Spring 2015

Environmental Systems Engineering - Swarthmore College, Swarthmore

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Environmental Systems Engineering

Engineering 66 Spring 2015

REQUIREMENTS

Readings:

Textbook: ReVelle and McGarity, *Design and Operation of Civil and Environmental Engineering Systems,* John Wiley and Sons, 1997.

Reserve Readings: reserve reading materials consisting of photocopies from textbooks and research papers have been assembled and are available online through the Moodle system. Regular assignments from these readings are included in the sylabus.

Computing Exercises: There will be one or more computing exercises associated with each unit. You will receive instructions during the laboratory period. You are encouraged to interact with other students on these exercises*. A paper in the style of a laboratory report is required for each exercise.* These papers serve jointly as your homework exercises and your lab reports. **Late report policy:** students can easily fall far behind in this course if reports are not prepared and submitted on time. For reports submitted late without an approved excuse, the report grade will be reduced by one letter for each day that it is late. Reports that are more than three days late (unexcused) will not be accepted.

Seminar Presentations: These student presentations involve preparing new material for presentation to the class in a seminar format. Students will be responsible for one or two seminar presentations (individually or in pairs, depending on the size of the class), which will be scheduled at the beginning of the semester. Students will schedule a planning session with the instructor in advance of the presentation.

Exams: There will be two exams; both will be take home exams. Each will involve the formulation of a model to solve a specific problem, solution of the problem by computer, and sensitivity analyses as specified in the problem statements. You will have one week on each exam. You may not consult with other students on the exams. **Late exam policy:** unexcused late exams will not be accepted.

Grading: Final grades will be determined by the following approximate weights: Computing Exercises - 40%, Seminar Presentations – 10%, Exams - 25% each.

SCHEDULE AND OUTLINE OF TOPICS

Most units will contain lectures and readings on:

* fundamentals of analysis
* descriptive models
* management (optimization) models

1. Air Pollution Models

- Monday, Jan. 19: Air Pollution Sources, Standards, and Control Technology. **Reading:** Davis and Cornwell, Chapter 6, pp. 414-443.
- Wednesday, Jan. 21: Atmospheric transport of pollutants and the Gaussian stack plume model. **Reading:** Davis and Cornwell, Chapter 6, pp. 452-461
- Friday, Jan. 23: Box model for prediction of pollutant concentration. **Reading:** Davis and Cornwell, Chapter 6, pp.. 461-493 to obtain a general introduction to air pollution control technology.

- Monday, Jan. 26: ***Lab Exercise 1***: Stack plume modeling
- Monday, Jan. 26: Air quality management model I - fuel substitution model. **Reading:** Textbook, Chapter 4 (Ellis), pp. 165-185. **Supplemental Reading:** "Chapter 10, Models for Water and Air Quality Management, Part B. Air Quality Management, pp. 384 – 400. by ReVelle and Ellis, from Handbooks in OR & MS, vol. 6, ed. by S.M. Pollock et al., 1994.
- Wednesday, Jan. 28: Air quality management model II - pollution control model. **Reading:** Ellis, McBean, and Farquhar "Deterministic Linear Programming Model for Acid Rain Abatement."
- Friday, Jan. 30: **Seminar:** Air Quality Management. **Reading:** Textbook, Chapter 4, pp. 165 – 203.
- Monday, Feb. 2: ***Lab Exercise 2*** - Optimization model for air quality management

2. Water Pollution Models

- Monday, Feb. 2: Single discharge model for oxygen sag analysis in freshwater streams - Streeter Phelps equation. **Reading:** Textbook, Chapter 2 pp. 41 - 54. **Supplemental Reading** (background on wastewater, treatment, and water pollutant transport in the environment)**:** Davis and Cornwell, "Chapter 4, Water Quality Management," pp. 261 – 304.
- Wednesday, Feb. 4 : Multi-reach, Multi-discharge water quality model for freshwater streams. **Reading:** Textbook, Chapter 2 (McGarity), pp. 54 – 64.
- Friday, Feb. 6 : Water quality management models I: linear programming model for dissolved oxygen management. **Reading:** Textbook, Chapter 2, pp. 64 – 72.
- Monday, Feb. 9: ***Lab Exercise 3***: Simulation model for dissolved oxygen sag analysis
- Monday, Feb. 9: **Supplemental Reading** (original research paper): "A Management Model for Water Quality Control," ReVelle, Loucks, and Lynn, Journal of the Water Pollution Control Federation, vol.39, no. 7, July, 1967.
- Wednesday, Feb. 11: Water quality management models II: generalized models and equity objectives. **Reading:** Textbook, Chapter 2, pp. 72 – 83. **Supplemental Reading** (literature review paper): "Chapter 10, Models for Water and Air Quality Management, Part A. Water Quality Management in Rivers and Estuaries," by ReVelle and Ellis, from Handbooks in OR & MS, vol. 6, ed. by S.M. Pollock et al., 1994. (see selection "b" in "Air Pollution" above)
- Friday, Feb. 13: ***Seminar***: Effluent Charges and Transferable Discharge Permits. **Reading:** Textbook, Chapter 15 (Brill), pp. 657 – 685.
- Monday, Feb. 16: ***Lab Exercise 4***: Water quality management model

3. Solid Waste and Sustainability Models

- Monday, Feb. 16: Introduction to solid waste problems and overview of solid waste models. **Reading:** Salvato, "Chapter 5, Solid Waste Management," pp. 662 – 679
- Wednesday, Feb. 18: Sustainability Concepts and Models; Solid waste technology. **Reading:** Meadows, et al. "Abstract," from *Limits to Growth,* Salvato, "Chapter 5, Solid Waste Management," pp. 679 – 766, "Delaware County Incinerator Description," (also, slides from this class lecture are posted online).
- Friday, Feb. 20: Solid waste transportation models **Reading:** Textbook, Chapter 5 (Liebman), pp. 205 – 231. *and* Vesilind and Rimer, "Chapter 2, Collection of Solid Waste," pp. 43 – 78.
- Monday, Feb. 23: ***Lab Exercise 5***: Solid waste transportation

4. Engineering Economics, Benefit Cost Analysis and Multiobjective Methods with Application to Flood Control and Electric Power Generation

- Monday, Feb. 23: Engineering economics fundamentals. **Reading:** ReVelle, Whitlatch, and Wright, "Chapter 13, Engineering Economics I: Interest and Equivalence."

- Wednesday, Feb. 25: Benefit cost analysis. **Reading:** ReVelle, Whitlatch, and Wright, "Chapter 14, Engineering Economics II: Choice Between Alternatives."
- Friday, Feb. 27: ***Seminar:*** Multiple-Criteria decision making and application to water resource planning . **Reading:** Textbook, Chapter 12 (Cohon and Rothley), pp. 513 – 534, 550 – 556.

*** **FRIDAY, Feb. 27: TAKE-HOME MIDTERM EXAM DISTRIBUTED IN CLASS** ***

- Monday, Mar. 2 – ***Midterm Exam work session in computing lab during lab period***
- Monday, Mar. 2 - Multiobjective programming: weighting and constraint methods with application to nuclear waste storage. **Reading:** Textbook, Chapter 12, pp. 535 – 550, 556 – 564.
- Wednesday, Mar. 4 - Application of multiobjective programming to environmental planning for electric utilities. **Reading:** Textbook, Chapter 11 (Hobbs), pp. 471 – 494.
- Friday, Mar. 6 – NO CLASS – exam due at 10:30 AM

***** FRIDAY, MAR. 6: MIDTERM EXAM DUE BY 10:30 AM *****

***** Mar. 9 - Mar. 13: SPRING BREAK *****

- Monday, Mar. 16 – NO LAB

5. Hazardous Waste and Environmental Risk Assessment Applied to Toxic Air Pollution

- Monday, Mar. 16: Fundamentals of environmental risk assessment. **Reading:** "Incinerator Risk Assessments: Change is in the Air," by D. Smith, A.L. Yuhas, and B. Magee, **plus:** "Assessing Risks from Health Hazards: An Imperfect Science," by D. Hattis and D. Kennedy, pp. 156 – 163, **plus** "Multi-Pathway Risk Assessment and the BIF Permitting Process," by K.E. Kelly.
- Wednesday, Mar. 18: Exposure pathways, dose-response curves, and risk simulation models **Reading:** "Ranking Possible Carcinogenic Hazards," by B.N. Ames, R. Magaw, and L.S. Gold, from Readings in Risk, ed. By T.S. Glickman and M. Gough, pp. 76 - 92., **plus:** "Technical Comment: Carcinogenic Risk Estimation," by S.S. Epstein and J.B. Swartz, pp. 93 – 95, **plus:** "Response to Samuel S. Epstein et al." By by B.N. Ames, R. Magaw, pp. 96 - 99.
- Friday, Mar. 20: - ***Seminar:*** Transportation of hazardous wastes. **Reading:** Textbook, Chapter 6, pp. 233 – 276.
- Monday, Mar. 23: - ***Lab Exercise 6***: Risk Assessment Model

6. Urban and Regional Facilities Planning

- Monday, Mar. 23: Introduction to facility location models, the p-median problem. **Reading:** "Facility Location: A Review of Context-free and EMS Models," by ReVelle, Bigman, Schilling, Cohon, and Church.
- Wednesday, Mar. 25: Location set covering and maximal covering problems. **Reading:** "Hidden Attributes and the Display of Information in Multiobjective Analysis," by Schilling, McGarity, and ReVelle
- Friday, Mar. 27: ***Seminar:*** Siting regional environmental facilities. **Reading:** Textbook, Chapter 14 (Whitlatch), pp. 615 – 652.
- Monday, Mar. 30: ***Lab Exercise 7***: Facility location model

7. Hydrology and Stormwater Management

- Monday, Mar. 30: Introduction to Hydrologic Processes: Precipitation and Infiltration **Reading:** Mays, Chapter 7: "Hydrologic Processes," pp. 191 - 227 and 233 - 246 (227 - 233 optional).

- Wednesday, Apr. 1: Storm Hydrographs. **Reading:** Ferguson, Chapter 1: "Stormwater and Environment," pp. 1 - 12 and Chapter 3: "Introduction to Hydrologic Concepts," pp. 31 - 44; Mays, Chapter 8: "Surface Runoff," pp. 247 - 261.
- Friday, April 3: Unit hydrograph determination by linear programming.**Reading:** Chow, Maidment, and Mays, "Chapter 7, Unit Hydrograph," pp. 216 - 223.
- Monday, Apr. 6: ***Lab Exercise 8 - Session 1***: Hydrology, GIS, and Stormwater Management
- Monday, Apr. 6: Runoff calculation methods for stormwater management: the rational and SCS curve number methods **Reading:** Ferguson, Chapter 4: "Storm Runoff," pp. 45 - 84.
- Wednesday, Apr. 8: Stormwater simulation and optimization modeling: the RunQual and StormWISE models. **Reading:** Selections from software manuals and research reports posted on Blackboard.
- Friday, Apr. 10: ***Seminar:*** Hydrologic and Stormwater modeling using Geographic Information Systems (GIS). **Readings:** Maidment, *Arc Hydro: GIS for Water* Resources, Chapter 4: "Drainage Systems," pp. 55 - 86; Evans, et. al. "A Comprehensive GIS-Based Modeling Approach for Predicting Nutrient Loads in Watersheds," Journal of Spatial Hydrology, Volume 2, No. 2.
- Monday, Apr. 13: ***Lab Exercise 8 - Session 2:*** Hydrology, GIS, and Stormwater Management

8. Surface Water Supply Systems

- Monday, Apr. 13: Introduction to surface water supply. **Readings:** (1) "Chapter 10, Water Resources: Supply and Demand," from Cutter, Renwick, and Renwick, pp. 199 – 228, (2) Textbook, Chapter 1 (ReVelle), pp. 1 – 12
- Wednesday, April 15: Water resource management models and the Deterministic linear decision rule model. **Reading:** (original research paper): ReVelle, Joeres, and Kirby, "The Linear Decision Rule in Reservoir Management and Design. 1, Development of the Stochastic Model," pp. 767 – 770.
- Friday, Apr. 17: **Reading:** Monday, April 21: Stochastic linear decision rule model. **Reading:** ReVelle, Joeres, and Kirby, "The Linear Decision Rule in Reservoir Management and Design. 1, Development of the Stochastic Model," pp. 771 – 776.
- Monday, Apr. 20: ***Lab Exercise 9:*** *Reservoir Sizing and Operation.*
- Monday, Apr. 20: Stochastic Linear Decision Rule, continued
- Wednesday, Apr. 22: Multireservoir systems. **Reading:** Textbook, Chapter 1, pp. 12 – 27.
- Friday, April 24 - ***Seminar*** - Water supply to Washington, D.C. and the Potomac River. **Reading:** Daniel Sheer, "Water Supply," pp. 50 – 53, *Civil Engineering*/ASCE. **Plus:** Palmer, Smith, Cohon, and ReVelle "Reservoir Management in the Potomac River Basin," pp. 47 – 64.

*** **Friday, APR. 24: TAKE-HOME FINAL EXAM DISTRIBUTED IN CLASS** ***

- Monday, April 27 - ***Final Exam work session in computer lab during lab period***

9. Groundwater Supply, Contamination, and Remediation

- Monday, Apr. 27: Introduction to groundwater and well analysis. **Reading:** Textbook, Chapter 3 (Yeh and Sun), pp. 97 – 108
- Wednesday, Apr. 29: ***Seminar:*** Groundwater contamination, remediation, and risk analysis. **Reading:** Textbook, Chapter 3 (Yeh and Sun), pp. 97 – 164.
- Friday, May 1 - NO CLASS – exam due at 10:30 AM

*** **Friday, May 1: FINAL EXAM DUE at 10:30 AM** ***