

CGN 6933: Groundwater Engineering
Department of Civil & Environmental Engineering
University of South Florida

Cunningham

Fall 2019

Course Description

Use of groundwater as a resource; physical factors governing groundwater flow; mathematical equations describing groundwater flow in aquifers; techniques for solving the relevant equations; applications of models to solve problems of environmental and/or engineering significance.

Course Objectives

During this semester, we will:

- review general concepts related to properties of porous media, properties of water, and flow through porous media;
- develop generalized flow equations that describe the movement of groundwater;
- see how “hydraulic potential” and “streamfunction” can be used as tools to quantitatively describe groundwater flow;
- develop analytical and numerical methods for quantitatively estimating and/or predicting groundwater flow rates, pressures, and elevations under a variety of conditions – confined and unconfined, homogeneous and heterogeneous, isotropic and anisotropic, steady and transient; and
- apply these methods to realistic problems of environmental and/or engineering significance (including problems containing pumps, rivers, lakes, ponds, recharge zones, and/or freshwater-saltwater interfaces, and with straight and/or circular boundary conditions).

Learning Outcomes

By the end of this semester, students should be able to:

- apply Darcy’s law to quantitatively describe the relationship between groundwater flux, hydraulic gradient, and hydraulic conductivity;
- apply the “analytic element” method to estimate groundwater flow rates, pressures, and/or elevations under homogeneous (spatial) and steady (temporal) conditions;
- write simple computer programs to estimate groundwater flow rates, pressures, and/or elevations under (relatively simple) heterogeneous (spatial) and steady (temporal) conditions;
- apply “classic” tools and techniques to estimate groundwater flow rates, pressures, and/or elevations under some specific non-steady/transient (temporal) conditions.

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- Lectures:** Tuesdays and Thursdays, 9:30–10:45 AM, room NES 104
- Credit:** 3 units, letter grade
- Instructor:** Professor J A Cunningham ENC (Engineering Bldg III), room 3215
cunning@usf.edu (813) 974-9540
- Office hours:** About 2–3 hrs/wk will be allocated for Groundwater Engineering office hours. I expect to announce the exact times during the first or second week of class.
- Text book:** *Groundwater Science*, **2nd edition**, by CW Fitts. Academic Press, 2012. ISBN 978-0-12-384705-8 for hard copy, or 978-0-12-384706-5 for e-book.
- Pre-requisites:** There are no specific pre-requisites for this class, but it is designed primarily for graduate students in engineering or geosciences. The class will include quantitative problem-solving. It would help if you have at least a little computer programming experience.
- E-mail:** Outside of class, I will use e-mail to disseminate information. This will be done through the Canvas program so I can reach all students at once. Make sure that Canvas delivers to an active e-mail account.
- Grading:** Final exam: 50%
Midterm exam: 25%
Homework (two “mini-projects” and two other graded assignments): 25%
- Web site:** Course documents – including homework assignments – will be posted on Canvas. I will also attempt to maintain a course web site linked to my home page.
- Reserves:** Once upon a time, we used the library to house books and references that were of general interest and benefit to the course. Nowadays, these are almost all available electronically, so we probably don’t need to use course reserves in the library any more. (For the youngsters in the class, a “library” is a physical brick-and-mortar building with a collection of “books”. If this sounds puzzling, you can google it for more details.)

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Course Schedule

The course schedule below is tentative. It is subject to change either in pace or in topics covered, although any changes to content will be minor. We will try to adhere to this schedule, but not to the point of detracting from students' learning the material.

Week #	Dates	Topics Covered	Assignment
Week 1	Aug 27 Aug 29	Course Introduction; groundwater as a resource Properties of water, properties of porous media	
Week 2	Sept 3 Sept 5	Darcy's law, conductivity, transmissivity Storativity; confined and unconfined aquifers	HW 1
Week 3	Sept 10 Sept 12	Flow equation Hydraulic potential: regional flow, extraction wells	HW 2
Week 4	Sept 17 Sept 19	Hydraulic potential: superposition, method of images Hydraulic potential: infiltration and recharge	HW 3
Week 5	Sept 24 Sept 26	Streamfunction and streamlines Streamfunction and streamlines	HW 4
Week 6	Oct 1 Oct 3	Flow modeling with potential and streamfunction Flow modeling with potential and streamfunction	
Week 7	Oct 8 Oct 10	Flow modeling with potential and streamfunction Anisotropy and principal directions	HW 5 (mini project 1)
Week 8	Oct 15 Oct 17	Anisotropy and principal directions <i>Midterm exam, covers material through Oct 8</i>	Midterm exam
Week 9	Oct 22 Oct 24	Heterogeneity Numerical modeling of groundwater flow	HW 6
Week 10	Oct 29 Oct 31	Numerical modeling of groundwater flow Numerical modeling; streamlines revisited	HW 7
Week 11	Nov 5 Nov 7	Well hydraulics, transient drawdown, Theis solution Pump tests	
Week 12	Nov 12 Nov 14	Jacob method; superposition, method of images Leaky aquifers	HW 8 (mini project 2)
Week 13	Nov 19 Nov 21	Falling-head permeameters, slug tests Special topic as time allows	HW 9
Week 14	Nov 26 Nov 28	Special topic as time allows <i>Thanksgiving holiday – no class</i>	
Week 15	Dec 3 Dec 5	Course wrap-up and evaluations <i>Reading day – no class</i>	HW 10
Week 16	Dec 10 Dec 12	Final exam, 7:30–9:30 AM (blech!)	Final exam

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Class Policies: 1, Homework Policy

- There will be 10 homework sets to be performed throughout the semester.
- Four of the homework assignments will be graded. Two of these will be homework #5 and #8. I haven't decided yet on which other assignments will be graded, but at the moment I am leaning towards #3 and #10.
- Students are *strongly* encouraged to complete *all* homework assignments diligently – even those which are not graded. Diligent completion of the homework assignments is the best way to prepare for the exams.
- The four graded assignments, together, will constitute 25% of the semester grade.
- Homeworks #5 and #8 are “mini-projects” and will count twice as much as the other two assignments. (If you work it out, that means that two of them are worth 4.167% each, and two of them are worth 8.333% each.)
- Graded assignments will be completed by *teams of two or three students* unless otherwise indicated. Ungraded assignments can be completed individually or in a group, as students prefer.
- The instructor will be available at least one hour each week, and probably more, to assist with homework problems. (Most likely about 2–3 hours per week.)
- Students may discuss the homework with each other. However, whatever work is submitted by a team should represent work actually completed by that team. Each team must conduct the actual computations and write up its own work without referring to the solutions of other teams. Copying the work of others (including text, computations, figures, tables, sections of computer programs, spreadsheets, or sections of lab reports) will be considered cheating.
- You may not refer to a previous year's solution sets when completing the homework. That constitutes referral to somebody else's work and is therefore considered cheating.
- Assignments will usually be distributed at least one week before the due date.
- Assignments are due in class on their due date unless otherwise noted. Occasionally, assignments will be due on a non-class day. In those cases, I will provide instructions on how to submit the completed work.
- Homework solutions will be provided, usually after the next class following the due date.
- Homework submitted in class on the due date will be considered on time and thus eligible for full credit. Thereafter, a 20% *late penalty* will be subtracted up until the homework solutions are distributed. After the solutions are posted, late homework will not be accepted.
- Homework should be neat and legible, on standard 8.5-by-11-inch or A4 paper, stapled.
- Report numerical answers to a reasonable number of significant digits. The point of this is that you should consider the level of uncertainty associated with your reported answer.
- Your homework solutions must include at least enough detail that I can follow your reasoning and calculations. An answer provided without this level of detail will be considered insufficient.
- Helpful hint: when performing calculations, be careful of your units. You will catch about 90% of your mistakes (yes, really) if you take proper care of your units.

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Class Policies: 2, Exam Policy

- There will be two exams during the semester: a midterm exam and a final exam.
- The midterm exam will be given in class. It will probably be on October 17, but the date could be changed if there is a good reason. I will announce a firm date in plenty of time for you to prepare.
- The final exam will be administered at the time designated by the registrar: Thursday, December 12, at 7:30 AM. This date and time cannot be changed because they are set by the university registrar, not by the instructor.
- Exam questions will be primarily quantitative (problem-solving), but there may be qualitative (definition, discussion) questions as well.
- Both examinations will be closed-book, but students are permitted to use *personal note sheets*: one double-sided 8.5-by-11-inch sheet for the midterm, and two such sheets for the final. Students may write whatever they like on these sheets, but they must be hand-written – no laser printing, scanning, photocopying, etc.
- Retrieval of information by any means other than the personal note sheets during the examination will be considered cheating.
- Students who will not be available for an exam should inform the instructor far enough *before* the exam to make alternate arrangements.
- Students who miss an exam unexpectedly (e.g., due to sudden illness, family emergency, or other unforeseen circumstances) must provide documentation or evidence of the reason for missing the exam. It will then be *up to the instructor's discretion* whether a “make-up” exam will be offered.
- My intention is to design exam questions such that students who have attended the class and who have diligently completed the homework assignments will be familiar with all the material needed to answer the questions. It will not be my intention to surprise you, only to challenge you.
- Generally, exam questions are intended to test the most important concepts of the class. A good exam should require the students to demonstrate their mastery of the material by synthesizing and applying the most important concepts of the course. Exam questions are not likely to test students on their recall of minutiae.
- Helpful hint: when performing calculations, be careful of your units!! You will catch about 90% of your mistakes (yes, really) if you take proper care of your units.

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Class Policies: 3, Attendance and Class Participation

- Attendance in class lectures is recommended but not required. It is likely that diligent attendance in class lectures will improve your understanding of the course material, and, hence, improve your semester grade.
- Attendance in class does not factor into your semester grade other than helping you to perform well on assignments and exams (i.e., there are no “class attendance points” awarded).
- If you miss class, there is no need to inform me or to provide me with documentation for your absence. (I don’t take it personally, really.) However, I do recommend that you acquire the lecture notes from a classmate.
- If you choose to attend class, I require that you do not engage in behavior that distracts me or that disrupts the class for others in attendance:
- In particular, please make sure mobile phones are turned off. **NO TEXTING DURING CLASS!**
- Laptop computers should be used only for taking notes, not for e-mail, web browsing, or any other activity that might distract your classmates or your instructor.
- Please do not chat with your classmates, read the newspaper, work on homework for other courses, or engage in any other behavior that is distracting to your classmates or to your instructor.
- If you need to do something other than participate in the class lectures, then please do so outside the classroom.
- Students who are engaged in such activities in class will be asked to leave.

Class Policies: 4, Grading

- Your overall grade will be a weighted average of your homework grade (25%), your midterm exam grade (25%), and your final exam grade (50%).
- This class does *not* use a fixed grading scale (e.g., 90=A, 80=B, etc.). The grading scale will be set depending on student performances on the exams and the homework assignments. That way, if the exams are particularly difficult or particularly easy this year, the grading scale will take that into account. However, based on past experience, an *approximate* grading scale is as follows.

90–100	A+	75–80	B+	< 65	C+ or lower
85–90	A	70–75	B		
80–85	A–	65–70	B–		
- It is my expectation that most or all students who diligently complete their work will earn a grade of A, A–, B+, or B. I call this the “target range”. Students who perform notably better than their peers may possibly earn a grade of A+. Students who perform notably worse than their peers may possibly earn a grade of B–, C+, C, or possibly even lower, but historically the lowest grade assigned (other than to students who cheat or plagiarize) is C. Grades below B are rare for students who are keeping up with the work and making a full effort.
- Students who cheat or plagiarize should expect to receive a grade of F or FF.

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Class Policies: 5, Copyrights and Academic Honesty

- Any handouts used in this course are copyrighted. “Handouts” means all materials generated for this class, which include, but are not limited to: syllabi, notes, quizzes, exams, in-class materials, review sheets, and additional problem sets. This includes materials that are posted on the web as well as materials distributed in class. Because these materials are copyrighted, you do not have the right to copy the handouts unless the instructor (or other copyright holder) expressly grants permission.
- Students may audio tape lectures for their own private, personal use, or for a classmate who is registered in the class during this semester. Audio tapes may not be sold or distributed to anybody who is not registered in the class this semester.
- No form of scholastic dishonesty (cheating, plagiarism, etc.) will be tolerated. As commonly defined, plagiarism consists of passing off as one’s own the ideas, words, writings, etc., which belong to another. In accordance with this definition, you are committing plagiarism if you copy the work of another person and turn it in as your own, even if you have permission of that person. This includes copying material from books, reports, journals, pamphlets, handouts, other publications, web sites, etc., without giving appropriate credit for those ideas and/or without identifying material as quotations when taken directly from another source.
- Cheating on homework and exams will not be tolerated. Cheating will be dealt with according to university policy.
- You may discuss homework assignments with other students. However, whatever work is submitted by a team should represent work actually completed by that team. Each team must conduct the actual computations and write up its own work without referring to the solutions of other teams. Copying homework from another team is considered plagiarism. See Class Policy 1, above.
- You may not copy homework solutions from a previous year’s solution set. That will be considered plagiarism because you are copying somebody else’s work.
- Violation of these rules -- *even unintentionally!* -- can result in disciplinary action including a grade penalty, up to and including an F or FF in the course, suspension, dismissal, and/or expulsion from USF. If you have any questions regarding plagiarism or other forms of scholastic dishonesty, please consult the relevant sections of the USF student catalogs, and/or ask the instructor.

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Course Policies: 6, Tips for Success

- USF recommends that each instructor give his/her students advice on how to succeed in a particular class. I am a bit hesitant to do that, because each student learns differently, and what I advise might not work for everybody. However, one thing that I can confidently recommend for every student is: Do the homework to the best of your ability, and come to office hours for help on any parts of the homework that you find difficult. To some of you, this might sound like obvious advice, but not every student seems to find it so obvious. If you follow this simple advice you will likely be well prepared for the exams.
- If you have full-time employment (~40 hrs/wk), and you are taking this class in addition to a full-time employment schedule, make sure it is your only class this semester. If you are working full time *and* taking this class *and* taking an additional class (or more), it is quite likely that you are spread too thin to succeed.

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Appendix: USF Academic Policies

On the pages that follow are a number of policies that USF has asked instructors to include in their syllabi. Students should read these policies carefully as they apply to *all* classes at USF.

For most of the policies that follow, only an abbreviated form of the official policy or regulation is provided in this syllabus. Complete details are generally available to students on-line. Specifically, USF's official wording for some of these policies is available at the following web sites.

<http://regulationspolicies.usf.edu/policies-and-procedures/>

<https://www.usf.edu/provost/faculty-info/core-syllabus-policy-statements.aspx>

<https://www.usf.edu/undergrad/students/academic-policies.aspx>

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Attendance for the Observance of Religious Days by Students (USF System policy 10-045)

All students, faculty, and staff within the USF System have a right to expect reasonable accommodation of their religious observances, practices and beliefs. The USF System will, at the beginning of each academic term, provide written notice of the class schedule and formal examination periods. The USF System, through its faculty, will make every attempt to schedule required classes and examinations in view of customarily observed religious holidays of those religious groups or communities comprising the USF System's constituency. Students are expected to attend classes and take examinations as determined by the USF System. No student shall be compelled to attend class or sit for an examination at a day or time prohibited by his or her religious belief. However, students should review the course requirements and meeting days and times to avoid foreseeable conflicts, as excessive absences in a given term may prevent a student from completing the academic requirements of a specific course. Students are expected to notify their instructors at the beginning of each academic term if they intend to be absent for a class or announced examination, in accordance with this Policy. Students absent for religious reasons, as noticed to the instructor at the beginning of each academic term, will be given reasonable opportunities to make up any work missed. In the event that a student is absent for religious reasons on a day when the instructor collects work for purposes of grading (homework, pop quiz, etc.), the student shall be given a reasonable opportunity to make up such work or shall not have that work averaged into the student's grade at the discretion of the instructor. Any student who believes that he or she has been treated unfairly with regard to the above may seek review of a complaint through established USF System Academic Grievance Procedures (found in the Graduate and Undergraduate Catalogs) and those provided by the University's Office of Diversity, Inclusion, & Equal Opportunity.

Statement of Academic Continuity (*or, in other words, emergencies*)

In the event of an emergency, it may be necessary for USF to suspend normal operations. During this time, USF may opt to continue delivery of instruction through methods that include, but are not limited to: Learning Management System (i.e., Canvas), online conferencing, e-mail messaging, and/or an alternate schedule. It is the responsibility of the student to monitor the Learning Management System for each class for course-specific communication, and the main USF, College, and Department websites, e-mails, and MoBull messages for important general information (USF System Policy 6-010). For additional guidance on emergency protective actions and hazards that affect the University, please visit www.usf.edu/em

(Instructor's note: examples of "emergency" could be a hurricane, outbreak of contagious disease, etc.)

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“Incomplete” Grades (<http://ugs.usf.edu/policy/IGradePolicy.pdf>, accessed August 2019)

An “I” grade indicates incomplete coursework and may be awarded to graduate and undergraduate students. (Undergraduate rules apply to non-degree-seeking students.) It may be awarded to an undergraduate student only when a small portion of the student’s work is incomplete and only when the student is otherwise earning a passing grade. The instructor will be required to complete the I-grade contract online when posting the semester grade at the end of the term, identifying the remaining coursework to be completed, the student’s last day of attendance, and the percent of work accomplished to this point. This online contract will be automatically copied to the student’s email and to the Registrar. Until removed, the “I” is not computed in the GPA for either undergraduate or graduate students. The time limit for removing the “I” is to be set by the instructor of the course. For undergraduate students, this time limit may not exceed two academic semesters, whether or not the student is in residence, and/or graduation, whichever comes first. “I” grades not removed by the end of the time limit will be changed to “IF” or “IU,” whichever is appropriate. If an instructor is willing, he or she may accept work from a student after an I grade has changed to an IF or IU grade, and assign the student a final grade in the course, unless the student has graduated. Whether or not the student is in residence, any change to “IF” grades will be calculated in the cumulative GPA and, if applicable, the student will be placed on appropriate probation or academically dismissed. Students are not required to re-register for courses in which they are only completing previous course requirements to change an “I” grade. However, if a student wants to audit a course for review in order to complete course requirements, full fees must be paid.

Academic Integrity (USF System regulation 3.027)

Academic integrity is the foundation of the University of South Florida System’s commitment to the academic honesty and personal integrity of its university community. Academic integrity is grounded in certain fundamental values, which include honesty, respect, and fairness. Broadly defined, academic honesty is the completion of all academic endeavors and claims of scholarly knowledge as representative of one’s own efforts. Knowledge and maintenance of the academic standards of honesty and integrity as set forth by the university are the responsibility of the entire academic community, including the instructional faculty, staff, and students. The final decision on an academic integrity violation and related academic sanction at any USF System institution shall affect and be applied to the academic status of the student throughout the USF System, unless otherwise determined by the independently accredited institution.

Disruption of Academic Process (USF System regulation 3.025)

Disruptive students in the academic setting hinder the educational process. Disruption of the academic process is defined as the act, words, or general conduct of a student in a classroom or other academic environment which in the reasonable estimation of the instructor: (a) directs attention away

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from the academic matters at hand, such as noisy distractions, persistent, disrespectful or abusive interruption of lecture, exam, academic discussion, or general University operations, or (b) presents a danger to the health, safety, or well-being of self or other persons.

Academic Grievance Procedure (USF System policy 10-002)

The purpose of [these procedures] is to provide all undergraduate and graduate students taking courses within the University of South Florida System an opportunity for objective review of facts and events pertinent to the cause of the academic grievance. An “academic grievance” is a claim that a specific academic decision or action that affects that student’s academic record or status has violated published policies and procedures, or has been applied to the grievant in a manner different from that used for other students.

Disability Access (USF System policy 0-108)

It is the policy of the University of South Florida System (USF System) to comply fully with the requirements of the Americans with Disabilities Act of 1990 as amended by the Americans with Disabilities Act Amendments Act of 2008 and all other federal and state laws and regulations prohibiting discrimination and assuring accessibility on the basis of disability. No qualified individual with a disability shall, by reason of such disability, be excluded from participation in or be denied the benefits of services, programs, or activities of the USF System, or be subjected to discrimination or lack of access by the USF System, as provided by law.

Students with disabilities are responsible for registering with Students with Disabilities Services (SDS) (SVC 1133) in order to receive academic accommodations. SDS encourages students to notify instructors of accommodation needs at least five (5) business days prior to needing the accommodation. A letter from SDS must accompany this request.

(Instructor’s note: The Americans with Disabilities Act is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation, please contact SDS as soon as possible.)

Sexual Misconduct / Sexual Harassment (USF System policy 0-004)

USF is committed to providing an environment free from sex discrimination, including sexual harassment and sexual violence (USF System Policy 0-004). The USF Center for Victim Advocacy & Violence Prevention is a confidential resource where you can talk about incidents of sexual harassment and gender-based crimes including sexual assault, stalking, and domestic/relationship violence. This confidential resource can help you without having to report your situation to either the

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Office of Student Rights and Responsibilities (OSSR) or the Office of Diversity, Inclusion, and Equal Opportunity (DIEO), unless you request that they make a report. Please be aware that in compliance with Title IX and under the USF System Policy, educators must report incidents of sexual harassment and gender-based crimes including sexual assault, stalking, and domestic/relationship violence. If you disclose any of these situations in class, in papers, or to me personally, I am required to report it to OSSR or DIEO for investigation. Contact the USF Center for Victim Advocacy and Violence Prevention: (813) 974-5757.

Auditing Privilege (USF System policy 10-006, section III.A.4.)

Accepted students eligible to enroll in courses may register to audit a course strictly on a space-available basis, provided the student:

- a. requests and receives any necessary approval as determined by the instructor or other designated responsible office;
- b. understands that no exams, grades, credit or other academic evaluations may be provided;
- c. officially registers to audit the course by the end of drop/add period and does not attend any class session prior to the official registration without affirmative approval by instructor;
- d. attends the class as a listener which means instructors may limit the auditing student's participation in class including class projects or other interactive graded or ungraded activities;
- e. complies with all University Regulations and Policies of the University;
- f. complies with all conditions of audit registration and any deviation from those conditions will be considered disruptive and a student found to be disruptive to the class or academic process may be removed from the class under USF3.025 Academic Disruption; and
- g. is responsible for all fees for audit which are the same as for full enrollment for credit, except out-of-state tuition is not charged.