Midterm 3: Exam Blueprint

CENG 340–Introduction to Environmental Engineering
Instructor: Deborah Sills

December 8, 2013

Exam Format

Exam will include mostly (if not all) problems, but may also include some short answer and multiple choice questions. When solving problems, make sure you write down what you know, and, if you're stuck, describe what you are thinking and how you are approaching the problem.

You should bring three double-sided pages of notes (written in reasonable font size) for the exam. Do not include small-scale versions of solutions to homework problems.

Learning Goals

Environmental Measurements

Relevant sections in Chapter 2 of the textbook: 2.1.1, 2.5.3

Topics Covered:

1. Calculate chemical concentrations in units of mass/volume, mole/volume, and eq/volume.
2. Calculate particle concentrations (TSS, VSS, FSS) in water.

Water Chemistry

Relevant sections of Chapter 3 in the textbook: 3.3 (reaction stoichiometry), 3.11(kinetics)

Topics Covered:

1. Apply the law of conservation of mass to write balanced chemical equations and to calculate masses of reactants and products.
2. State, in differential form, a change in concentration with time according to zero- and first-order reaction kinetics.
3. Solve (or integrate) the differential form of zero- and first-order reaction kinetics.
4. Given sufficient data, calculate C, C_0, k, or t for zero- and first-order reactions.

Mass Balance with (or without) reactions

Relevant sections of Chapter 4 in the textbook:pp. 106–127

Topics Covered:

1. Describe the term "mass balance" in words and write the general mass balance equation.
2. Conduct a mass balance on a node where multiple streams meet and mix completely.
3. Conduct a mass balance on a control volume with multiple inputs and outputs, including recycle flows.
4. Prepare a labeled diagram of reactor systems that includes inputs, outputs, control volume, known and unknown variables.
5. Derive equations for batch and CMFR reactors that describe C as f(time), or t as f(C, C_0).

Biological Oxygen Demand

Relevant sections of Chapter 5 in the textbook: 5.4 through 5.4.4

Topics Covered:

1. Define the following terms: theoretical oxygen demand (ThOD), biochemical oxygen demand (BOD), carbonaceous biological demand (CBOD), ultimate BOD (BOD_u or L_0), L(t), y(t), and nitrogenous biological demand (NBOD).
2. Calculate carbonaceous and nitrogenous ThOD given the chemical formula of a waste.
3. Explain NBOD and when and why it might influence BOD analysis.
4. Be able to interpret plots of BOD as L(t) and y(t).
5. Calculate ultimate BOD from results of a BOD test.
6. Describe the laboratory procedures for determining BOD, and state the standard conditions for a BOD test.
7. Calculate the volumes of waste and dilution "water" needed to set up a BOD test, given concentrations of dissolved oxygen and BOD for both solutions.
8. Calculate the effect of temperature on k (BOD decay rate coefficient), L(t), and y(t).
9. Conduct a mass balance on a node to calculate BOD concentrations of mixed streams.

Growth of Microorganisms

Relevant sections of Chapter 5 in the textbook:pp. 164–168, pp. 171–175, Table 5.4

Topics Covered:

1. Describe the four stages of microbial growth.
2. Define and identify the parameters included in the Monod model: μ_{max}, K_s, X, μ, and S.
3. Analyze the Monod model and describe conditions that result in zero- or first-order kinetics.
4. Use the yield coefficient, Y, to calculate mass of biomass (microorganisms) produced per mass of substrate (waste) consumed.

Ecosystems: Trophic Structure and Bioaccumulation

Relevant sections of Chapter 5 in the textbook:pp. 186–187, pp. 204–207

Topics Covered:

1. Define "primary producers", "primary consumers", "secondary consumers", and explain their roles in a food web.
2. Describe and contrast the terms, bioconcentration and bioaccumulation, and provide an example of each term.

Nutrient Cycling

Relevant sections of Chapter 5 in the textbook:pp. 201–203

Topics Covered:

1. Describe the carbon, nitrogen, and phosphorous cycles, and the human-caused impacts on each cycle.

Wastewater Treatment

Relevant sections of Chapter 11 in the textbook: pp. 461–466, pp. 473–487

Topics Covered:

1. Draw a block-flow diagram of a conventional wastewater treatment facility.
2. Match major constituents in wastewater—TSS, BOD, and pathogens—with the unit process(es) that remove a significant amount of each constituent.
3. With respect to centralized domestic wastewater treatment, describe the general purpose of screening, grit removal, primary treatment, secondary treatment, anaerobic digestion, and sludge dewatering.

4. Given the following microbial growth parameters: μ_{max}, Y, K_s, and k_d; and influent BOD concentration S_0, determine the minimum (or critical) solids retention time (SRT) for an aerobic biological treatment reactor.

5. From the verbal description of solids retention time, calculate SRT for a biological treatment reactor (CMRF) with or without recycle of solids from the secondary clarifier.

6. Given SRT, μ_{max}, Y, K_s, and k_d, calculate the effluent BOD concentration from conventional sewage treatment.

7. Given SRT, flow rate, Y, influent (S_0) and effluent (S) substrate concentration , biomass concentration in the aeration tank (X) and k_d, calculate the volume of the aeration tank.

8. Use solids retention time to calculate secondary sludge production in an activated sludge system.

9. Describe how a plan operator would change X to accommodate a change in influent (mass) flux of BOD (Q_0S_0).

10. Calculate HRT, SRT, and F/M for an aeration tank given sufficient information.