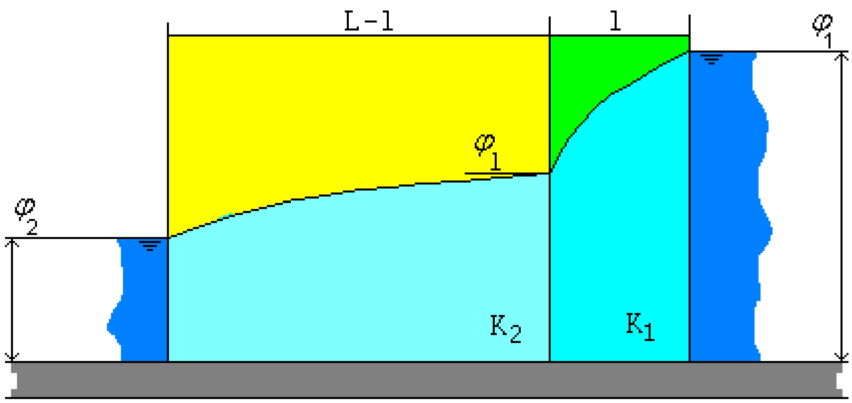
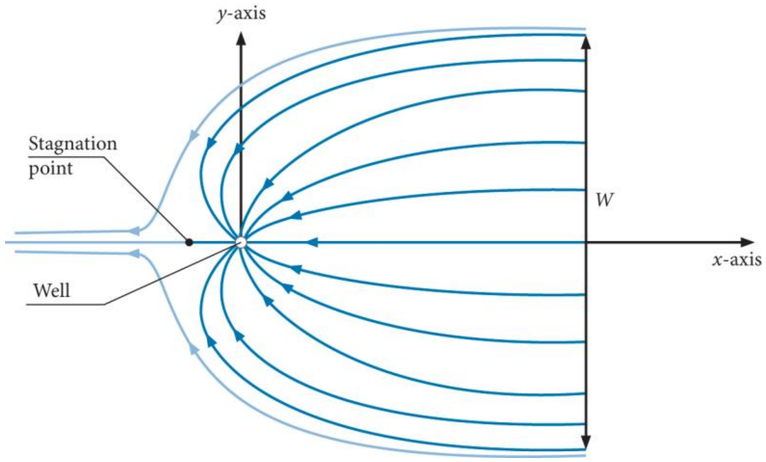
Addis Ababa Institute of Technology (AAiT), School of Civil and Environmental Engineering

CENG 6606: GROUNDWATER HYDRAULICS, Exercise 1

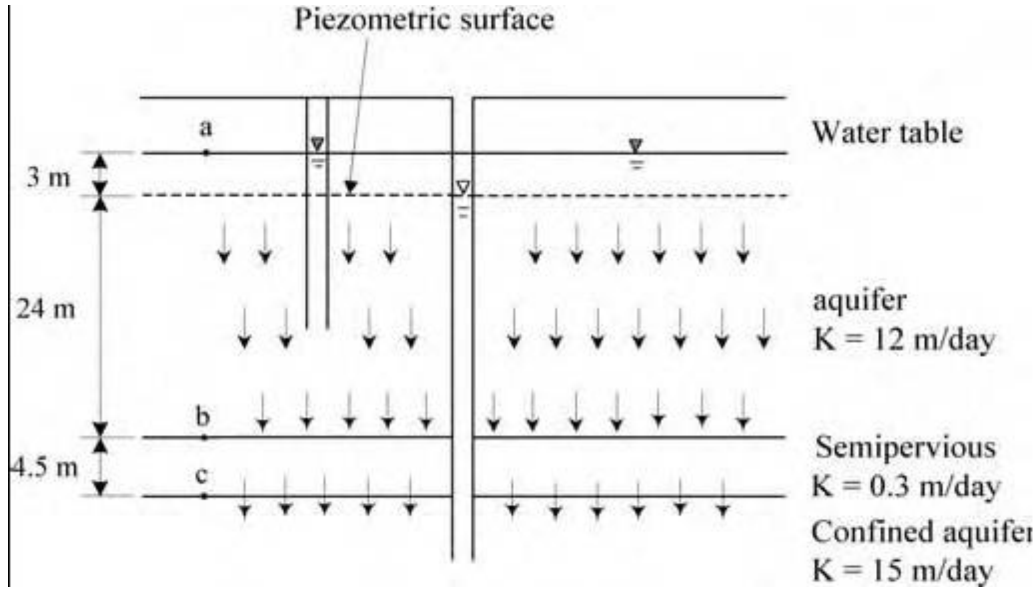
1. Below a dam is sketched consisting of two segments with different permeability. Calculate the discharge through the dam. Dimensions and permeability of the segments are: K_1 = 0.1 m/day; l = 2 m; φ_1 = 10 m; K_2 = 0.5 m/day; L = 10 m; φ_2 = 2 m



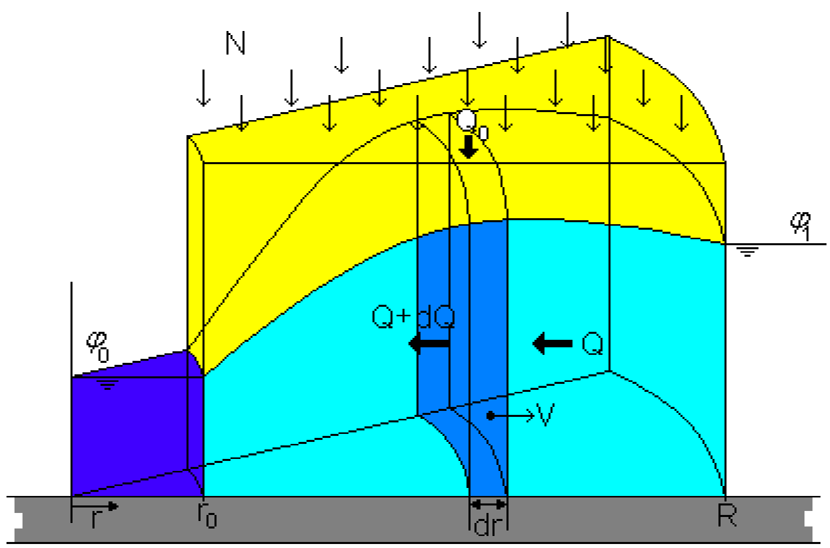
2. The figure below shows streamlines due to groundwater extraction by a pumping well in a regional flow field in plan view. As shown in the figure below a fully penetrating well pumps water from a confined aquifer with a thickness of 50 m. Before pumping there existed a uniform groundwater flow parallel to the x-axis in a negative direction; the hydraulic gradient of this uniform flow field is 0.001. The aquifer has a hydraulic conductivity of 10 m/day. The well pumps water with a discharge or volume flux of 628.32 m^3/day. Determine the maximum width W of the area from which water is extracted by the well.



3. As shown in Figure below, a semi-impervious aquitard separates an overlying water table aquifer from an underlying confined aquifer. Determine the rate of flow that takes place between the aquifers.



4. The ends of a soil column 200 cm long have heads 30 cm and 80 cm at A and B, respectively until steady state prevails. The heads of the ends A and B are changed to 40 cm and 80 cm, respectively. Find the head distribution in the soil column as a function of time and length. Take Ss as 10^{-3} and K as 10^{-5} cm/s
5. Develop the steady-state flow equation in an aquifer that has the following hydraulic conductivity function: $K = K_0\left(a + be^{cx} + de^{fy}\right)$ where K_0, a, b, c, d, and f are parameters of the system.
6. For phreatic aquifer and radial groundwater flow with recharge of N (See Figure below), proof that the equation for the water table profile is given by: $h^2 = \varphi_1^2 + \frac{N}{2K}\left(R^2 - r^2\right) + \frac{Q}{\pi K}\ln\left(\frac{r}{R}\right)$



Below there are 5 questions about a case with a phreatic aquifer. The situation is shown in the picture above. The aquifer consists of a circular "island". The problem is axi-symmetric. Numerical values for several parameters are given at the right side of the picture.

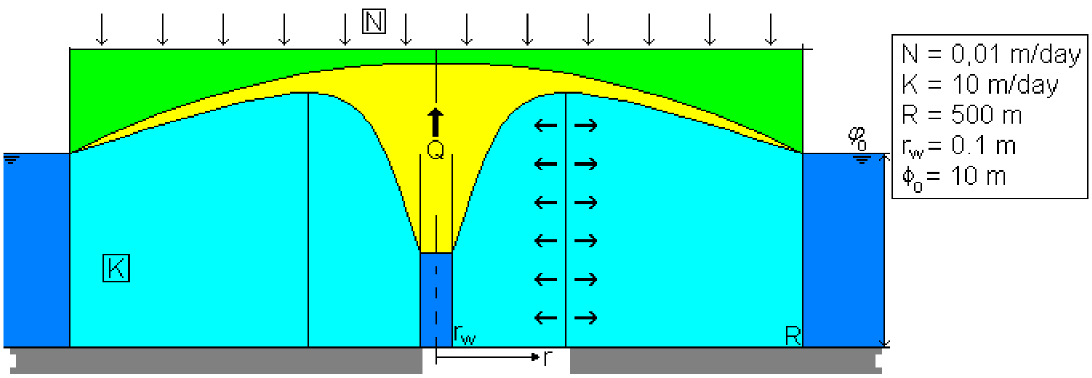
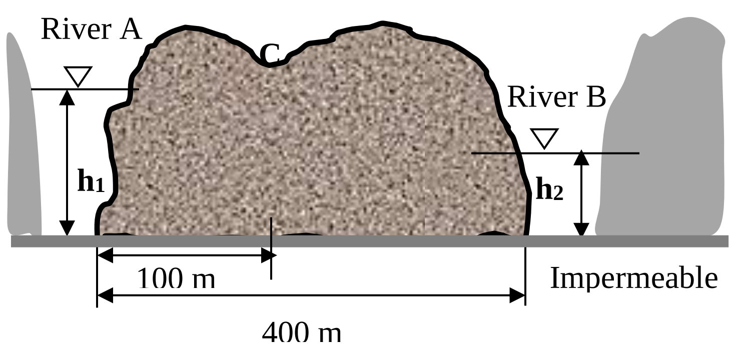


Figure (for the next five problems)

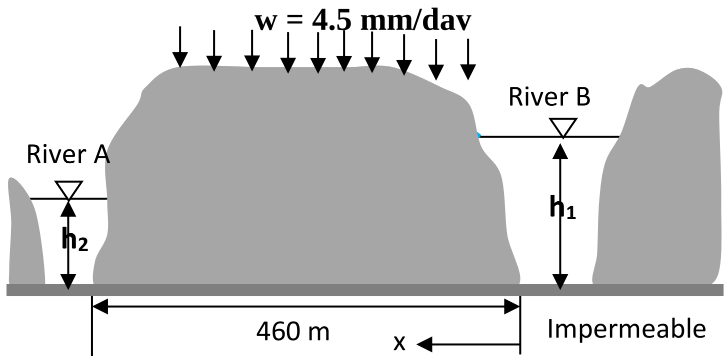
7. Here, there is only recharge from the top. The well at the center is not active yet. The water table is the curving line between the green and yellow area. What is the water table height at the center of the island? (*r=0*)
8. A well is placed at *r* = *0*. The discharge of the well is such that no intrusion at the side takes place (there is no water flowing from the surrounding water to the island). What is the value of the discharge *Q*?
9. With the discharge found in (7), what is the drawdown at the well?
10. If the head in the well is 3 m, then what is the discharge *Q*?
11. With the discharge found in problem 9, at what *r* is then the water divide and what is the water level there?
12. An unconfined aquifer (where Dupuit assumption is valid) of clean sand and gravel is located between two fully penetrating rivers (see the figure below) and has a hydraulic conductivity of 0.01 cm/s. At point C (100 m away from River A and at 1592 m elevation) a marsh land was observed during study time. The water surface elevations in rivers A and B are 1590 m and 1585 m, respectively. The top impermeable structure level is at 1580 m elevation. Estimate: **(30%)**
    a. The maximum elevation of the water table and the location of the stagnation point.
    b. The travel time from the stagnation point to River A (Take effective porosity of 0.35)



13. In exercise above project is proposed to drain the marsh land to 2 m depth below point C, so that dry space is created. If Dupuit's assumption is valid here:
    a. Keeping river B level at 1585, what will be water level in river A that results in proposed project?
    b. The maximum elevation of the water table and the location of the stagnation point after the project.
    c. The travel time from the stagnation point to River A (Take effective porosity of 0.35)

14. An unconfined aquifer of clean sand and gravel that is located between two fully penetrating rivers (see the figure below) has a hydraulic conductivity of K = 0.01 cm/s and an effective porosity of 0.35. The aquifer is subjected to a uniform recharge of 4.5 mm/day. The water surface elevations in rivers A and B are 1588.5 m and 1590.0 m, respectively, above the bottom (which is at 1580.0 m). Estimate:

   a. The maximum elevation of the water table and the location of the stagnation point.
   b. The travel time from the stagnation point to both rivers
   c. The daily discharge per kilometer from the aquifer in to both rivers.



15. For an isotropic aquifer (K_x = 0.0004m/s and K_y= 0.0001 m/s) the following flow net was drawn on the transformed section. The broken lines represent the flow lines and the solid lines represent equipotential lines. Estimate the flux through the medium. **(10%)**