 5 pm (Lab 3 graded; Lab 4 not graded)

Week 5 (Lab 5)

Topics: **Calculation lab:** pumping test and slug test analysis

References: GTA: Elli

Location: Seminar Room

Due: Friday of Week 6 by 5 pm (not graded)

Week 6 (Lab 6)

Topics: **Computer lab:** software for interpreting common aquifer tests (AquiferTest)

References: GTA: Elli

Location: Computer Lab

Due: Friday of Week 7 by 5 pm (graded)

Week 7 (Lab 7)

Topics: **Calculation lab:** groundwater resource extraction/understanding regional flow systems

References: GTA: Elli

Location: Seminar Room

Due: Friday of Week 8 by 5 pm (not graded)

Week 8 (Lab 8)

Topics:	**Water lab**: 1) investigation of flow, pumping and contaminant transport using a physical aquifer model (fractured bedrock) and 2) intro to core logging
References:	GTA: Elli Laboratory Technician: Ryan

Location: Soils Lab

Due: Friday of Week 9 by 5 pm (not graded)

Week 9 (Lab 9 or Lab 10)

Topics:	**Within your lab section, you will be split into two groups this week and next week (same split as weeks 3 and 4).** Half of you (Group A) will do Lab 10 with Ryan (field lab outside), and half of you (Group B) will do Lab 11 with Elli (in your Seminar Room). **Lab 9, Field Lab:** measuring groundwater levels, conducting slug tests, and intro to field equipment for pumping tests at the Morwick Groundwater Research Centre, 360 College Ave. E **Lab 10, Calculation Lab:** hydraulic characterization methods (pumping tests)
References:	Lab 9: Ryan (Laboratory Technician) Lab 10: Elli (GTA)

Location: Lab 9 at the Morwick Groundwater Research Centre, 360 College Ave. E and Lab 10 in Seminar Room

Due: Friday of Week 10 by 5 pm (Lab 9 graded; Lab 10 graded)

Week 10 (Lab 10 or Lab 9)

Topics:	Opposite of what you did during Week 9 (see above description)
References:	See above

Location: See above

Due: Friday of Week 11 by 5 pm (Lab 9 graded; Lab 10 graded)

Week 11 (Lab 11)

Topics: **Calculation lab:** solute transport in porous media

References: GTA: Elli

Location: Seminar Room

Due: Friday of Week 12 by 5 pm (not graded)

Week 12 (Lab 12)

Topics: **Computer lab:** constructing a simple finite difference model to examine flow system properties (investigate effect of changing aquifer parameters and boundary conditions)

References: GTA: Elli

Location: Computer Lab

Due: End of lab period (graded)

---

6 Assessments

6.1 Marking Schemes & Distributions

Name	Scheme A (%)
Labs (5 graded)	30
Midterm exam	30
Laboratory participation	5
Final exam	35
Total	100

6.2 Assessment Details

Labs (30%)
Learning Outcome: 1, 2, 3, 4, 5
See lab schedule for due dates

5 labs graded (6% each)

Midterm Exam (30%)
Date: Tue, Feb 27, 11:30 AM - 12:50 PM, In class
Learning Outcome: 1, 2

Laboratory Participation (5%)
Date: Mon, Jan 8 - Mon, Apr 8
Learning Outcome: 1, 2, 3, 4, 5

Final Exam (35%)
Date: Thu, Apr 11, 08:30 AM - 10:30 AM, Room TBA on WebAdvisor
Learning Outcome: 1, 2, 3, 4

---

7 Course Statements

7.1 Course Grading Policies

Missed Assessments: If you are unable to meet an in-course requirement due to medical, psychological, or compassionate reasons, please email the course instructor. See the undergraduate calendar for information on regulations and procedures for Academic Consideration:
http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml

Accommodation of Religious Obligations: If you are unable to meet an in-course requirement due to religious obligations, please email the course instructor within two weeks of the start of the semester to make alternate arrangements. See the undergraduate calendar for information on regulations and procedures for Academic Accommodation of Religious Obligations:
http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-accomrelig.shtml

Passing grade: In order to pass the course, you must pass either the midterm exam or the final exam. Students must obtain a grade of 50% or higher on either the midterm or final exam portions of the course in order for the laboratory assignment and laboratory participation portion of the course to count towards the final grade.

Missed tests: If you miss the midterm exam due to grounds for granting academic consideration or religious accommodation, the weight of the missed midterm exam will be added to the final exam. There will be no makeup midterm exam.

Lab Work: You must attend and complete all laboratories. If you miss a laboratory due to grounds for granting academic consideration or religious accommodation, the weight of that missed assessment will be added to the final exam.

Late Lab Reports: Late submissions of lab reports will not be accepted.

8 School of Engineering Statements

8.1 Instructor's Role and Responsibility to Students

The instructor’s role is to develop and deliver course material in ways that facilitate learning for a variety of students. Selected lecture notes will be made available to students on Courselink but these are not intended to be stand-alone course notes. Some written lecture notes will be presented only in class. During lectures, the instructor will expand and explain the content of notes and provide example problems that supplement posted notes. Scheduled classes will be the principal venue to provide information and feedback for tests and labs.

8.2 Students' Learning Responsibilities

Students are expected to take advantage of the learning opportunities provided during lectures and lab sessions. Students, especially those having difficulty with the course content, should also make use of other resources recommended by the instructor. Students who do (or may) fall behind due to illness, work, or extra-curricular activities are advised to keep the instructor informed. This will allow the instructor to recommend extra resources in a timely manner and/or provide consideration if appropriate.

8.3 Lab Safety

Safety is critically important to the School and is the responsibility of all members of the School: faculty, staff and students. As a student in a lab course you are responsible for taking all reasonable safety precautions and following the lab safety rules specific to the lab you are working in. In addition, you are responsible for reporting all safety issues to the laboratory supervisor, GTA or faculty responsible.

9 University Statements

9.1 Email Communication

As per university regulations, all students are required to check their e-mail account regularly: e-mail is the official route of communication between the University and its students.

9.2 When You Cannot Meet a Course Requirement

When you find yourself unable to meet an in-course requirement because of illness or compassionate reasons please advise the course instructor (or designated person, such as a teaching assistant) in writing, with your name, id#, and e-mail contact. The grounds for Academic Consideration are detailed in the Undergraduate and Graduate Calendars.

Undergraduate Calendar - Academic Consideration and Appeals
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml

Graduate Calendar - Grounds for Academic Consideration
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/index.shtml

Associate Diploma Calendar - Academic Consideration, Appeals and Petitions
https://www.uoguelph.ca/registrar/calendars/diploma/current/index.shtml

9.3 Drop Date

Students will have until the last day of classes to drop courses without academic penalty. The deadline to drop two-semester courses will be the last day of classes in the second semester. This applies to all students (undergraduate, graduate and diploma) except for Doctor of Veterinary Medicine and Associate Diploma in Veterinary Technology (conventional and alternative delivery) students. The regulations and procedures for course registration are available in their respective Academic Calendars.

Undergraduate Calendar - Dropping Courses
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-drop.shtml

Graduate Calendar - Registration Changes
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/genreg-reg-regchg.shtml

Associate Diploma Calendar - Dropping Courses
https://www.uoguelph.ca/registrar/calendars/diploma/current/c08/c08-drop.shtml

9.4 Copies of Out-of-class Assignments

Keep paper and/or other reliable back-up copies of all out-of-class assignments: you may be asked to resubmit work at any time.

9.5 Accessibility

The University promotes the full participation of students who experience disabilities in their academic programs. To that end, the provision of academic accommodation is a shared responsibility between the University and the student.

When accommodations are needed, the student is required to first register with Student Accessibility Services (SAS). Documentation to substantiate the existence of a disability is required; however, interim accommodations may be possible while that process is underway.

Accommodations are available for both permanent and temporary disabilities. It should be noted that common illnesses such as a cold or the flu do not constitute a disability.

Use of the SAS Exam Centre requires students to make a booking at least 14 days in advance, and no later than November 1 (fall), March 1 (winter) or July 1 (summer). Similarly, new or changed accommodations for online quizzes, tests and exams must be approved at least a week ahead of time.

For Guelph students, information can be found on the SAS website
https://www.uoguelph.ca/sas

For Ridgetown students, information can be found on the Ridgetown SAS website

https://www.ridgetownc.com/services/accessibilityservices.cfm

9.6 Academic Integrity

The University of Guelph is committed to upholding the highest standards of academic integrity, and it is the responsibility of all members of the University community-faculty, staff, and students-to be aware of what constitutes academic misconduct and to do as much as possible to prevent academic offences from occurring. University of Guelph students have the responsibility of abiding by the University's policy on academic misconduct regardless of their location of study; faculty, staff, and students have the responsibility of supporting an environment that encourages academic integrity. Students need to remain aware that instructors have access to and the right to use electronic and other means of detection.

Please note: Whether or not a student intended to commit academic misconduct is not relevant for a finding of guilt. Hurried or careless submission of assignments does not excuse students from responsibility for verifying the academic integrity of their work before submitting it. Students who are in any doubt as to whether an action on their part could be construed as an academic offence should consult with a faculty member or faculty advisor.

Undergraduate Calendar - Academic Misconduct
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-amisconduct.shtml

Graduate Calendar - Academic Misconduct
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/index.shtml

9.7 Recording of Materials

Presentations that are made in relation to course work - including lectures - cannot be recorded or copied without the permission of the presenter, whether the instructor, a student, or guest lecturer. Material recorded with permission is restricted to use for that course unless further permission is granted.

9.8 Resources

The Academic Calendars are the source of information about the University of Guelph's procedures, policies, and regulations that apply to undergraduate, graduate, and diploma programs.

Academic Calendars
https://www.uoguelph.ca/academics/calendars

9.9 Illness

Medical notes will not normally be required for singular instances of academic consideration, although students may be required to provide supporting documentation for multiple missed assessments or when involving a large part of a course (e.g.. final exam or major assignment).