

Course Outline
EARTH SCIENCES 458
PHYSICAL HYDROGEOLOGY
Fall Term 2016

INSTRUCTORS

Lectures (Earth 458)

Jason Davison
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Laboratories (Earth 458L)

Dr. Will Robertson
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TEACHING ASSISTANT

Maxime Salman
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Office hours: *To Be Announced*

MEETING TIMES AND PLACES

Lectures

Monday	2:30 pm – 3:20 pm in B2 350
Wednesday	2:30 pm – 3:20 pm in B2 350
Friday	2:30 pm – 3:20 pm in B2 350

Laboratories

Friday	11:30 am – 2:20 pm in EIT 1013 (may meet at other locations for field work)
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COURSE MATERIALS

Text book: *Fundamentals of Ground Water* F.W. Schwartz and H. Zhang,
Applied Hydrogeology, C.W. Fetter,
Groundwater, R.A. Freeze and J.A. Cherry
(<http://hydrogeologistswithoutborders.org/wordpress/textbook-project/>)

Class notes: The lectures will be provided online through LEARN.

Laboratory Manual: Purchased from the Davis Centre Copy Centre (~\$10)

GRADING

Earth 458:

- Assignments (40%) (~5 assignments) **Group Assignments (Groups of 4 to 5 Students)**
- Mid-Term Exam (30%) **Date to be announced; likely second week in October**
- End-of-Term Exam (30%) ** Date to be announced; likely fourth week in November**
- (No final exam)

Earth 458L:

- Laboratories (100%) (6 Labs)

CLASSROOM POLICY

Group Assignments

The students will pick their own class groups, and each group will be between 4 and 5 students. **Every student is expected to solve each problem individually.** Afterwards, the students will work with their teammates and create one master document to turn in. All assignments must follow typical industry standards (e.g. typed or neatly hand written, significant figures, logical problem solving steps). **Please follow the homework guidelines.**

Travel Plans and the Final Exam

The mid-term and end-of-term exams for the term are to be held during class, most likely during the second week of October and fourth week of November, respectively. The schedule will be determined during class. Note: ***Do not make travel plans that will cause you to miss these exams***, the university does not consider this to be a valid excuse and student travel is not considered acceptable grounds for granting an alternative examination times. (see <http://www.registrar.uwaterloo.ca/exams/finalexams.html>).

Submission of work:

All assignments and laboratories will have specific due dates and times. Late submission may be made in the event of illness (or extraordinary circumstances) but *the professor* must be notified of the illness (e.g., via email) *prior* to the assignment deadline. **No late assignments or labs will be accepted.** No makeup assignments or labs will be provided for missed assignments or labs.

Attendance policy:

Attendance at every laboratory is mandatory. The fieldwork is a critical part of this course and often you will be working in teams and so your lack of attendance will likely result in some hardship for your group. You must be present for each lab in order to get full credit for that lab. Exceptions may be made in the event of illness (or extraordinary circumstances) but *the professor* must be notified of the illness (e.g., via email) prior to the lab.

DESCRIPTION OF THE CLASSROOM COURSE

This course is an introduction to Physical Hydrogeology and will examine fundamental physical processes affecting flow of groundwater and contaminants in the subsurface. Hydrogeology is a multidisciplinary field that incorporates topics such as geology, hydrology, chemistry, physics, and mathematics. We will be examining a wide range of topics including properties of materials (geologic and fluid), groundwater flow systems, fundamental groundwater flow equations, aquifer testing, unsaturated zone flow, groundwater/surface-water interactions, and contaminant transport. Emphasis will be placed on the application of theory and quantitative methods to solve practical problems. This course will provide you with an understanding of fundamental hydrogeologic principles and the tools necessary to investigate common groundwater related problems.

STUDENT RESPONSIBILITIES

Note for Students with Disabilities:

The AccessAbility Service (AAS), located in Needles Hall, Room 1401, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with the AAS at the beginning of each academic term.

Academic Integrity:

In order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect and responsibility.

Note on Avoidance of Academic Offences:

Studying and working in groups to learn material can be a very valuable practice and is encouraged. However, plagiarism and cheating will not be tolerated and will be considered an academic offense and subject to disciplinary action. Plagiarism is the act of presenting the ideas, words or other intellectual property of another as one's own, whether in written, oral or other form, in an examination, report, or assignment. Cheating includes (but is not limited to) copying from another student's work or allowing another student to copy one's own work, submitting another person's work as one's own, fabrication of data, consultation with any unauthorized person during an examination or test (in oral, written or other form), and use of unauthorized aids.

All students registered in the courses of the Faculty of Science are expected to know what constitutes academic integrity, to avoid committing academic offences (e.g., cheating and plagiarism), and to take responsibility for their actions. When the commission of an offence is established, disciplinary penalties will be imposed in accord with Policy #71 (Student Academic Discipline). For information on categories of offences and types of penalties, students are directed to consult Policy #71

<http://www.adm.uwaterloo.ca/infosec/Policies/policy71.htm>. If you need help in learning what constitutes an academic offence; how to avoid offences such as plagiarism, cheating, and double submission; how to follow appropriate rules with respect to "group work" and collaboration; or if you need clarification of aspects of the discipline policy, ask your TA and/or your course instructor for guidance. Other resources regarding the discipline policy are your academic advisor and the Undergraduate Associate Dean. You should also refer to the document titled "Student Misconduct: What you need to know" found at <http://www.adm.uwaterloo.ca/infosec/students/studentmisconduct.htm>. The Faculty of Arts also has an excellent website on "Avoiding Academic Offences" which can be found at http://arts.uwaterloo.ca/arts/ugrad/academic_responsibility.html and Science students can also benefit from reviewing this information.

Ethical Behavior:

You should also be aware of University Policy #33 regarding Ethical Behavior. The policy aims to ensure an environment of tolerance and respect and believes that the right of individuals to advance their views openly must be upheld throughout the University. People should be free from discrimination, harassment, sexual harassment, and a "poisoned environment". The policy can be found at:

<http://www.adm.uwaterloo.ca/infosec/Policies/policy33.htm>

Student grievances:

Students who believe that they have been wrongfully or unjustly penalized have the right to grieve and they should refer to Policy #70, Student Grievance, <http://www.adm.uwaterloo.ca/infosec/Policies/policy70.htm>

Student appeals:

Concerning a decision made under Policy 33 (Ethical Behavior), Policy 70 (Petitions and Grievances) or Policy 71 (Student Discipline), a student may appeal the findings, the penalty, or both. Students who believe that they have grounds for an appeal should refer to Policy 72 (Student appeals),

<http://www.adm.uwaterloo.ca/infosec/Policies/policy72.htm>

TENTATIVE LECTURE SCHEDULE FOR CLASSROOM COURSE

Note: the lecture schedule/content is subject to change depending on how the course evolves over the term

Part 1

Week No. 1 and 2:

Introduction and scope of the course; Groundwater in the hydrologic cycle, porosity, aquifers and aquitards.

Week No. 3:

Concepts of fluid potential, hydraulic head and porosity, hydraulic gradient, monitoring wells and piezometers.

Week No. 4:

Darcy's Law and its applicability, permeability and hydraulic conductivity, overview of methods for measuring hydraulic conductivity grain size distribution, permeameters, specific discharge (Darcy flux) versus groundwater velocity.

Week No. 5: Anisotropy and heterogeneity in hydraulic conductivity; geometric and harmonic means, introduction to flow nets.

Week No. 6: (Midterm Exam week) Flow lines and flow nets; Refraction of flow lines Compressibility, specific storage and storage coefficient and Specific yield; Steady versus transient flow; case histories.

Part 2

Week No. 6:

Mass continuity equations for steady state and transient groundwater flow.

Week No. 7:

Soil moisture in the unsaturated (vadose) zone; capillarity and soil-water tension, relative permeability; continuity equation for unsaturated flow; Infiltration, recharge and runoff; case histories.

Week No. 8:

Regional groundwater flow systems; Water budgets and evaluation of components; Safe yield concept; groundwater-surface water interactions.

Week No. 9:

Cone of depression and capture zones due to groundwater pumping; Aquifer hydraulics.

Week No. 10:

Hydraulic testing: single well response tests and pumping tests, introduction to fractured rock environments.

Week No. 11:

Introduction to groundwater contamination, types and sources of contamination; Physical processes affecting contaminant migration (advection, mechanical dispersion, molecular diffusion), chemical and biological attenuation; Contaminant travel times, breakthrough curves; Advection-dispersion (continuity) equation for solute transport; Simple solutions and behavior.

Week 12: (End of term exam)

Exam Review

TENTATIVE LABORATORY SCHEDULE

First lab starts on September 16th.

Each Lab will meet at EIT 1013 (unless otherwise noted) at 11:30 am Friday. An introductory tutorial, as well as the pertinent information or handout, will be given at the beginning. Then class will adjourn to wherever the Lab is being held (e.g., North campus field site — behind the Optometry Building)

Introduction and form groups
Core logging
Permeameter & Grain Size Lab
Piezometer Response Test (Slug Test) Lab
Water table/Flow Net Lab
Water table/Flow Net Tutorial
Pumping Test
Pumping Test Tutorial
Nitrate Plume Fate
Nitrate Plume tutorial, end of course, final lab assignment due

Each Lab is due in one week unless otherwise stated above