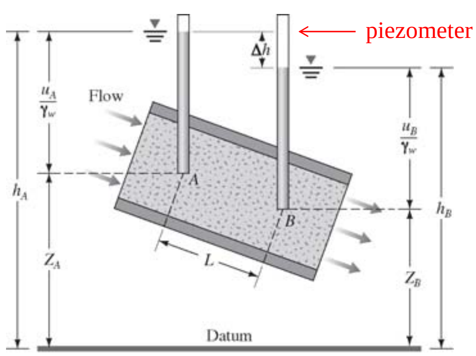
Hydraulic Conductivity

Chapter 6

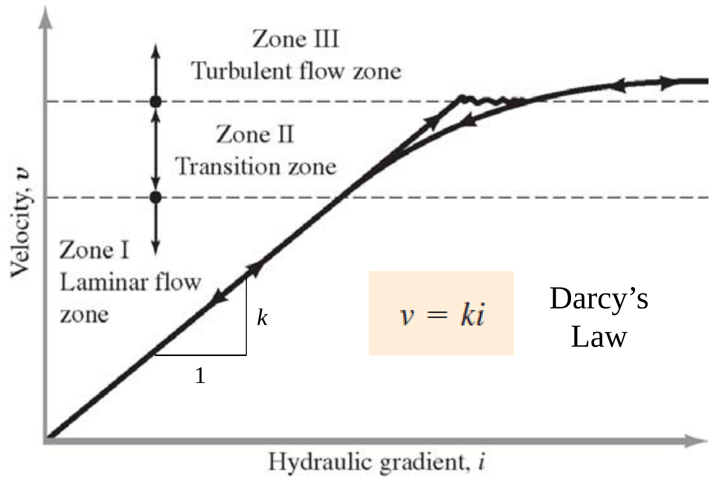
Bernouli's Equation



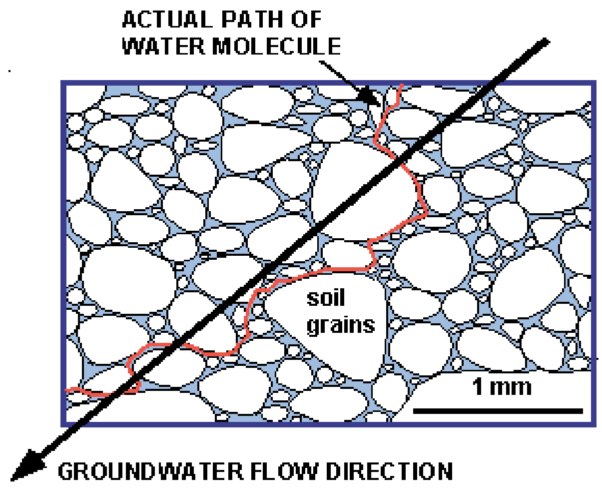
$$\Delta h = h_A - h_B = \left(\frac{u_A}{\gamma_w} + Z_A\right) - \left(\frac{u_B}{\gamma_w} + Z_B\right)$$

$$\frac{\Delta h}{L} = i \text{ (hydraulic gradient)}$$

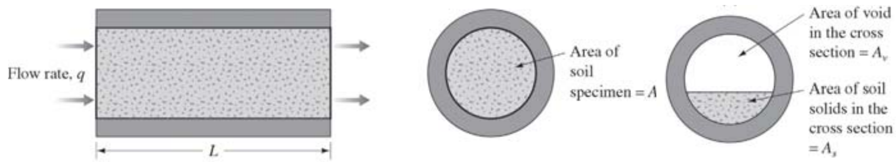
Flow Regimes



Seepage Velocity



Seepage Velocity



$$q = vA = v_s A_v$$

$$\frac{v_s}{v} = \frac{A}{A_v} = \frac{L}{L}\frac{A}{A_v} = \frac{V}{V_v} = \frac{1}{n}$$

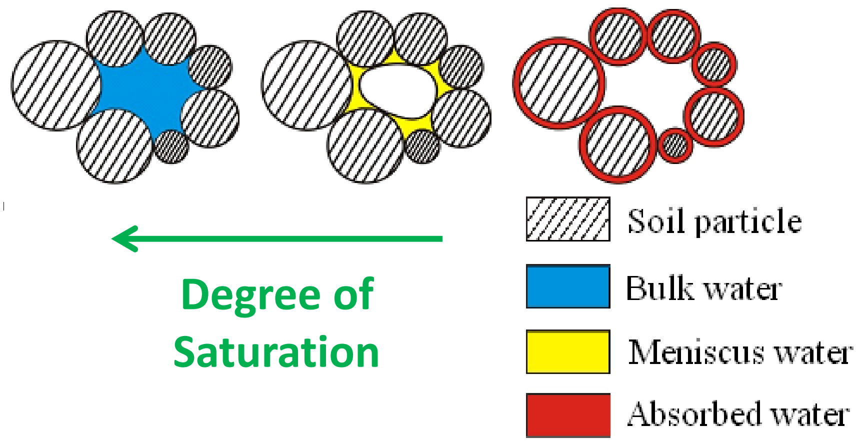
$$v_s = \frac{v}{n} = v\left(\frac{1+e}{e}\right)$$

Hydraulic Conductivity

Table 6.1 Typical values of hydraulic conductivity for saturated soils

Soil type	*k* (cm/sec)
Clean gravel	100–1
Coarse sand	1.0–0.01
Fine sand	0.01–0.001
Silty clay	0.001–0.00001
Clay	<0.000001

Hydraulic Conductivity



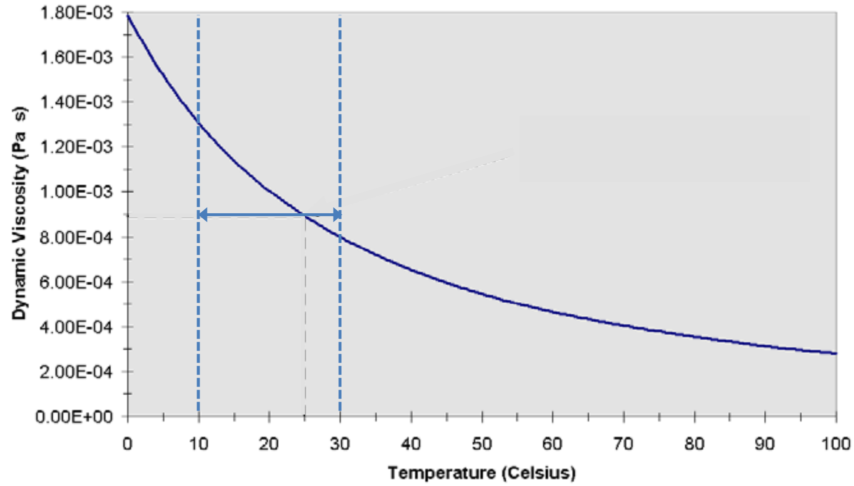
Absolute Permeability

Hydraulic Conductivity (Soil / Water Property) → $k = \frac{\gamma_w}{\eta}\overline{K}$ ← Absolute Permeability (Soil Property Only)

$$k\frac{\eta}{\gamma_w} = \overline{K}$$

$$k_{T_1}\frac{\eta_{T_1}}{\gamma_{w(T_1)}} = k_{T_2}\frac{\eta_{T_2}}{\gamma_{w(T_2)}}$$

Viscosity of Water



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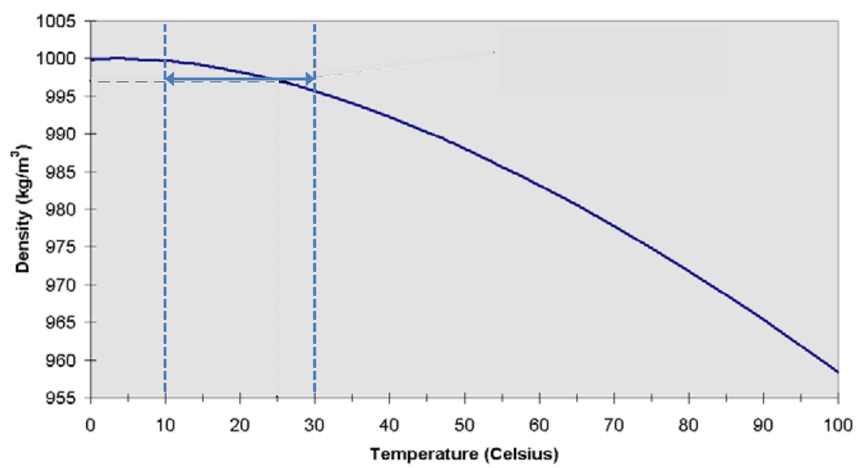
Density of Water



Source: www.ce.texas.edu

Hydraulic Conductivity

Soil / Water Property → $$k = \frac{\gamma_w}{\eta}\overline{K}$$ ← Soil Property

$$k\frac{\eta}{\gamma_w} = \overline{K}$$

$$k_{T_1}\frac{\eta_{T_1}}{\cancel{\gamma_{w(T_1)}}} = k_{T_2}\frac{\eta_{T_2}}{\cancel{\gamma_{w(T_2)}}}$$

$$k_{T_1} = k_{T_2}\frac{\eta_{T_2}}{\eta_{T_1}}$$

Hydraulic Conductivity

$$k_{20^\circ C} = \left(\frac{\eta_{T^\circ C}}{\eta_{20^\circ C}}\right)k_{T^\circ C}$$

Table 6.2 Variation of $\eta_{T^\circ C}/\eta_{20^\circ C}$

Temperature, *T* (°C)	$\eta_{T^\circ C}/\eta_{20^\circ C}$	Temperature, *T* (°C)	$\eta_{T^\circ C}/\eta_{20^\circ C}$
15	1.135	23	0.931
16	1.106	24	0.910
17	1.077	25	0.889
18	1.051	26	0.869
19	1.025	27	0.850
20	1.000	28	0.832
21	0.976	29	0.814
22	0.953	30	0.797

Constant Head Test

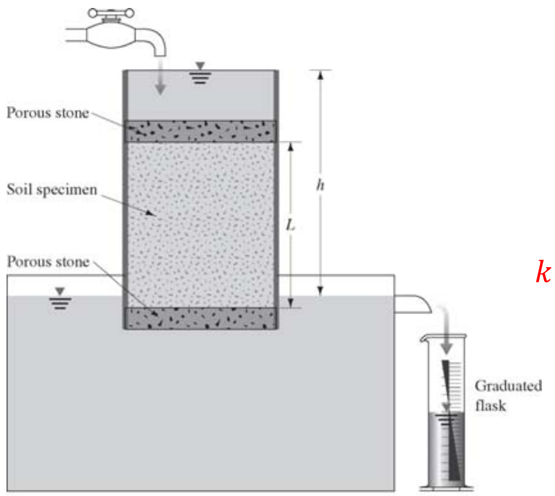


Figure 6.4 Constant head permeability test

$$k = \frac{QL}{Aht}$$

Falling Head Test

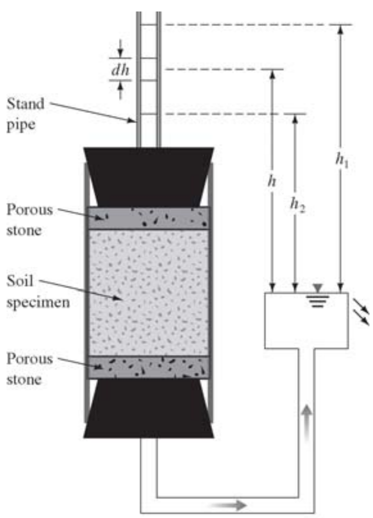


Figure 6.5 Falling head permeability test

$$k = 2.303\frac{aL}{At}\log_{10}\frac{h_1}{h_2}$$

Example

Example 6.1

For a constant head laboratory permeability test on a fine sand, the following values are given (refer to Figure 6.4):

- Length of specimen = 300 mm
- Diameter of specimen = 150 mm
- Head difference = 500 mm
- Water collected in 5 min = 350 cm^3

Determine

a. Hydraulic conductivity, k, of the soil (cm/sec)
b. Discharge velocity (cm/sec)
c. Seepage velocity (cm/sec)

The void ratio of the soil specimen is 0.46.

$$k = \frac{QL}{Aht}$$

$$v = ki = k\frac{h}{L}$$

$$v_s = v\left(\frac{1+e}{e}\right)$$

Example

Example 6.3

For a falling head permeability test, the following values are given: length of specimen = 38 cm, area of specimen = 19.4 cm^2, and $k = 2.92 \times 10^{-3}$ cm/sec. What should be the area of the standpipe for the head to drop from 64 cm to 30 cm in 8 min?

$$k = 2.303\frac{aL}{At}\log_{10}\frac{h_1}{h_2}$$

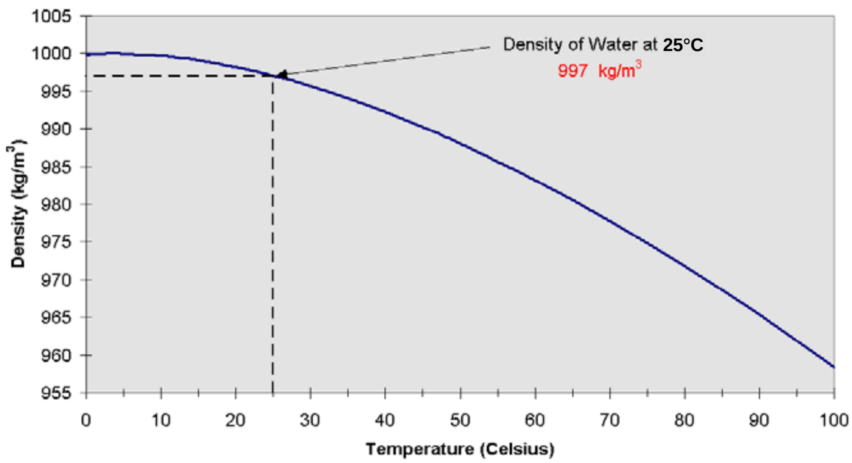
Example

Example 6.4

The hydraulic conductivity of a clayey soil is 3×10^{-7} cm/sec. The viscosity of water at 25°C is 0.0911×10^{-4} g·sec/cm^2. Calculate the absolute permeability, $\overline{K}$, of the soil.

$$k = \frac{\gamma_w}{\eta}\overline{K} \quad \rightarrow \quad \overline{K} = \frac{k\eta}{\gamma_w}$$

Density of Water



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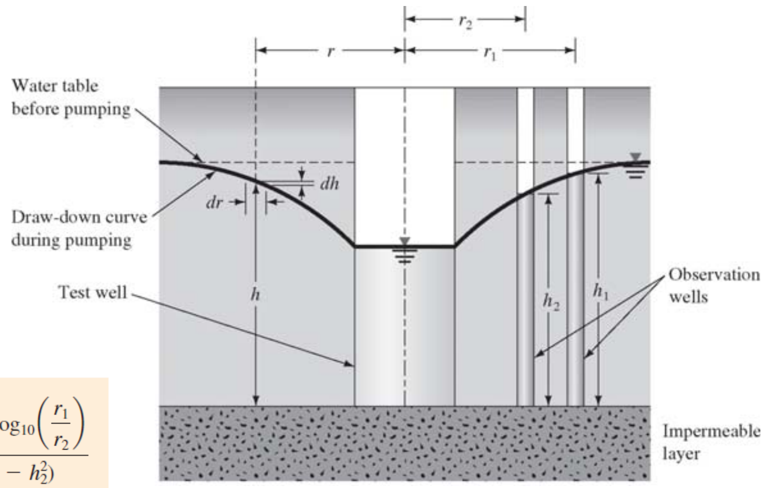
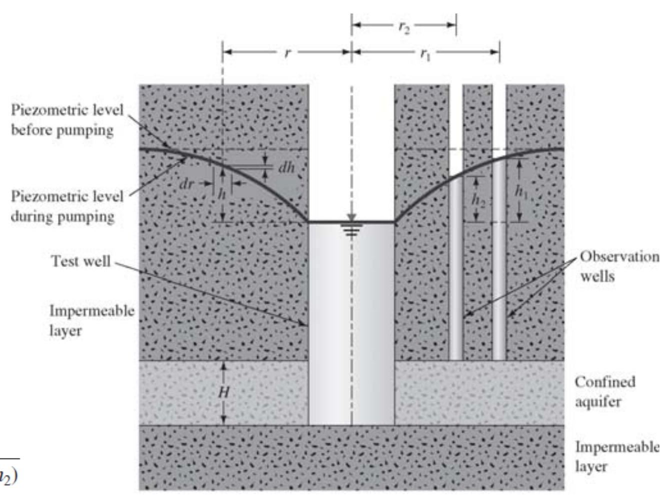
Well Pumping



$$k = \frac{2.303 q \log_{10}\left(\frac{r_1}{r_2}\right)}{\pi(h_1^2 - h_2^2)}$$

Well Pumping

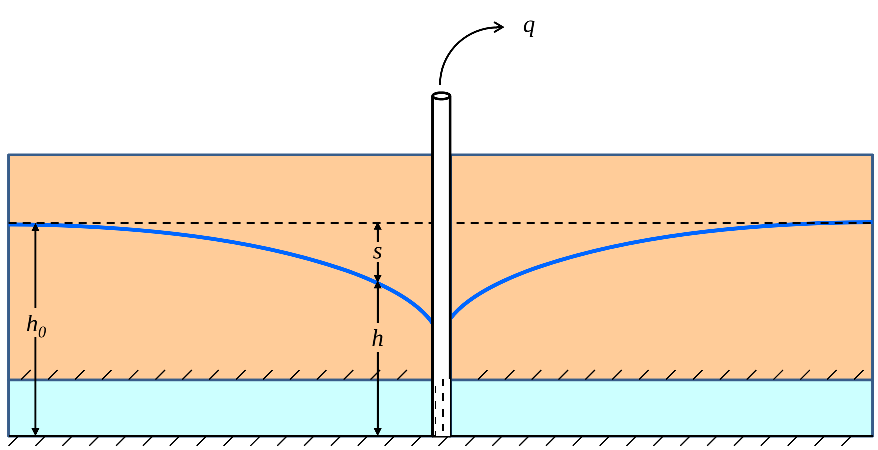


$$k = \frac{q \log_{10}\left(\frac{r_1}{r_2}\right)}{2.727\, H(h_1 - h_2)}$$

Example

A 200-mm-diameter well that fully penetrates a 25-m-thick confined aquifer is pumped at a rate of 2000 m^3/day. The drawdown in an observation well 100 m away is 1.4 m and the drawdown in an observation well 50 m away is 4 m. What is the horizontal permeability of the aquifer?

Drawdown



Example

What would be the horizontal permeability of the aquifer if it was unconfined instead? Assume the static water level in the aquifer is 100 m above the impervious layer.

Drawdown