Instructor: Dr. Joseph Kasprzyk (pronounced Kas – pry – zick ☺)
Email: joseph.kasprzyk@colorado.edu
Office Location: My main office is in the SEEC building on East Campus, room C244 in the environmental engineering pod. Because our course is held in the Engineering Center, I will hold office hours in a room in the Engineering Center. If we have to have a meeting outside of office hours, I am flexible on the meeting location and can meet in either the Engineering Center or SEEC, within reason.
Office Hours and Location: Monday and Wednesday, 8:30 – 10:00 am (or by appointment) in ECCE 1B57, a room in the basement of the civil engineering wing of the engineering center

Description: Introduces water resources planning and management as an integrated systems problem that satisfies multiple competing objectives under constraints and uncertainty. Includes problem formulation and solution using decision support systems, optimization with and without uncertainty, stochastic simulation, and multiobjective optimization. Introduces water resources economics and planning under uncertainties such as climate change and increasing urbanization.

Requirements: There are no formal prerequisites for this course, but I assume that you have familiarity with matrix algebra, calculus, probability, statistics, and basic computer skills (including the ability to apply or learn Python and R programming). Because the course focuses on water resources planning and management, some knowledge of fluid mechanics and hydrology is also assumed. However, students that come from different disciplinary backgrounds should be able to learn enough about water resources to do well in the course.

Required Textbook:

Supplementary Textbooks and Resources:
5. Water Programming: A Collaborative Research Blog. A selection of tips and tricks on technical material related to modeling and optimization by Prof. Kasprzyk and others: http://waterprogramming.wordpress.com
Topics covered:

- Classical mathematical programming and its application to water resources and civil engineering problems
- Reviews, criticisms, and insights on systems analysis approaches in real-world decision making contexts
- Simulation modeling and RiverWare
- Simulation-optimization approaches including multiobjective evolutionary algorithms
- Examples of water resources planning and management research
- Stochastic streamflow generation
- Sensitivity analysis and diagnostic approaches
- Western water issues

Course Objectives

At the end of the course, students will be able to:

1. Formulate and solve classical optimization-based problem formulations for decision support in water and other civil engineering problems.
2. Formulate and solve simulation-optimization decision support approaches using multiobjective evolutionary algorithms, and other multiobjective decision analysis techniques, for water and other civil engineering problems.
3. Understand the strengths and limitations of systems analysis approaches applied to water and civil engineering problems.
4. Understand the current research in the field and where research gaps exist.
5. Identify important water resources challenges related to uncertainty and environmental change.
6. Carry out an independent research project using the techniques above on a problem of their choosing.

Tentative Course Schedule (Please see D2L for updated schedules as the course continues. The main reading assignments are focused on the journal articles; the textbook can be used for supplemental reference of topics in the lectures.)

<table>
<thead>
<tr>
<th>Week / Date</th>
<th>Topic</th>
<th>Reading and Assignments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 / Jan 12</td>
<td>1. Intro to water resources and reservoir concepts</td>
<td>T: Ch 1</td>
</tr>
<tr>
<td>1 / Jan 14</td>
<td>2. Hydrologic cycle and its importance for water resources management</td>
<td>T: Ch 11 (Milly et al., 2008)</td>
</tr>
<tr>
<td>2 / Jan 19</td>
<td>3. Reservoir sizing and sequent peak analysis</td>
<td>T: Ch 11 (see above)</td>
</tr>
<tr>
<td>2 / Jan 21</td>
<td>4. Reliability, resilience, vulnerability</td>
<td>T: Ch 10 (Hashimoto et al., 1982)</td>
</tr>
<tr>
<td>3 / Jan 26</td>
<td>5. Simulation modeling</td>
<td>T: Ch 2 (Simonovic, 1992)</td>
</tr>
<tr>
<td>3 / Jan 28</td>
<td>RiverWare Lecture #1</td>
<td></td>
</tr>
<tr>
<td>4 / Feb 2</td>
<td>SNOW DAY NO CLASS</td>
<td></td>
</tr>
<tr>
<td>4 / Feb 4</td>
<td>RiverWare Lecture #2</td>
<td></td>
</tr>
<tr>
<td>5 / Feb 9</td>
<td>6. Statistics and Monte Carlo analysis</td>
<td>T: Ch 7 (Nowak et al., 2010)</td>
</tr>
<tr>
<td>5 / Feb 11</td>
<td>Intro to R Programming</td>
<td>Quiz 1 in class</td>
</tr>
<tr>
<td>6 / Feb 16</td>
<td>7. Stochastic Streamflow Generation</td>
<td></td>
</tr>
<tr>
<td>6 / Feb 18</td>
<td>RiverWare Lecture #3</td>
<td>Project Letter of Intent Due</td>
</tr>
<tr>
<td>7 / Feb 23</td>
<td>8. Reservoir operations and rule curves</td>
<td>(Lund and Guzman, 1999)</td>
</tr>
<tr>
<td>Date</td>
<td>Topic</td>
<td>Source(s)</td>
</tr>
<tr>
<td>------------</td>
<td>----------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>7 / Feb 25</td>
<td>Intro to optimization modeling and linear programming (LP) problem formulations</td>
<td>T: Ch 4</td>
</tr>
<tr>
<td>8 / Mar 1</td>
<td>LP continued</td>
<td>T: Ch 4 (see above)</td>
</tr>
<tr>
<td>8 / Mar 3</td>
<td>Optimization II</td>
<td>T: Ch 4 (see above)</td>
</tr>
<tr>
<td>9 / Mar 8</td>
<td>Optimization II</td>
<td>T: Ch 9 (Zeleny, 1981)</td>
</tr>
<tr>
<td>9 / Mar 10</td>
<td>Optimization II</td>
<td></td>
</tr>
<tr>
<td>10 / Mar 15</td>
<td>Project Discussions</td>
<td></td>
</tr>
<tr>
<td>11 / Mar 22</td>
<td>Spring Break – No Class ☺</td>
<td>Quiz 2 in class</td>
</tr>
<tr>
<td>11 / Mar 24</td>
<td>Spring Break – No Class ☺</td>
<td></td>
</tr>
<tr>
<td>12 / Mar 29</td>
<td>Optimization III</td>
<td></td>
</tr>
<tr>
<td>12 / Mar 31</td>
<td>Multi-Objective Optimization I</td>
<td>(Cohon and Marks, 1975; Kasprzyk et al., 2009; Knowles et al., 2008; Nicklow et al., 2010)</td>
</tr>
<tr>
<td>13 / Apr 5</td>
<td>Multi-Objective Optimization I</td>
<td></td>
</tr>
<tr>
<td>13 / Apr 7</td>
<td>Multi-Objective Optimization II</td>
<td>(Reed et al., 2013; Smith et al., 2016)</td>
</tr>
<tr>
<td>14 / Apr 12</td>
<td>Multi-Criteria Decision Analysis (MCDA)</td>
<td>(Borsuk et al., 2001)</td>
</tr>
<tr>
<td>14 / Apr 14</td>
<td>MCDA</td>
<td>Quiz 3 in class</td>
</tr>
<tr>
<td>15 / Apr 15</td>
<td>Global sensitivity analysis</td>
<td>(Saltelli et al., 2000)</td>
</tr>
<tr>
<td>15 / Apr 21</td>
<td>Bottom-up decision making frameworks for robust decision making</td>
<td>(Herman et al., 2015)</td>
</tr>
<tr>
<td>16 / Apr 26</td>
<td>Catch-up day</td>
<td>Project draft report due</td>
</tr>
<tr>
<td>16 / Apr 28</td>
<td>Course Wrap-Up</td>
<td>T: Ch 14</td>
</tr>
</tbody>
</table>

**Final Report Due**: Sunday, May 1, 7:30 pm

**Final Project Presentations**: Sunday, May 1, 7:30 pm – 10:00 pm, ECCE 1B41.

**Notes**: During the final exam session, we typically have the final project presentations. I provide snacks and light refreshments. However, this year's final exam is scheduled from 7:30 pm – 10:00 pm on Sunday May 1 which may not be convenient for all students. Closer to the exam time, I can poll the class to see if there is another mutually agreeable time.

**Required Reading**


**Other Suggested Readings:**


Grading:

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assignments</td>
<td>40%</td>
</tr>
<tr>
<td>In-Class Participation</td>
<td>5%</td>
</tr>
<tr>
<td>Quizzes</td>
<td>15%</td>
</tr>
<tr>
<td>Project</td>
<td>40%</td>
</tr>
</tbody>
</table>

I reserve the right to increase grades for exemplary participation, effort, or achievement. I also reserve the right to reduce your grade if there is a breach of the code of ethics or if you fail to participate in class, projects, or activities.

**Project:** See supplemental project handout.

**Homework:**

- Homework is due by the end of class on the day the assignment is due. No late assignments will be accepted.
  - The lowest assignment will be dropped.
- Each assignment requires:
  - Your name on each page of solutions. Assignments must be **stapled** and written with legible handwriting or typed.
  - A legible, step-by-step presentation of your calculations.
  - Where appropriate, show **units** on every value in the calculation and the answer to the problem. For example, if the answer is 5 m/s, please write “m/s” after the number. Otherwise, I’ll assume the answer is 5 chickens!
  - **Box** the answer, with appropriate units.
  - You are allowed to discuss the homework with your peers, but **everyone must turn in their own assignment** that represents individual effort. Essay answers must be **in your own words**. It will be considered cheating if you copy/paste others’ work and turn it in as your own.
  - The grader and I reserve the right to take off points for neatness or if you have not followed the rules above.
- For assignments that require research, you must **document your sources**, even if the source is a website. Points will be taken off, or no credit given for the assignment at all, if I find that you have used material from a source without citing it. As this is a graduate class, I will be **very strict** with this. I suggest using the Harvard citation style ([http://guides.is.uwa.edu.au/harvard](http://guides.is.uwa.edu.au/harvard)) and a citation management software such as LaTeX or Zotero ([http://www.zotero.org/](http://www.zotero.org/)). If you have a question about citations feel free to ask us.

**Quizzes:**

- Three in-class quizzes will be administered during the semester, mainly to test course concepts.
  - Tentative dates for the quizzes are February 11, March 10, and April 12, but these dates are subject to change.
- Exam policies regarding open book/closed book/reference materials will be announced before the exam.
- Bring a calculator with working batteries to the exam. All other electronic devices must be turned off and put away during the exam.
• If you must miss a quiz for a legitimate reason (e.g. religious holiday, job interview) or if you have special needs, you must make arrangements with Dr. Kasprzyk prior to the exam. All relevant university policies apply (see below).

• The final exam period will be used for the final project presentations. The final exam period is Sunday, May 1, 7:30 pm – 10:00 pm in ECCE 1B41.

Reading Assignments and In-Class Participation:

• I will notify you via email of the course reading schedule, and you will be responsible for reading material before class.

• I reserve the right to give short reading quizzes to enforce the reading assignments, and count for a grade in the “in-class participation” portion of the class. I will not announce the date of these quizzes in advance. Generally, more focus will be given to the journal article readings than the textbook readings.

• If you must miss class, please let me know ahead of time.

• Assignments turned in for in-class participation can also be used to gauge course attendance and get feedback from students. If so, these assignments will be graded only for completion (in other words, all assignments turned in get full credit).

Additional University Policies:

If you qualify for accommodations because of a disability, please submit to your professor a letter from Disability Services in a timely manner (for exam accommodations provide your letter at least one week prior to the exam) so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities. Contact Disability Services at 303-492-8671 or by e-mail at dsinfo@colorado.edu.

Campus policy regarding religious observances requires that faculty make every effort to deal reasonably and fairly with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. In this class, please let me know ahead of time and I will make arrangements with you. See full details at http://www.colorado.edu/policies/fac_relig.html.

Students and faculty each have responsibility for maintaining an appropriate learning environment. Those who fail to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with differences of race, color, culture, religion, creed, politics, veteran’s status, sexual orientation, gender, gender identity and gender expression, age, disability, and nationalities. Class rosters are provided to the instructor with the student’s legal name. I will gladly honor your request to address you by an alternate name or gender pronoun. Please advise me of this preference early in the semester so that I may make appropriate changes to my records. See policies at http://www.colorado.edu/policies/classbehavior.html and at http://www.colorado.edu/studentaffairs/judicialaffairs/code.html#student_code.

The University of Colorado Boulder (CU-Boulder) is committed to maintaining a positive learning, working, and living environment. The University of Colorado does not discriminate on the basis of race, color, national origin, sex, age, disability, creed, religion, sexual orientation, or veteran status in admission and access to, and treatment and employment in, its educational programs and activities. (Regent Law, Article 10, amended 11/8/2001). CU-Boulder will not tolerate acts of discrimination or harassment based upon Protected Classes or related retaliation against or by any employee or student. For purposes of this CU-Boulder policy, "Protected Classes" refers to race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, or veteran status. Individuals who believe they have been discriminated against should contact the
Office of Discrimination and Harassment (ODH) at 303-492-2127 or the Office of Student Conduct (OSC) at 303-492-5550. Information about the ODH, the above referenced policies, and the campus resources available to assist individuals regarding discrimination or harassment can be obtained at http://www.colorado.edu/odh.

Academic Integrity:

University Policy: All students of the University of Colorado at Boulder are responsible for knowing and adhering to the academic integrity policy of this institution. Violations of this policy may include: cheating, plagiarism, aid of academic dishonesty, fabrication, lying, bribery, and threatening behavior. All incidents of academic misconduct shall be reported to the Honor Code Council (honor@colorado.edu; 303-735 2273). Students who are found to be in violation of the academic integrity policy will be subject to both academic sanctions from the faculty member and non-academic sanctions (including but not limited to university probation, suspension, or expulsion). Other information on the Honor Code can be found at http://www.colorado.edu/policies/honor.html and at http://www.colorado.edu/academics/honorcode/.

CEAE Policy: The Department of Civil, Environmental, & Architectural Engineering (CEAE) requires all students to adhere to a strict policy of academic integrity. These expectations are in accordance with the University of Colorado Boulder Honor Code, but this policy is intended to provide more specific guidelines for all undergraduate and graduate students in CEAE. Ethical behavior in college sets the stage for a lifetime of professional and ethical behavior that is expected of all engineering professionals. This policy describes the academic sanctions that will be imposed by CEAE faculty members. Faculty retain the right to set academic sanctions, and if they choose individual courses can deviate from the expectations stated below; these changes will be noted in the course syllabus. All incidents of academic misconduct will be reported to the Honor Code Council. Non-academic sanctions are the purview of the Honor Code Council.

Any activity that could give you an unfair advantage over other students may be cheating. Specific examples of actions that are considered to be cheating and therefore violations of academic integrity:

- Plagiarizing a homework, lab report, or problem set. On assignments that require you to use supplemental materials, you must properly document the sources of information that you used. If you are uncertain about allowable reference materials or how to document your sources, ask your instructor in advance. Specific examples of plagiarism include:
  - copying from a solution manual
  - copying from Internet sites
  - copying from previous semester’s homework set or lab report
  - copying directly from classmates
  - copying lab data that you yourself did not participate in collecting
  - Plagiarizing content in a paper, report, thesis, or dissertation, by copying material from a published sources or the internet, without appropriate citation format and attribution
  - Using unapproved information during a closed-book test or quiz (such as a reference sheet, information stored in a calculator, iPhone, information written on your skin)
• Copying from another student during a quiz, exam, or test
• Working in groups on web based quizzes, exams, or tests
• Working in groups on take-home quizzes, exams, or tests
• Asking another student about questions on an exam that you have not yet taken
• Changing the answer on your test/homework after it was graded and then telling the instructor that there was a grading mistake
• Allowing another student to copy your homework, lab report, or allowing another student to look at your answers during a quiz or exam

The list above is not exhaustive; other violations are possible. Any violation will be reported to the Honor Code Council. Any first violation of academic integrity on graded course activities (i.e. homework, lab reports, exams) will result in a minimum sanction of a zero score and an entry in your department file. Instructors can increase these penalties to assigning a failing grade (F) for the entire course. The department will retain a list of all instances of academic integrity violations. Additional sanctions will be imposed for subsequent violations.