Course Outline

EARTH SCIENCES 458
PHYSICAL HYDROGEOLOGY
Spring Term 2013

INSTRUCTORS

**Lectures (Earth 458C)**

Dr. David Rudolph  
Office: PHY 229B  
Telephone: (519) 888-4567 x36778  
Email: drudolph@uwaterloo.ca  
*Office hours: by e-mail appointment*

**Laboratories (Earth 458L)**

Dr. Will Robertson  
Office: EIT 2049  
Telephone: (519) 888-4567 x36800  
Email: wroberts@sciborg.uwaterloo.ca  
*Office hours: by e-mail appointment*

TEACHING ASSISTANTS

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<th><em>Office hours:</em></th>
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MEETING TIMES AND PLACES

**Lecture**  
Monday 12:30 - 1:20 pm in MC 2034  
Friday 12:30 - 2:20 pm in MC 2034

**Laboratories**  
Thursday 4:30 – 7:20 pm in CEIT 1013 (but may meet at other locations for field work)

COURSE MATERIALS


**Class notes:** Available from Davis copy centre week of May 6th, 2013.

**Laboratory Manual:** Available from the EIT copy centre.
GRADING

Earth 458C:

- Assignments (40%) (5 assignments)
- Mid-Term Exam (30%) **Friday, June 21, 2013 with location to be announced**
- End of term Exam (30%) **Friday, July 26, 2013 with location to be announced**
- (No final exam)

Earth 458L:

- Laboratories (100%) (6 Labs)

Travel Plans

_Do not make end of the term travel plans that will cause you to miss the mid-term or end of term 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 time. (see [http://www.registrar.uwaterloo.ca/exams/finalexams.html](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 will be accepted after corrected assignments have been returned to other students. No makeup assignments or labs will be provided for missed assignments or labs.

Penalties:

Late assignments will be deducted 10% for each day past the due date.
Labs will not be accepted past the due date.

Attendance policy:

Attendance at every laboratory is mandatory. The field work 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 Office for Persons with Disabilities (OPD), located in Needles Hall, Room 1132, 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 OPD 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, storage coefficient and specific yield; steady versus transient flow; case studies.

Part 2

Week No. 6: Mass continuity equations for steady state and transient groundwater flow. Regional groundwater flow systems.

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:
Groundwater-surface water interactions.

Week No. 9: (Canada Day)
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
Each Lab will meet at EIT 1013 on Thursday afternoon (unless otherwise noted), from 4:30 to 7:30. 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)

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<thead>
<tr>
<th>Date</th>
<th>Event</th>
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<tbody>
<tr>
<td>May 16</td>
<td>Form lab groups</td>
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<td>May 23</td>
<td>Core logging</td>
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<td>May 30</td>
<td>Permeameter &amp; Grain Size Lab</td>
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<td>June 6</td>
<td>Piezometer Response Test (Slug Test) Lab</td>
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<td>June 13</td>
<td>Water table/Flow Nets</td>
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<td>June 20</td>
<td>Water table/Flow Net Tutorial</td>
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<td>June 27</td>
<td>Pumping Test Lab in the field</td>
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<td>July 4</td>
<td>Pumping Test Tutorial</td>
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<td>July 11</td>
<td>Nitrate Plume Fate Lab Handed Out</td>
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<td>July 18</td>
<td>Nitrate Plume Fate Lab Tutorial</td>
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<tr>
<td>July 25</td>
<td>Final assignment due, end of course</td>
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***Each Lab is due in a week unless otherwise stated above***