Earth Sciences 146: Groundwater, Spring 2016

Instructor	**Teaching Assistant**	**Teaching Assistant**
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Office hours:	Office hours:	Office hours:
A209, M, Tu 1-2	A170 M, Tu: 12-1	A170 M 3-4, Tu: 2-3

Course hours: MWF, 9:30-10:40
Course location: E&MS D250
Laboratory hours: (1) Weds 13:30-16:30, (2) Weds 17:30-20:30, or (3) Thur 12:30-15:30
Laboratory location: E&MS D250 (and occasionally in the field or Kresge 317-computer lab)

Field trip: Scott Creek (or Waddell Creek): **Saturday 5/7**, 0800 - 1700 (more or less…)
Saturday 5/14 is a rain date, so please keep this open if possible…
(Lab on Campus Hydrogeology – week of 4/25 – will also take us into the field)
Assignments: nine lab exercises, nine problem sets, technical report
Exams (both closed-book): Midterm – **Wednesday, 5/4, 9:30-10:40 (regular time)**
Final - **cumulative, Wednesday 6/8, 8:00-11:00**
Grades/Evaluations are to be based on the tests, labs, class participation, and assignments:

- 25% Labs and technical report
- 25% Problems sets
- 20% Midterm
- 25% Final
- 5% Class participation/demonstration of PMA and ROV

Required text: Fetter, 2001, *Applied Hydrogeology*, 4th edition
Supplementary reading: Freeze and Cherry, 1979, *Groundwater*
(on reserve in Science Library)
More reading: at the course website in a "virtual reader"
es.ucsc.edu/~afisher/Courses/Eart146, login required

Notes about reading and other assignments:
Please complete reading *prior* to class discussion, ask questions in class, visit during office hours. It can be read more carefully a second time after topic is discussed in detail or used in lab.

Labs and problem sets normally due one week after being handed out. Late assignments may be accepted, but points will be deducted. Chronic lateness is not acceptable.

All work turned in for grading should be neat and easy to read. Copy calculations to a clean page, if necessary. Working together is encouraged, but the work you turn in should be your own. All plots are to be generated using a computer (using Excel, Kaleidagraph, Matlab, R, etc.). Please see instructor, TA, and/or your colleagues for help.

Lecture, Lab, Assignment and Reading List
Subject to revision as the quarter progresses

Date	Presentation/Lab topic(s)	Readings/Problem sets
Week 1 M 3/28 – F 4/1 ***First class: M 3/28***	1. Introduction, motivation, overview, terminology	Fetter 1.1-1.10, 2.1-2.9 Freeze & Cherry 1.1-1.3 Stephens, 2009 (GW careers) Davis, 1994 and Focht, 1995 (GW careers)
	First week, no lab meetings	
	2. Terminology, water and soil properties	Fetter 3.1-3.3, 6.1-6.2 Freeze & Cherry 2.5 Nelson, 1997 (units) + conversion table **Hand out PS #1**
Week 2 M 4/4 – F 4/8	3. Darcy's Law, potential and head, aquifers	Fetter 3.4-3.6, 4.1-4.3, 4.5-4.6 Freeze & Cherry 2.1-2.3
W 4/6 or Th 4/7	*Lab 1: Darcy's law and soil properties*	*Fetter 3.4-3.5, 4.6*
	4. Water table, aquifer properties, measuring head, flow in aquifers	Fetter 3.7-3.9, 3.11-3.12 Freeze & Cherry 2.4, 2.7-2.8,2.10 Saines, 1981 **Hand in PS #1, hand out PS #2**
Week 3 M 4/11 – F 4/15 **Fri 4/15, no class**	5. Limitations of Darcy's law and the REV, flow refraction, flownets, conservation of mass equations	Fetter 4.7-4.12 Freeze & Cherry 2.11-2.12, 5.1 DWR: Fractured aquifers
W 4/13 or Th 4/14	*Lab 2: Flow nets and seepage*	*Fetter 4.9-4.12*
	6. Wells: design, hydraulics, testing	Fetter 5.1-5.5, 10.4 **Hand in PS #2, hand out PS #3**
Week 4 M 4/18 – F 4/22	6. Wells: design, hydraulics, testing (continued)	Fetter 5.1-5.5, 10.4 Freeze & Cherry 8.2 (p.312-314), 8.3, 8.6; DWR: groundwater wells
W 4/20 or Th 4/21	*Lab 3: Aquifer test analysis - by hand*	*Fetter 5.1-5.9*
	7. Wells: multiple pumping, boundaries aquifer properties, single well tests	Fetter 5.6-5.10 Freeze & Cherry 8.5-8.6 Rovey and Cherkauer, 1995 **Hand in PS#3, hand out PS #4**
Week 5 M 4/25 – F 4/29	8. Capture zones, confined vs. unconfined 1-D eqns, regional flow	Fetter 10.10, 4.13-4.14, 7.1-7.7 Freeze & Cherry 6.1-6.3
W 4/27 or Th 4/28 ***ON-CAMPUS FIELD TRIP***	*Lab 4: Campus (karst) hydrogeology*	*Fetter 8.3.4* *Johnson et al., 1989* *Freeze & Cherry, 11.4 (p. 513-515)*
	9. Effective stress, subsidence, groundwater modeling	Fetter 3.10, 13.1-13.4 Freeze & Cherry 2.9, 8.8, 8.10, 10.1 Bredehoeft and Hall, 1995 **Hand in PS #4, hand out PS #5**
Week 6 M 5/2 – F 5/6	10. Unsaturated properties, flow, and infiltration	Fetter 6.1-6.7 Freeze & Cherry 6.4, 8.1-8.2 Deming, 2002: 6.1-6.2
W 5/4 or Th 5/5	*Lab 5: Aquifer test analysis - by computer* ***(Kresge 317)***	*Fetter 5.1-5.9, 5.6, 5.9-5.10*
Wednesday, 5/4	**MIDTERM EXAMINATION** **12:30-1:40 (regular time), D250**	***covers material discussed through (and including) Week 5, closed book***
	10. Unsaturated properties, flow, and infiltration (continued)	**Hand in PS #5, Hand out PS #6**

SATURDAY 5/7 ***OFF-CAMPUS FIELD TRIP***	***Lab 6: Scott Creek/Waddell Creek*** **8 am – 5 pm, *details to follow…***	*Lee and Cherry, 1978*
Week 7 M 5/9 – F 5/13 *No lab meetings this week*	11. Unsaturated zone monitoring, groundwater chemistry	Fetter 10.5, 9.1-9.8, 9.13-9.14 Freeze & Cherry 3.1-3.3, 3.5
	Turn in Lab 5 at regular time, work on Lab 6	*Work with templates for report, rubric, etc.*
	12. Groundwater solute transport	Fetter 10.6 Freeze & Cherry 2.13, 3.4, 9.2 Wood, 1996 **Hand in PS #6, hand out PS #7**
SATURDAY 5/14 ****BACK-UP* FIELD TRIP***	***Lab 6: Scott Creek/Waddell Creek*** ***If rained out earlier…***	*Lee and Cherry, 1978*
Week 8 M 5/16– F 5/20 *W 5/18 or Th 5/19*	13. Groundwater contamination, well head protection	Fetter 10.1-01.4, 10.7 Freeze & Cherry 9.1, 9.3-9.5 Andrews, 1998 + Stanley, 1998
	*Lab 7: Groundwater modeling I (**Kresge 317**)*	*Fetter 13.1-13.4, 13.6-13.8* *Bredehoeft and Hall, 1995*
	14. Groundwater remediation	Fetter 10.8-10.9 Bredehoeft, 1994; Dasch et al., 1997; Nyer and Suthersan, 1996; Nyer and Fierro, 1998 **Hand in PS #7, hand out PS #8**
Week 9 M 5/23 – F 5/27 *W 5/25 or Th 5/26*	15. Salt water intrusion	Fetter 4.4; 8.7-8.9 Freeze & Cherry 8.13 Izbicki, 1996
	Lab 8: Tracer experiment	*Fetter 10.6*
	16. Groundwater management, groundwater law	Fetter 11.1-11.11 Freeze & Cherry 8.10-8.11 Dragonetti, 1998; Bredehoeft et al., 1982; Alley, 2004; Devlin, 2005; DWR GW management; DWR GW adjudication **Hand in PS #8, hand out PS #9**
Week 10 T 5/31 – F 6/3 ***Memorial Day, 5/30*** *W 6/1 or Th 6/2* **Last week of classes!**	17. Special topics in groundwater (I): geology, basins, and convection	Fetter 8.1-8.4, 8.10 Freeze & Cherry 4.1-4.6, 11.3
	*Lab 9: Groundwater modeling II? (**Kresge**)*	*Fetter 13.1-13.4, 13.6-13.8*
	18. Special topics in groundwater (II): ores and oil, geophysical logging	Freeze & Cherry 11.2 and 11.5 Fetter, 12.4 **Hand in PS #9**
Wednesday 6/8, 8-11 am	**FINAL EXAMINATION**	***Cumulative, closed book***