Take Home Exam 2
Environmental Science 318
Applied Hydrogeology

1. Define porosity. Compute the porosity of a sample that has the following characteristics:

The sample fills a cylinder of radius 2cm and length 10cm
After the sample is soaked, approximately 1cc of water can be recovered from it.

$$n = \frac{1cm^3}{\pi(2cm)^2 \cdot 10cm} = 0.00797$$

2. Using the graph provided, find

d_{60}: the grain size that is 60% finer by weight
d_{10}: The effective grain size (the grain size that is 10% finer by weight)
C_u: The uniformity coefficient

$$d_{60} = 0.22mm$$
$$d_{10} = 0.14mm$$
$$C_u = \frac{d_{60}}{d_{10}} = \frac{0.22}{0.14} = 1.57$$

What does it mean for a sample to be "well sorted" and how can you judge this from the shape of the grains size distribution curve.

"Well sorted" means that the grains are of uniform size--the more well sorted the more uniform.

3. Define Q and relate it to Darcy's Law. Use this relationship to find the Hydraulic conductivity for the following conditions taken from a constant head permeamter.

Cylindrical sample has radius 10cm
Difference in head is 2cm over a length of 1m
Flow is 20cc in 30 s.

$$Q = KA\frac{\Delta h}{L}$$
$$K = \frac{QL}{A\Delta h} = \frac{(20cm^3/30s)\cdot 100cm}{\pi(10cm)^2 \cdot 2cm} = 0.106\ cm/s$$

4. Using the information in 3, define the intrinsic permeability of the sample Take

$$\rho = 1g/cm^3$$
$$\mu = 0.008$$

$$K = K_i \frac{\rho g}{\mu}$$

$$K_i = \frac{K\mu}{\rho g} = \frac{0.106(cm/s)\cdot 0.008 g/s\cdot cm}{1.0 g/cm^3 \cdot 980 cm/s^2} = 8.65\times 10^{-7} cm^2$$

Is this a high or low intrinsic permeability.

We should compute the permeability in Darcys.

$$K = 8.65\times 10^{-7} cm^2 \cdot \frac{1\, darcy}{9.87\times 10^{-9}} = 87.6\, darcy$$

5. Use the Hazen method and the information in 2, and 3 to find the shape factor for the sample. If this value is on the table, what kind of soil is this?

$$K = C\, d_{10}^{\;2}$$

$$C = \frac{K}{d_{10}^{\;2}} = \frac{0.106 cm/s}{(0.014 cm)^2} = 540.8!$$

6. An unconfined aquifer loses $3\times 10^7 m^3$ when its head falls by 0.4m. If the aquifer is circular and has a radius of 5km, what are the storativity and specify yield for this aquifer.

For an unconfined aquifer, the Storativity equals the specific yield...

$$V_w = SA\Delta h$$

$$S = \frac{V_w}{A\Delta h} = \frac{3\times 10^7 m^3}{\pi \cdot (5000 m)^2 \cdot 0.4 m} = 0.955$$

$$S = S_y$$

7. A confined aquifer has a skeleton compressibility of $3\times 10^{-7} m^2/N$ and a porosity of 0.25. If the compressibility of water is $4.6\times 10^{-10} m^2/N$:

a) What is the specific storage of this aquifer?

$$S_s = \rho g(\alpha + n\beta)$$
$$= (1000 kg/m^3)\cdot(9.8 m/s^2)\cdot(3\times 10^{-7} m^2/N + 0.25\cdot 4.6\times 10^{-10} m^2/N)$$
$$= 2.94\times 10^{-3}$$

b) If the aquifer is 2m thick, what is the storativity?

$$S = bS_s = 2\cdot 2.94\times 10^{-3} = 5.88\times 10^{-3}$$

c) If the area of the aquifer is $1\times 10^6 m^2$ and the head falls by 0.25 m, what volume of water is expelled?

$$V_w = SA\Delta h$$
$$= 5.88\times 10^{-3}\cdot 1\times 10^{6} m^2 \cdot 0.25\text{ m}$$
$$= 1470 m^3$$

8. Four layers in an aquifer have the following characteristics:

Hydraulic Conductivity(ft/day)	Layer thickness
K_A=10 ft/day	22 ft
K_B=20 ft/day	42 ft
K_C=5 ft/day	12 ft
K_D=25 ft/day	32 ft

Compute the horizontal and vertical conductivity for this aquifer.

$$K_H = \frac{22\text{ ft}\cdot 10\text{ ft/day} + 42\text{ ft}\cdot 20\text{ ft/day} + 12\text{ ft}\cdot 5\text{ ft/day} + 32\text{ ft}\cdot 25\text{ ft/day}}{22\text{ ft} + 42\text{ ft} + 12\text{ ft} + 32\text{ ft}}$$
$$= 17.7\text{ ft/day}$$

$$\frac{22\text{ ft} + 42\text{ ft} + 12\text{ ft} + 32\text{ ft}}{K_V} = \frac{22\text{ ft}}{10\text{ ft/day}} + \frac{42\text{ ft}}{20\text{ ft/day}} + \frac{12\text{ ft}}{5\text{ ft/day}} + \frac{32\text{ ft}}{25\text{ ft/day}}$$
$$\frac{108\text{ ft}}{K_V} = 7.98\, day$$
$$K_V = \frac{108\text{ ft}}{7.98} = 13.5\, ft/day$$

9. Consider the potentiometric map at the end of the test.
a) What is a potentiometric map and what does a map like this show.

A potentiometric map shows lines of constant head. This give a picture of the surface the aquifer.

b) Describe what might be happening in this map. What human activity could cause the depression in the potentiometric surface that is shown

There is a depression in the water table. This could be due to pumping in a well.

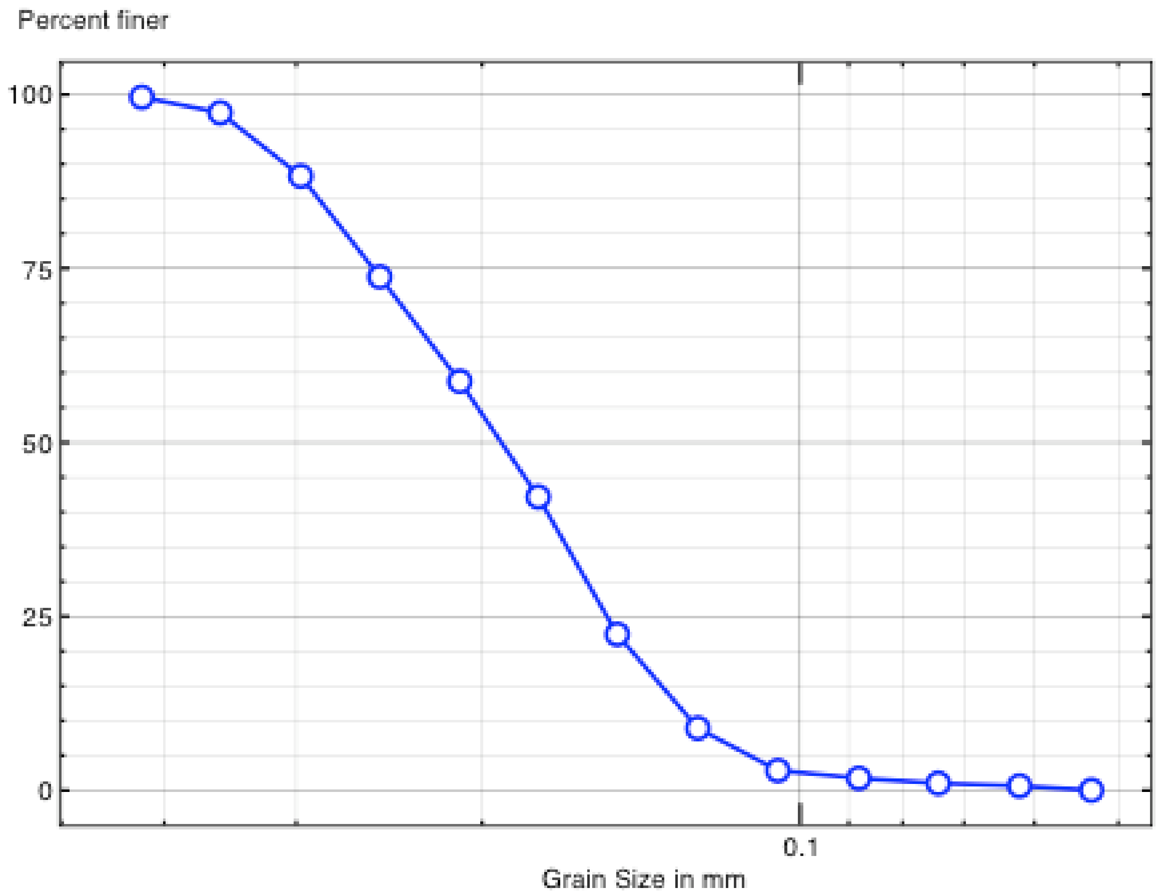
c) What is the gradient of the potentiometric surface and why is the gradient important.

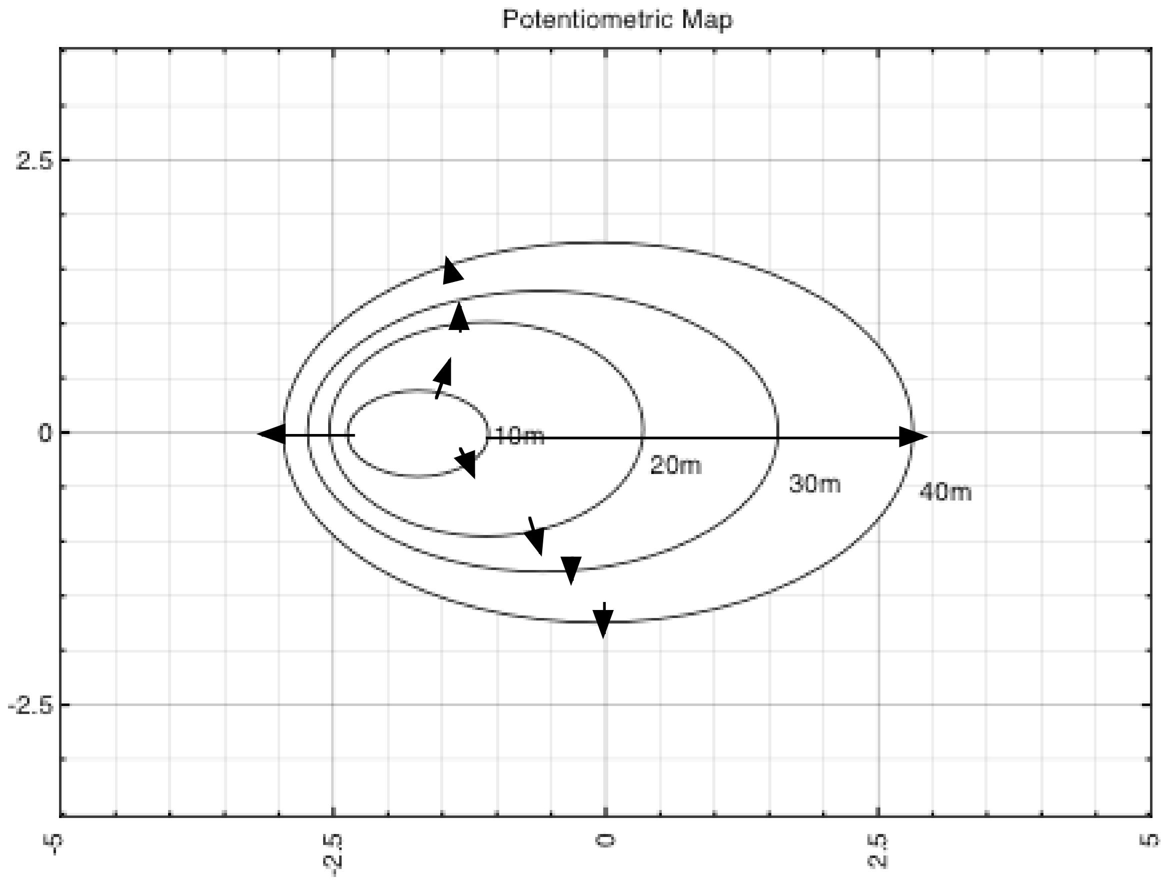
The gradient is the slope of the potentiometric surface. It can be used to determe what direction water will flow.
d) Draw in gradient arrows for the surface shown. Where is the gradient largest?
Gradient points toward larger head. The water flow is opposite this. The gradient is largest where

the potentiometric lines are closest together...

St. Peter Sandstone (quoted from http://www.cs.pdx.edu/~ian/geology2.5.html)

> "The St. Peter Sandstone has undergone an extensive multicyclic depositional history. It's last depositional episode was as a beach sand along a transgressing sea. During at least one of its previous depositional episodes the sand grains were eolian (wind transported) deposits. Consequently, the range of particle sizes is somewhat restricted owing to the narrow range of particle sizes that can be transported by wind. Due to its extensive depositional history the St. Peter Sandstone is texturally, and mineralogically very mature."





Potentiometric Map
2.5
0
-2.5
-5
-2.5
0
2.5
5
10m
20m
30m
40m