GEOL3140 HYDROGEOLOGY
Problem Set #1
Darcy's Law

Show all relevant work, label/caption all plots, label units where appropriate
Due: Start of class Feb. 18th

Henry Philibert Gaspard Darcy conducted laboratory experiments to examine how water flows through a pipe filled with sediment. His revelations demonstrated the proportional relationships between groundwater flow, hydraulic head, and hydraulic conductivity. Darcy's Law is the fundamental equation of hydrogeology.

$$Q = -KA\frac{dh}{dl}$$

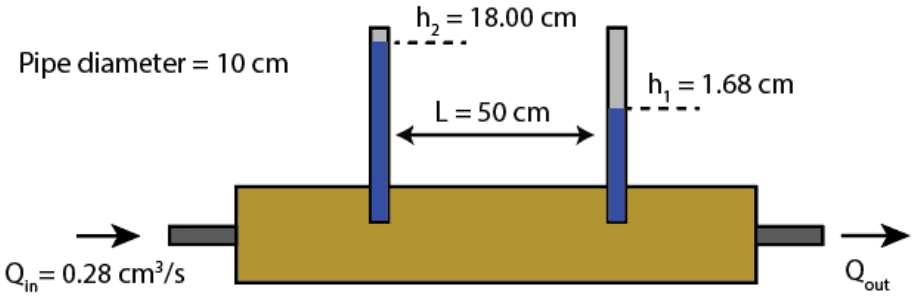
Q = groundwater discharge (L^3/T)
K = hydraulic conductivity (L/T)
A = Cross sectional area of the aquifer in the direction of flow (L^2)
dh = change in hydraulic head (L)
dl = distance between head observations (L)

This problem set is designed to use Darcy's Law to test and design an Excel model similar to the physical model used in Darcy's famous 1856-1857 experiment.

Part 1. Determining K of a geologic material

1. A Darcy column is shown below. Use Darcy's Law and the hydraulic conductivity (K) handout to determine K (cm/s) and the type of material.

   K: Material:



2. Suppose you fill the column with silty sand (K = 0.0001 cm/s) and try to force 1.7 cm^3/s through the column.
   i) What is the resulting dh?
   ii) Do you have any column design recommendations or suggested modifications?

Part 2. Effect of parameter variations on hydraulic head

A spreadsheet Darcy model can be downloaded from the course website (jamesheiss.com/GEOL3140S19) to test the effect of changing values of flow, pipe diameter, and pipe length (dl), on change in head (dh). Values for Q, K, L, and A are all set to 10 by default.

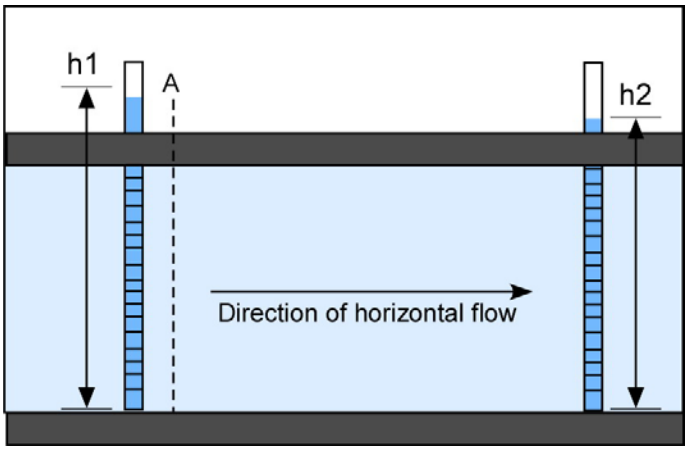
1. On Sheet1, plug in the values from Part 1 Question **2** to confirm your calculations for dh are the correct, then experiment with changing various hydraulic and physical parameters in SOLID GREEN cells to see what happens to dh. There are no deliverables here. Just think about why each adjustment results in the changes to the other Darcy variables. Don't save changes.

2. On Sheet1, plug in the values from Part 1 Question **1** in the SOLID GREEN cells only and simply change the flow (discharge; Q) by reducing/increasing the flow rate. Use at least five different values of Q, and in turn dh, and create a small graph in Excel of this relationship. Submit a screenshot of the graph and one-sentence caption explaining the effect of Q on dh.

3. On Sheet2, plug in the values from Part 1 Question **1** in the SOLID GREEN cells only. Now change the diameter of the pipe. PVC comes in 2, 4, 6, 8, and 12 inch diameters. How does this change discharge? Plot a graph as you did in step 2. Submit a screenshot of the graph and a one-sentence caption explaining the relationship. Remember to label axes and units!

Part 3. Flow through an aquifer

Two wells are fully screened in a confined aquifer and located 1.5 km apart. Aquifer thickness is 20 m, porosity is 0.22, and hydraulic conductivity is $8x10^{-4}$ m/s. Hydraulic heads at the wells are h1 = 26.3 m and h2 = 23.7m.



What is the volumetric flow rate (Q) between wells 1 and 2 per 100 m of aquifer width (dimension into the paper)? Give answers in m^3/d.

How long will it take a particle of water to move between the two piezometers? Give answer in years.