Groundwater with Darcy

https://www.youtube.com/user/MartinRHendriks/videos

Source: Wikipedia

There is only one correct calculation method:

A. Hydraulic conductivity = 1 cm day^{-1}, then groundwater travels 1 m in 100 days.

B. Hydraulic conductivity = 1 cm day^{-1} and the porosity = 0.4, then groundwater travels 2.5 m in 100 days.

C. Specific discharge = 1 cm day^{-1}, then groundwater travels 1 m in 100 days.

D. Specific discharge = 1 cm day^{-1} and the porosity = 0.4, then groundwater travels 2.5 m in 100 days.

Cross-section of the subsurface

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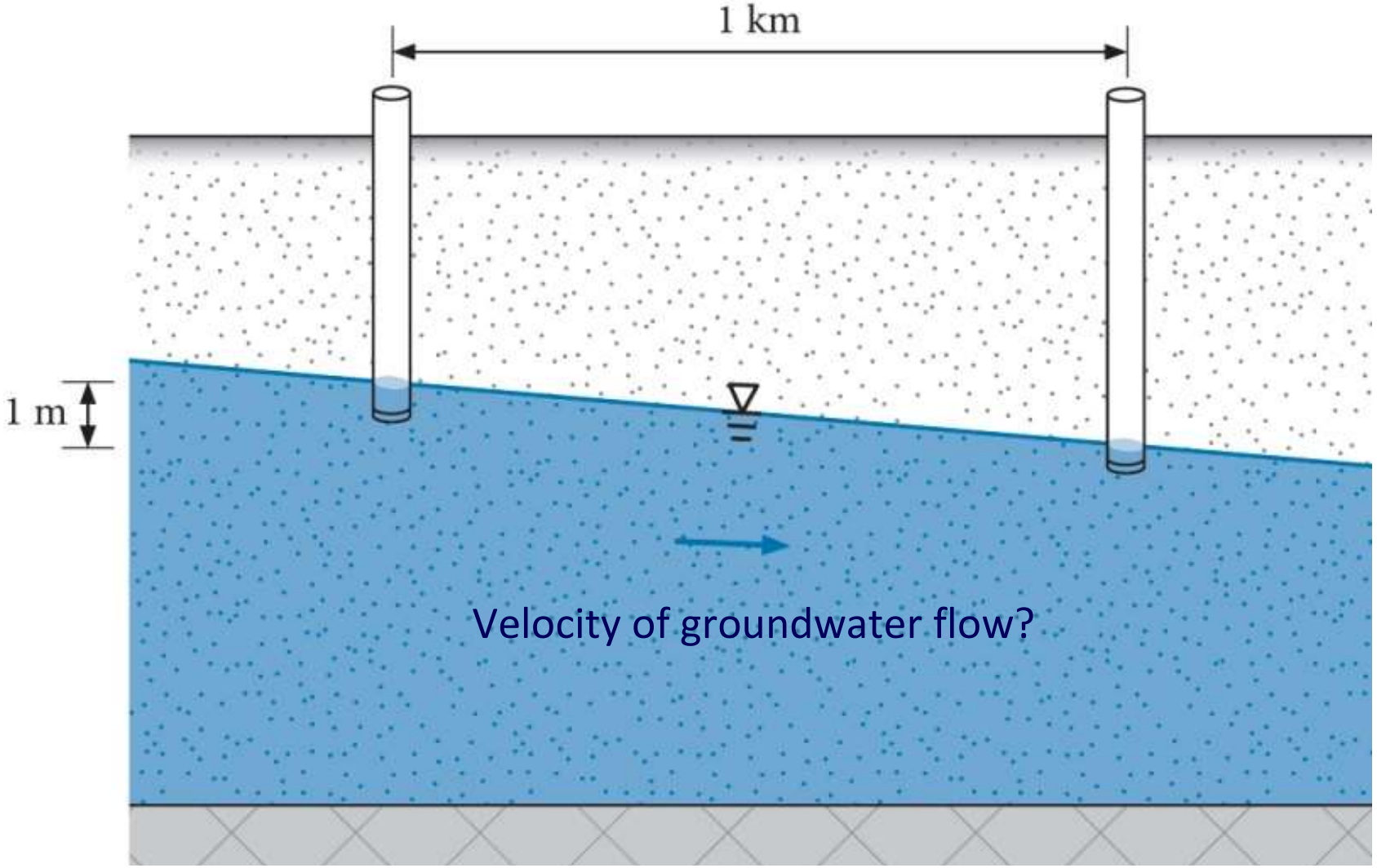

Experimental setup

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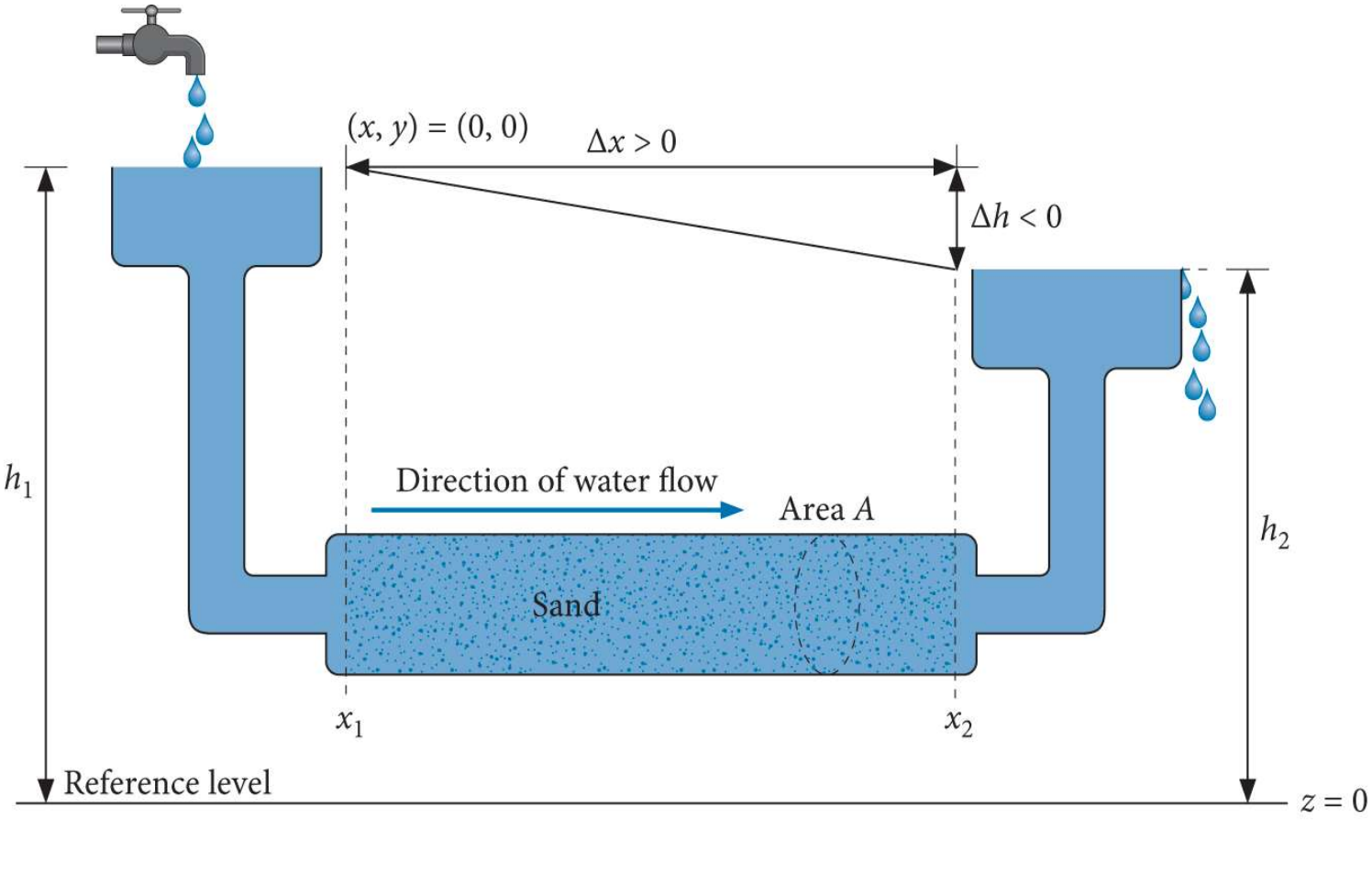

Thought experiment

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$$(h_1 - h_2) \uparrow$$

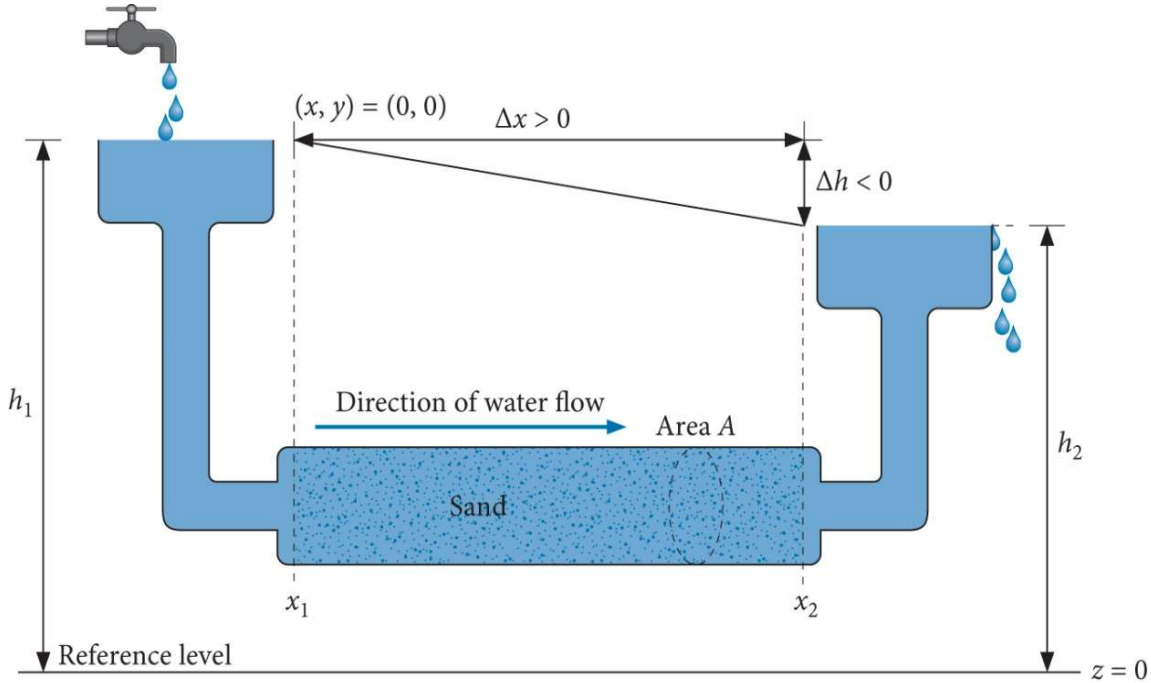
$$(h_1 - h_2) \uparrow \Rightarrow Q \uparrow$$

$$(x_2 - x_1) \downarrow$$

$$(x_2 - x_1) \downarrow \Rightarrow Q \uparrow$$

$$A \uparrow$$

$$A \uparrow \Rightarrow Q \uparrow$$



$$Q \approx \frac{h_1 - h_2}{x_2 - x_1} A$$

Darcy's law

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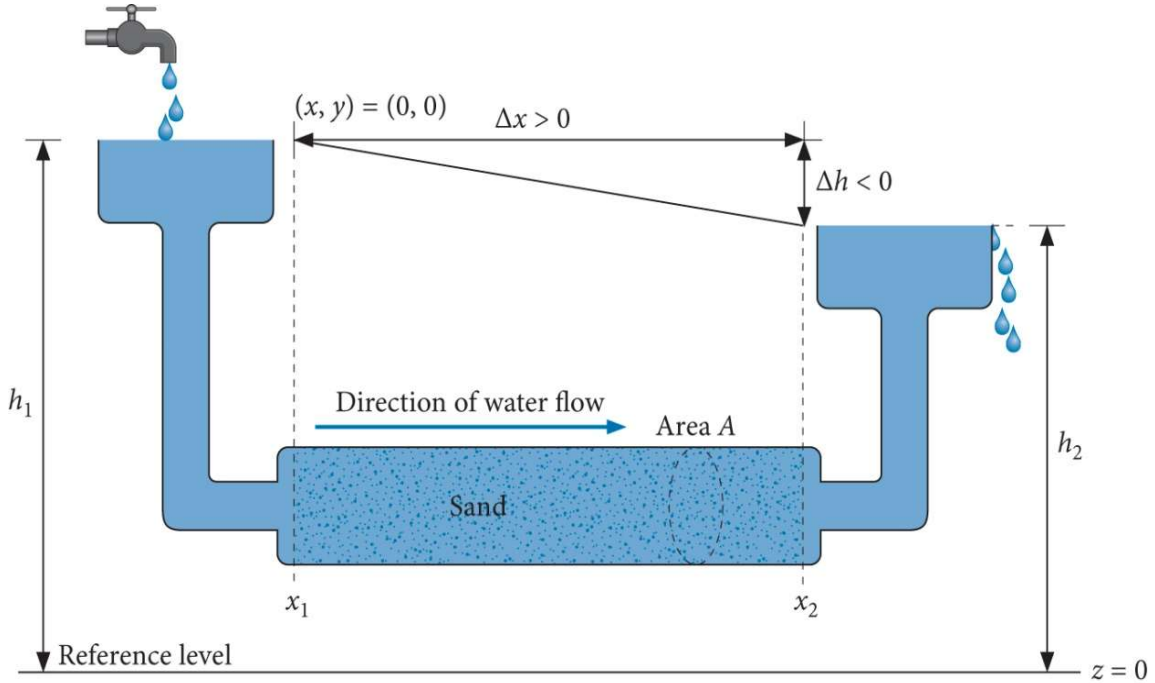
$$Q \approx \frac{h_1 - h_2}{x_2 - x_1} A$$

$$Q \approx -\frac{h_2 - h_1}{x_2 - x_1} A = -i\,A$$

$$Q = -K\,i\,A$$

$$q = \frac{Q}{A} = -K\,i$$



Hydraulic conductivity K (m day^{-1})

Darcy's law and effective velocity

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$$Q = -K\,i\,A$$

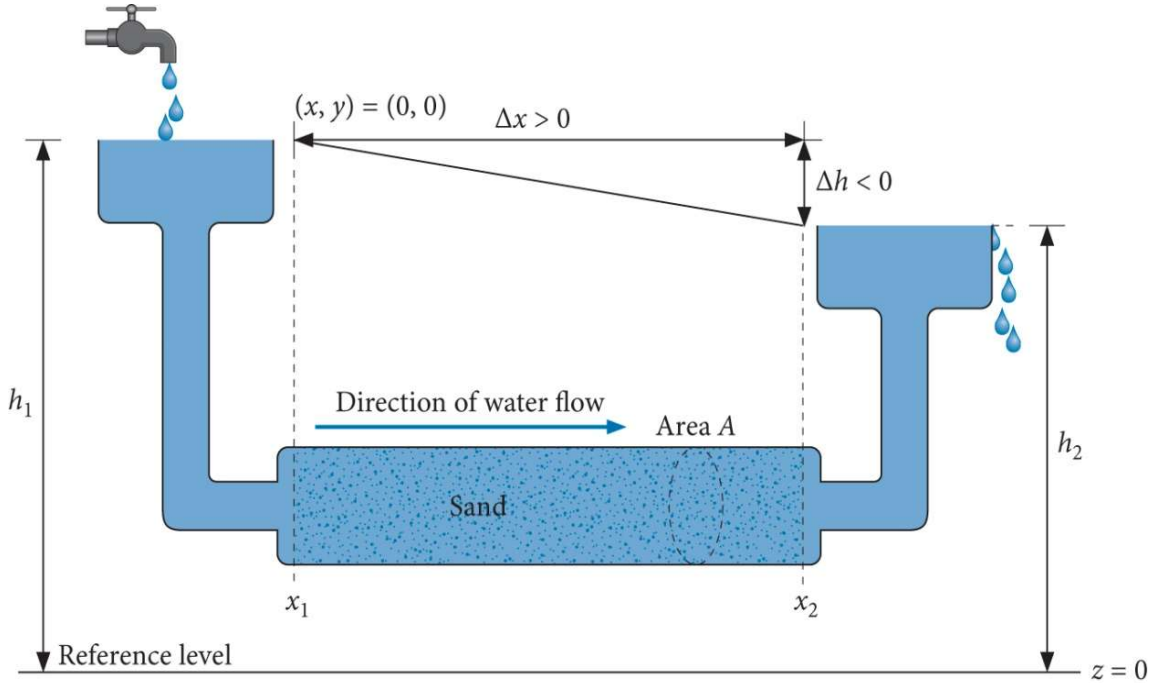
$$q = \frac{Q}{A} = -K\,i$$

Volume flux or discharge Q ($m^3\ day^{-1}$)

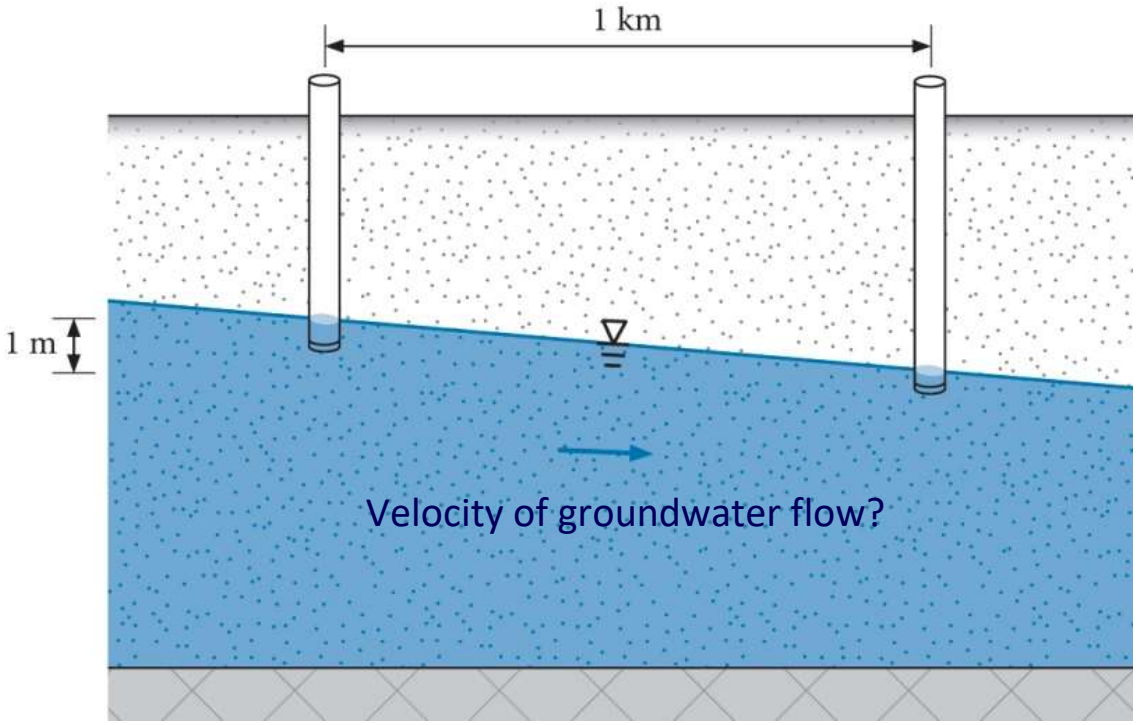
Volume flux density or specific discharge q ($m\ day^{-1}$)

$$v_e = \frac{q}{n_e}$$

Effective groundwater velocity v_e ($m\ day^{-1}$)



Velocity of groundwater flow



$$q = -K\,i = -10 \times -10^{-3} = 10^{-2} \text{ m day}^{-1}$$

$$v_e = \frac{q}{n_e} = \frac{10^{-2}}{0.4} = 2.5 \times 10^{-2} \text{ m day}^{-1} = 2.5 \text{ cm day}^{-1}$$

2.5 m in 100 days (answer D)

9 m year^{-1}

less than 1 km century^{-1}

a mere stretch of 10 km in 1100 years

Groundwater generally flows very slowly!

Take home messages

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Unconfined groundwater can flow along curved pathways.

Groundwater flows in the direction of a lower hydraulic head.

Groundwater generally flows very slowly.

The minus sign in Darcy's law and the differences between specific discharge = volume flux density, hydraulic conductivity and effective velocity (all in m day^{-1}) have been explained.

Exercises

https://www.youtube.com/user/MartinRHendriks/videos

Introduction to Physical Hydrology (Oxford University Press)
http://ukcatalogue.oup.com/product/9780199296842.do