Again, this homework assignment is to be completed in your homework group. If your group has not already submitted a sheet on its expectations, please submit it with this assignment. Also, remember that only the problems with stars are required.

8. To determine the hydraulic conductivity of a clay, you conduct a test with a falling head permeameter. The soil sample is 10 ± 0.05 cm long, and its cross sectional area is 100 ± 0.5 cm². The cross sectional area of the tube in which the water falls is 4 ± 0.02 cm². The uncertainty in the head is 0.1 cm, and the uncertainty in the time is 5 seconds. Do parts a-e of problem 8 for this problem.

<table>
<thead>
<tr>
<th>Time (days)</th>
<th>Head (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5.0</td>
</tr>
<tr>
<td>1</td>
<td>4.6</td>
</tr>
<tr>
<td>2</td>
<td>4.4</td>
</tr>
<tr>
<td>5</td>
<td>3.4</td>
</tr>
<tr>
<td>10</td>
<td>3.1</td>
</tr>
<tr>
<td>15</td>
<td>1.8</td>
</tr>
<tr>
<td>20</td>
<td>1.4</td>
</tr>
<tr>
<td>25</td>
<td>0.9</td>
</tr>
</tbody>
</table>

*9. Measure the hydraulic conductivity of a soil sample using a falling-head test. The soil is from the Ackmore-Colo complex; it is 15.5% sand, 51% silt, and 33.5% clay. Your group will schedule a time to meet in the lab with me and Delise Lockett of ABE. Before you go to the lab, discuss the measurements that you will need and prepare a data sheet. You will also need to estimate the measurement uncertainty for each parameter that you measure.

a. Measure and plot the head as a function of time since the start of the test.

b. Compute the hydraulic conductivity.

c. Compute the measurement uncertainty in the hydraulic conductivity.

d. Verify that Darcy’s law is valid for this experiment.

e. Write a paragraph discussing your results. Discuss the magnitude of the hydraulic conductivity by comparing it with the ranges in Fetter’s book. Are any of the points in your plot suspect? Is the uncertainty in K large? What could be done to improve this experiment? If you wanted to decrease the uncertainty, where would you put your effort?
10. A confined aquifer has length $L = 7.5\text{ km}$, thickness $b = 30\text{ m}$, hydraulic conductivity $K = 3 \times 10^{-5}\text{ m/s}$, and effective porosity $n = 30\%$. The head on the west side of the aquifer is $h_0 = 2.5\text{ m}$, and the head on the east side is $h_L = 1\text{ m}$.

a. What is the flow per unit width?

b. Is Darcy’s law valid in this aquifer?

c. How long does it take water to travel from one side of the aquifer to the other?

*11. Two German researchers investigated the movement of organic compounds in the groundwater at a former gasworks site. The figure for this problem on the web site shows the contaminant plume and layout of the site. The study found the aquifer to be $3.5\text{ m}$ thick with a hydraulic conductivity of $2.6 \times 10^{-4}\text{ m/s}$, effective porosities between $6\%$ and $37\%$, and a hydraulic gradient between $0.036\%$ and $1\%$. Estimate the range of times for the contaminant to travel from site B49 to site NT01.

*12. A confined aquifer has a heterogeneous distribution of hydraulic conductivity.

a. Derive an expression for the effective hydraulic conductivity in the aquifer below.

b. Show that your result satisfies at least two special cases.

c. Compute the effective conductivity if $L_1 = 600\text{ m}$, $L_2 = 300\text{ m}$, $K_1 = 3 \times 10^{-6}\text{ m/s}$, and $K_2 = 10^{-4}\text{ m/s}$.

d. Plot the head as a function of $x$ if $h_0 = 10\text{ m}$, $h_L = 9\text{ m}$, and $b = 15\text{ m}$.

e. Which soil controls the effective hydraulic conductivity of the aquifer—the low conductivity soil or the high conductivity soil?

13. Steady flow occurs in a confined aquifer with thickness $27\text{ m}$ and width $250\text{ m}$. The hydraulic conductivity is $4 \times 10^{-6}\text{ m/s}$. The head at an observation well is $25\text{ m}$. If the flow is $5 \times 10^{-5}\text{ m}^3/\text{s}$, what is the head $1400\text{ m}$ downgradient?

14. For the same flow in a confined aquifer, which has a larger gradient—coarse sand or silt? For the same gradient in a confined aquifer, which has a larger flow—coarse sand or silt?
Suppose you are asked to set up a groundwater model for a confined aquifer consisting of silty soils. Heads are measured at three observation wells, as shown below. To calibrate your model, you must choose the values and spatial distribution of the hydraulic conductivity.

a. Choose a field of hydraulic conductivity to reproduce the measured heads.
b. Compute the flow per unit width in the aquifer if the thickness is 5 m.
c. Discuss any challenges or uncertainty you may have encountered in this problem.