

**1.85 WATER AND WASTEWATER TREATMENT ENGINEERING
TAKE-HOME MID-TERM EXAM
DUE FRIDAY NOVEMBER 4, 2005 AT 1:00 PM**

This is an open-book exam, with the exception that you are asked to restrict your use of Internet sources to the links included on the 1.85 course webpage and to routine information sources like unit conversions. Unlike the homework, collaboration is not permitted—please do not work with others on this exam. If you have questions, you can reach Pete Shanahan.

1. (28 points)
Stormwater detention ponds are intended to serve both to attenuate flood flows by providing temporary water storage and to improve stormwater quality by removing sediment. The Massachusetts Stormwater Technical Handbook recommends that stormwater detention ponds provide an average of 24 hours detention time. The guidelines also indicate that ponds can be between 3 and 12 feet (1 and 4 meters) deep.
Given these guidelines, what size particle can be entirely removed in:
 - a. A 3-foot (1-meter) deep pond?
 - b. A 12-foot (4-meter) deep pond?Provide your solutions in metric units. You can assume Type I settling and a particle density of 2.6 g/cm^3 .
 - c. Do you think the 24-hour detention pond guideline is adequate to ensure that detention ponds will remove sediment from the stormwater?
 - d. Do you think it is realistic for the state to give a single detention-time guideline when the pond depth is variable? (Phrased another way, do you think the state should provide different detention-time guidelines for 1-meter deep and 4-meter deep ponds.) Why or why not?

2. (28 points)
On-site wastewater treatment via a septic tank and disposal to a subsurface leaching field is a common means to manage wastewater in rural and suburban areas. The technology depends upon the soil to act as a filter to remove bacteria and viruses. Please answer the following essay questions regarding your expectations of the mechanisms and effectiveness of this filtration technique.
 - a. Bacteria and viruses are generally negatively charged. If the soil below the leaching field is a sandy soil that is fully saturated with water, would you expect the soil to be generally effective or ineffective in removing bacteria and viruses? Why or why not?
 - b. Experimental data show that virus removal by soil is generally more effective from regular tap water than from distilled water. Provide an explanation for this observation.
 - c. Studies have shown that the number of fecal bacteria found in the ground water below a newly constructed leaching field is higher after it first starts to be used but then decreases with time until it reaches an approximately steady level. Provide an explanation for this observation.
 - d. Very coarse sands allow fast infiltration of wastewater and thus enable smaller, less expensive leaching fields to be constructed. However, many states ban septic systems in very coarse sands. Provide a technical explanation for why leaching fields would be banned in very coarse sands.

3. Short answer questions (3 points each, 30 points total).
For each of the following indicate if the designated technology is appropriate for the indicated water-quality problem. Explain why or why not (answer in no more than a few sentences).
- A 60-micron household filter for cryptosporidium.
 - Ion exchange for waste contaminated by radioactive cesium and strontium.
 - A strong-base ion exchange resin for nitrate.
 - Slow sand filtration for highly turbid water.
 - Activated carbon for ground water contaminated by BTEX (benzene, toluene, ethylbenzene, and xylene) from a gasoline spill.
 - Filtration for taste and odor.
 - Lime treatment for hardness of 90 mg/L as CaCO_3 .
 - Ion exchange for hardness of 90 mg/L as CaCO_3 .
 - Lime treatment for iron.
 - Suspended sediment removal in a vigorously mixed fully-mixed tank.
4. (14 points)
In designing a sedimentation basin, indicate whether the first stated design characteristic would require a smaller, larger, or same size basin to achieve the same sediment removal as the second stated characteristic. Give a short (one or two sentences) explanation of your answer.
- Large particles vs. small particles of the same density with Type I settling.
 - A 3-meter deep tank vs. a 5-meter deep tank.
 - Type II vs. Type I settling of influent particles of the same size and density.
 - Mineral (e.g., quartz) particles vs. organic particles of the same size.
 - Particles with a single settling velocity, V_s , vs. particles with a distribution of settling velocities with a mean settling velocity equal to V_s .
 - A long, narrow tank vs. a circular center-feed tank.
 - Average supply water temperature of 20°C vs. 5°C