CE 5364 Groundwater Transport Phenomena
Spring 2020
Exam 1

You have 2.5 hours (150 minutes) to complete your work on this exam except as modified by a disability. That time does not count the time required to print out the exam pages for you to write on or to scan your work into a single pdf file to email back to Dr. Rainwater. If you don't print out the exam to write your answers, write your answers on your own paper, making sure you identify which answer goes with which question. You can also supplement your own paper if the exam printout is too short for you. Please don't waste time copying the entire problem statement or question, just make sure you show where you are like this, spacing them out on the pages wo you can complete your work. If I can't figure it out, it's wrong.

Format if you provide all your own paper for the exam, and don't write your solutions on your printout of the exam

Verbal Questions

1. *followed by your answer*
2. *followed by your answer*
    and so on

Problems

1. *followed by your answer*
2. *followed by your answer*
3. *followed by your answer*
    [a] followed by your answer
    [b] followed by your answer
    [c] followed by your answer
4. *[a] followed by your answer*
    [b] followed by your answer

The verbal part of the exam is to be completed without any books, notes, old homework, or electronic access to anything or anybody. For the problems, you can use your notes, homeworks, and the provided text pdfs on your computer. You are not allowed to use any other digital or paper aids beyond that list. You can use the typical NCEES calculator that you are used to in our courses. You are also prohibited from making the downloaded exam file available to anyone else at any time or selling it to a coursework collection service like Chegg. You must also sign this academic honor pledge and record the clock time for your beginning and ending of the exam. Once you start the exam, you must continue until you finish, with only short interruption for bathroom needs. I hope you will put it behind you during the 10:00 a.m.-12:30 p.m. time slot so you can get on with your other responsibilities.

Pledge (copy this by hand if you don't print out the exam) Absolutely required!

On my honor, I have neither given nor received any aid on this exam. I followed all the given instructions as required.

Signature_____   Start time_____   Stop time_____

Name_____

I. Verbal Questions (28 points total, 4 points each). **CLOSED BOOK PORTION.**   Answer 7 of the following 8 questions briefly and concisely. Use complete English sentences when appropriate. Clearly mark the questions you omit.

1. Describe how you can use the areal extent of a groundwater contaminant plume with a known source to estimate the local groundwater velocity.

2. List four transport mechanisms that affect solute migration in groundwater flow.

3. Why are dispersivity values small (~ cm) for lab column tests and large (~ m) for field transport modeling?

4. List four soil characteristics that affect sorption in groundwater solute transport.

5. Define natural attenuation as applied in groundwater contamination studies.

6. Distinguish between Remedy A and Remedy B approaches in their need for risk assessment for a contaminated site as defined in the TCEQ's Texas Risk Reduction Program.

7. Calculation of a reference dose for human exposure usually requires mathematical extrapolation of data from animal exposure studies through the use of uncertainty factors. Specifically list four types of uncertainty that these factors represent.

8. Explain the conservative nature of the process of setting an MCL for a contaminant in drinking water based on the use of animal toxicity testing, assuming you are talking to a TV reporter and you have a 40-second sound bite.

Name_____

II. Problems (90 points total). **OPEN BOOK, NOTES, AND TEXT PDFS PORTION. Work all four problems. Show your work clearly for full credit. Watch your units!! Clearly mark your answers.** If you need more paper, provide your own.

1. (15) The hydraulic gradient in a homogeneous, anisotropic aquifer has a magnitude of 0.0045, with head decreasing in the direction 35° north of east. The hydraulic conductivity tensor is $\overline{K} = \begin{bmatrix} 20 & 6 \\ 6 & 12 \end{bmatrix} m/d$ in the same Cartesian coordinate system. **Find the angle between the specific discharge vector and the head gradient. (Hint: Use a sketch to keep oriented, and remember the sign on the head gradient.)**

2. (15) A one-dimensional column test was performed with a 30-cm long packed column of soil. The injected solute concentration was 10.0 mg/L, and the actual seepage velocity during the experiment was 0.20 cm/min.   The dispersivity of the solute in this soil is known to be 4.0 cm. **Find the concentration in mg/L of the solute in the column effluent at a time of 90 minutes after the injection began.**

3. (30 total) One kilogram of toluene was spilled into a well that fully penetrates an aquifer. The toluene immediately dissolved, and mixed completely into the water in the well. The well's effective diameter is 0.60 m, and the aquifer has a uniform saturated thickness of 8.5 m, so the source area is 5.1 m². The seepage velocity is 95 m/yr in the x-direction to the west, the longitudinal dispersivity is 3.5 m, and the transverse dispersivity is 0.50 m. The aquifer material has bulk density of 1.6 g/cc and porosity of 0.40. The linear distribution coefficient K_d is 0.84 L/kg for toluene in this soil. The toluene has a first-order decay rate of 0.021 d^{-1}.

[a] (6) **Find the retardation factor R for toluene in this aquifer.**

[b] (6) **How long in years does it take for the center of mass of the contamination plume to travel 5 m in the direction of flow?**

[c] (18) A well is located as shown to the west and north of the well with the spill. **Find the toluene concentration at the second well in mg/L at the time you found in part [b].**
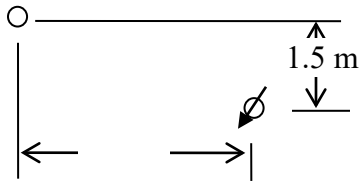
4. (30 total) *A contaminated site has large concentrations of lead, a toxic non-carcinogen with separate RfD values of 5.7×10^{-4} mg/kg-d by inhalation and 6.60×10^{-4} mg/kg-d for dermal contact. On-site concentrations include 350 mg/kg in the soil and 0.042 mg/m³ in the air. If no action is taken at the site, the off-site workers will be exposed to the soil through ingestion and dermal exposure, and the air concentration through inhalation. Off-site residents will also be at risk through the inhalation pathway at the same concentration as measured on-site.*

[a] (15) **Find the intake value in mg/kg-d and hazard quotient for dermal exposure for off-site workers.**

[b] (15) **Find the intake value in mg/kg-d and hazard quotient for inhalation for off-site children residents 6-12 years of age.**