COURSE SYLLABUS
CIVE 645: Computer Aided Water Management and Control

Credits: 3

Term(s) to be offered: Fall Semester

Class Time/Place: M 11:00-12:50 (lab); T Th Lecture 10:00-10:50; Rm C205 Engineering

Prerequisites: ENGR 510 or CIVE 546, or equivalent, or consent of the instructor

Catalog Description: Real-time management and control of water resources systems; application of computer control concepts to improve system performance.

Instructor: John W. Labadie, Engr. B-211, Phone: (970)491-6898

Textbook: Free on-line book: *Water Resources Systems Planning and Management: An Introduction to Methods, Models and Applications*, by D. P. Loucks and E. van Beek, UNESCO and Delft Hydraulics, The Netherlands, 2005.

Software: All students (on-campus and distance) will be provided access to CSUDP and MODSIM software, as well as software for artificial neural networks (ANN) and genetic algorithm (GA).

Course Objectives: Present modern computer-aided tools of systems analysis to planning, design, and operation of water resource systems. Topics covered include: optimal operation of multipurpose reservoir systems; optimal flood control system operations; coordinated unit commitment in hydropower systems; optimal multicrop allocation of seasonal and intraseasonal irrigation water; risk-based design of stochastic reservoir operating policies; economic evaluation of integrated design of water storage and conveyance systems; optimal conjunctive use of surface water and groundwater; optimal reservoir operations for water quality management; and optimal investment timing and selection of water resource projects. Several case studies are presented for river basins in the U.S., Dominican Republic, Brazil, Sri Lanka, India, Egypt, and Korea. Systems analysis tools studied include dynamic programming, stochastic optimization, network flow optimization, genetic algorithms, neural networks, agent-based reinforcement learning methods, multiobjective optimization, and fuzzy optimization.

Course Topics/Weekly Schedule:

Week **Topic**

1. Application of optimization methods in water resource systems analysis—state-of-the-art review; implicit vs. explicit stochastic optimization; combining simulation and optimization; introduction to sequential decision problems in water resources.
2. Sequential decision problems in water resources; introduction to dynamic programming (DP); use of generalized software package CSUDP; example reservoir optimization problem.
3. Feedback vs. open loop policies; reaching vs. pulling DP; max-min solutions; resource allocation problems; continuous DP; *Case Study:* Nizao River Basin, Dominican Republic.
4. Optimal multicrop allocation of seasonal and intraseasonal irrigation water; spatial and temporal decomposition; application of Lagrange multipliers with dynamic programming; *Case Study:* Nagarjunasagar Irrigation District, India

5. Efficient solution of large-scale, multi-state dynamic programming problems; *Case Study:* Mahaweli Project, Sri Lanka: Hydroelectric generation.
6. Economic valuation for optimal integrated design of water storage and conveyance systems; *Case Study:* Colony Project, Colorado; optimal investment selection and timing of water projects; *Case Study:* Selection of salinity control projects in the Colorado River Basin.
7. Spatial decision support system for integrated river basin flood control; optimal control of hydraulic systems; inclusion of flow routing in dynamic programming; *Case Study:* Han River Basin, Korea.
8. Introduction to stochastic dynamic programming; Markov decision processes and optimal stationary policies; certainty equivalence and the LDQ problem; including risk in stochastic reservoir optimization; *Case Study:* Aswan High Dam, Egypt.
9. Agent-based reinforcement learning methods for stochastic optimization of water resource systems; Q-learning strategies; *Case Study:* Geum River Basin, Korea.
10. Introduction to MODSIM generalized river basin management model; *Case Study:* Poudre River Basin, Colorado.
11. Conjunctive use of surface and groundwater resources; application of MODSIM to integrated water quantity and quality management: *Case Study:* Lower Arkansas River Basin, Colorado.
14. Introduction to artificial neural networks (ANN); neural-optimal control algorithm for real-time regulation of in-line storage in combined sewer systems; *Case Study:* King County combined sewer system, Seattle, Washington.
15. Introduction to genetic algorithms and fuzzy rule-based systems; multiobjective optimization of frequency distribution of storm-water discharges for coastal ecosystem restoration: *Case Study:* St. Lucie watershed and estuary, Florida.

Instructional Methodology: Two hours of class lectures and one to two hours of laboratory per week.

Mode of Delivery: Traditional lectures and lab exercises given in class, and also published to Canvas for online access by distance students.

Methods of Evaluation: The course grade will be based on the following distribution:

Homework/Lab Exercises	30%
Midterm Examination	30%
Final Class Project or Final Examination (to be determined)	40%