CEE 491/591 — Groundwater Hydrology
Assignment 1: Porous Media and the Water Balance

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Module 1

Submission Instructions

All answers must be submitted as a single **Excel file**.

- Each problem must be solved on a **separate worksheet**.
- **All calculations must be performed using Excel formulas** (no hard-coded numerical results).
- All formulas must be **visible and preserved** in the submitted file.
- Clearly label the given data, intermediate calculations, and final answers, with units for all results.
- Write short explanations in a text cell next to the related calculation.
- Upload the `.xlsx` file to **Brightspace** → **Assignments**.

Problem 1: Porosity and Volumetric Water Content (25 points)

A cylindrical soil core is extracted from a sandy aquifer. The core has a diameter of 6 cm and a length of 25 cm. The mass of the sample immediately after extraction is 1,416 g, and the oven-dry mass is 1,217 g. The density of the soil mineral grains is 2.65 g/cm^3.

(a) Calculate the total volume of the soil sample.

(b) Determine the dry bulk density of the soil.

(c) Calculate the porosity of the soil.

(d) Compute the volumetric water content, θ.

(e) Comment on whether the soil is likely fully saturated.

Problem 2: Reservoir Water Balance and Residence Time (25 points)

A water-supply reservoir has a surface area of 3.4 km^2 and a mean depth of 6 m. During a dry month with no rainfall, one stream flows in at 14,000 m^3/day and the dam releases 11,500 m^3/day. Evaporation from the water surface is 3.5 mm/day, and the water level is falling at 1.5 mm/day. The only other flux is the net exchange with groundwater.

(a) Express the surface area in m^2.

(b) Compute the rate of change of storage, dS/dt (m^3/day).

(c) Compute the evaporation loss in m^3/day.

(d) Write the hydrologic balance for the reservoir and solve for the net groundwater inflow G (negative if water leaves the reservoir to the aquifer).

(e) Is the reservoir gaining water from, or losing water to, the aquifer?

(f) Compute the volume of the reservoir.

(g) Estimate the residence time of water in the reservoir, defined as volume divided by total outflow (dam release plus evaporation), in days and (h) in years.

Problem 3: Specific Yield and Specific Retention (25 points)

A soil sample has a measured porosity of $n = 0.42$. Laboratory drainage experiments indicate that 0.26 m^3 of water drains under gravity from a fully saturated sample with a total volume of 1.0 m^3.

(a) Calculate the specific yield of the soil.

(b) Determine the specific retention.

(c) Verify the relationship between porosity, specific yield, and specific retention.

(d) Based on your results, comment on the likely soil texture.

Problem 4: Infiltration and Runoff with the Horton Equation (25 points)

A dry soil has Horton parameters $f_0 = 75$ mm/h, $f_c = 8$ mm/h and $k = 2.2$ h^{-1}. A storm delivers rain at a constant intensity of $i = 30$ mm/h for 3 h. Assume the infiltration capacity follows $f_p(t) = f_c + (f_0 - f_c)e^{-kt}$ from the start of the rain, and that all rain infiltrates while $i \le f_p$.

(a) Find the time t_p at which the infiltration capacity drops to the rainfall intensity (the start of runoff).

(b) Compute the infiltration capacity at the end of the storm.

(c) Compute the total infiltration depth during the storm. (Hint: before t_p the infiltration rate is i; after t_p it is $f_p(t)$, which you can integrate analytically.)

(d) Compute the runoff depth.

(e) Compute the runoff coefficient (runoff depth / rainfall depth).