CHAPTER 4. FLOW OF WATER INTO AND THROUGH SOILS

Water has energy.

Energy of Flowing Water.

1. **Potential Energy, P. E. = $(P/\gamma) + y$**

   (P/γ) = pressure head

   γ = specific weight of water

   y = elevation head

   $v^2/2g$ = velocity head

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Energy of Flowing Water.

2. Kinetic Energy, K. E. = $(v^2/2g)$

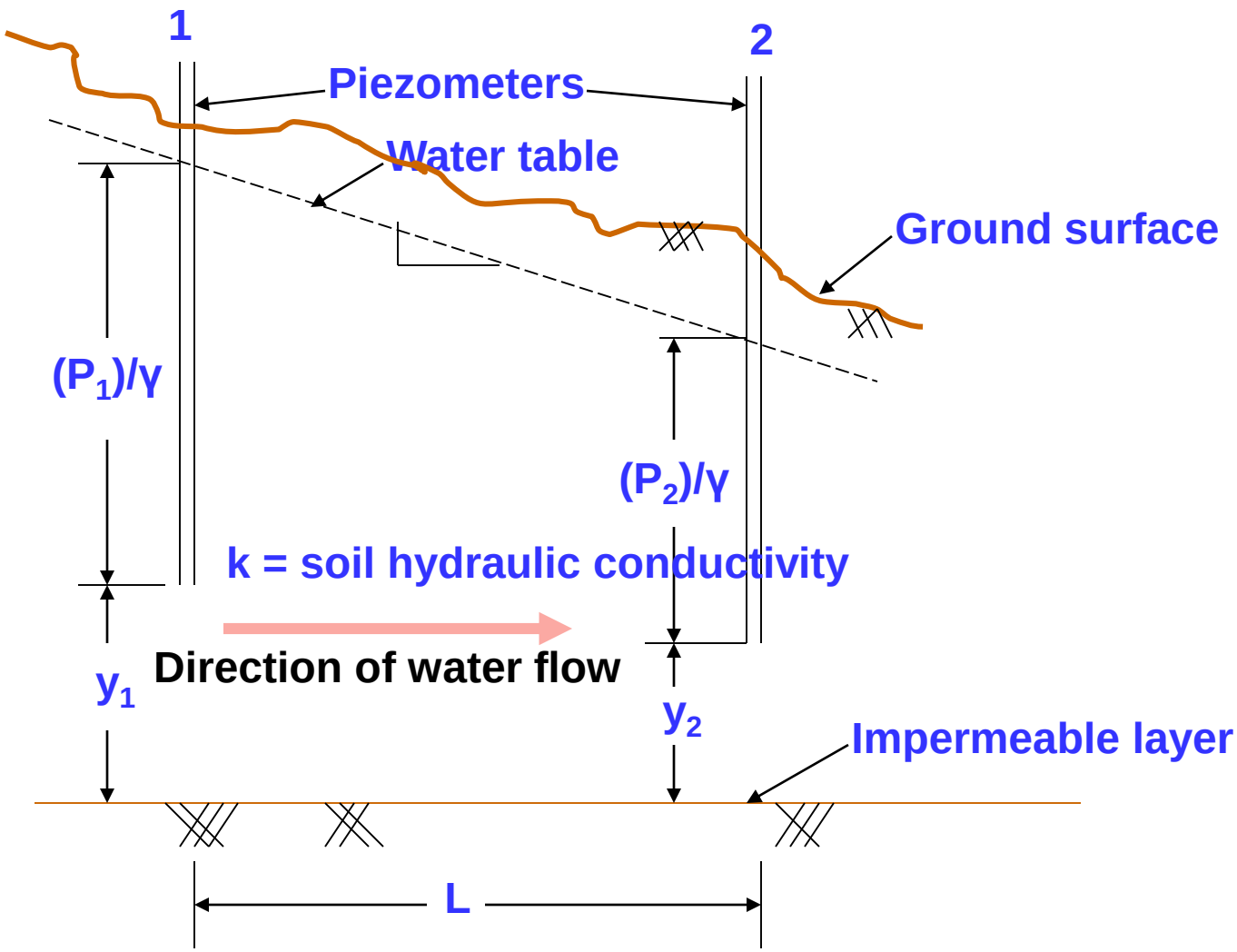
$v^2/2g$ = velocity head

Combined Energy H = P.E. + K.E.

or $H = (P/\gamma) + y + v^2/2g$

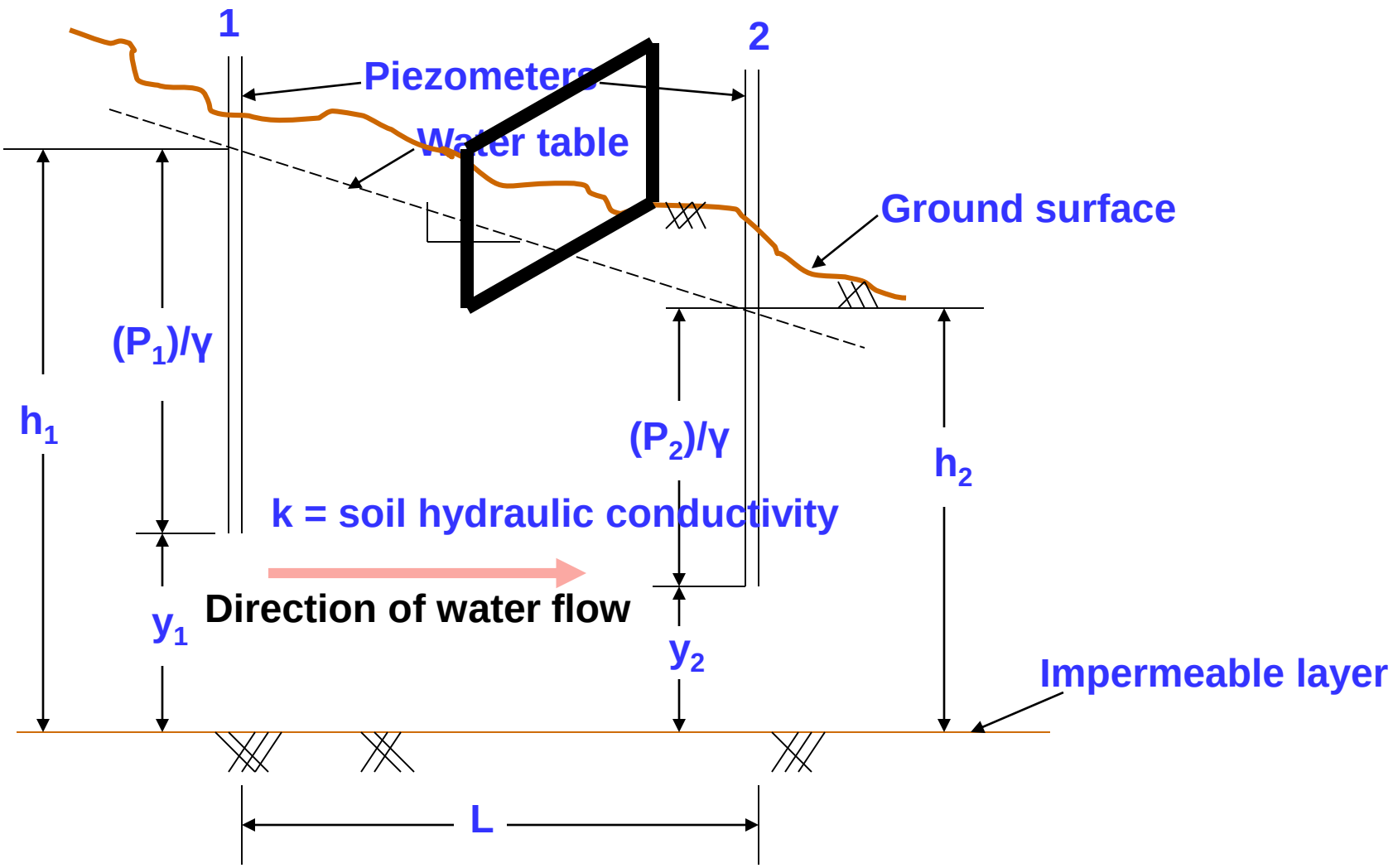
This is also known as Bernoulli's equation.

Hydraulic head, $h = (P/\gamma) + y$



$h_1 = p_1/\gamma + y_1$ Hydraulic gradient, $i_1 = h_1/L$, $i_2 = h_2/L$ $i = \Delta h/L$

$h_2 = p_2/\gamma + y_2$ Hydraulic head loss, $\Delta h = h_1 - h_2$



$h_1 = p_1/\gamma + y_1$ Hydraulic gradient, $i_1 = h_1/L$, $i_2 = h_2/L$ $i = \Delta h/L$

$h_2 = p_2/\gamma + y_2$ Hydraulic head loss, $h_l = h_1 - h_2 = \Delta h$

Example:

At Piezometer 1:

$h_1 = (p_1/\gamma) + y_1 = 50$ m

At Piezometer 2:

$h_2 = (p_2/\gamma) + y_2 = 40$ m

Flow distance, L = 100 m

$i = (\Delta h/L) = (h_1 - h_2)/L = (50 - 40)/100 = 10/100$

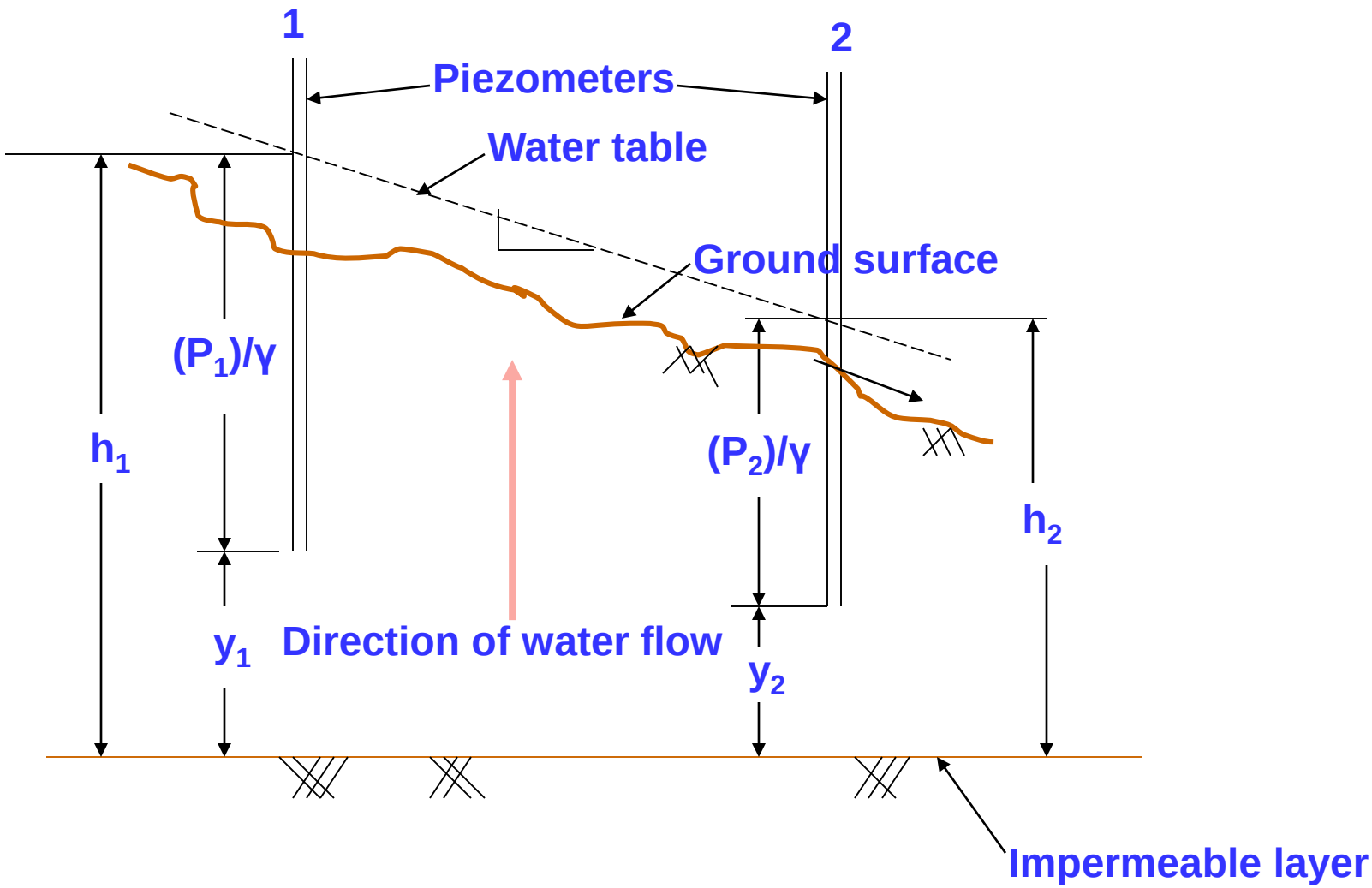
i = slope or hydraulic gradient

k = 350 m/year

A = 1000 m wide, 20 m deep

Q = Aki = (1000 x 20)(350)(10/100) = 700,000 m^3/yr

Q = flow through the section 1000 m wide, 20 m deep



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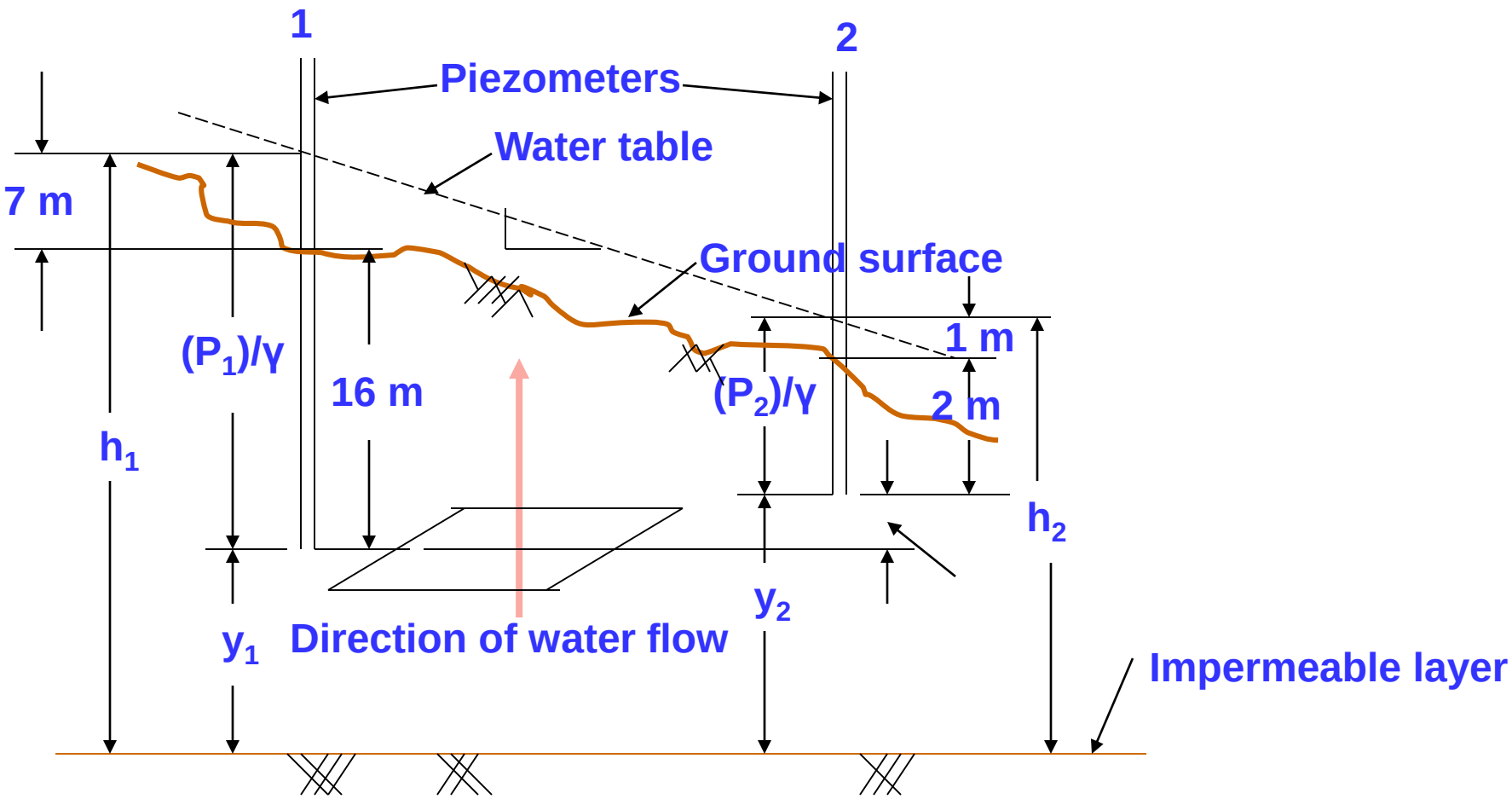


$h_1 = p_1/\gamma + y_1 = 23 + y_1$

$h_2 = p_2/\gamma + y_2 = 3 + y_2$

$y_2 = y_1 + 14$

$h_2 = 3 + (y_1 + 14) = 17 + y_1$

$\Delta h = h_1 - h_2 = (23 + y_1) - (17 + y_1) = 6$

$i = \Delta h/L = 6/(16-2) = 0.43$

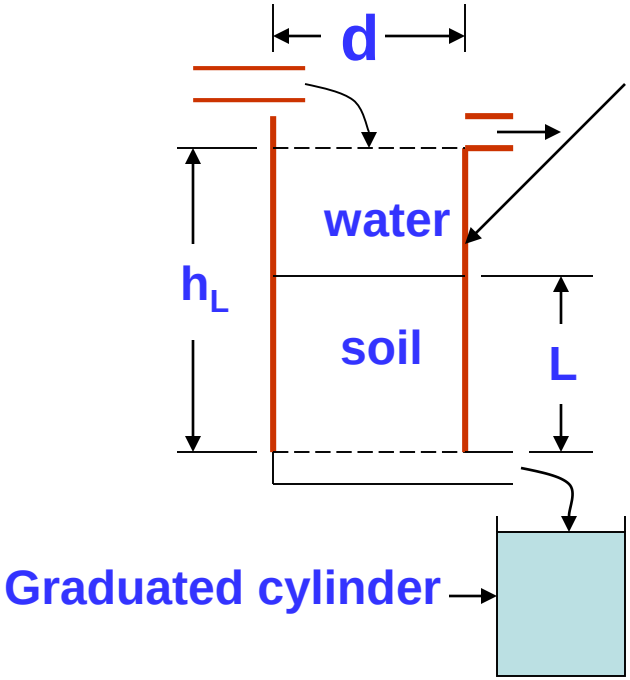
If $k = 2$ m/yr & $A = 1$ ha, then

$v = kh_L/L = 2(0.43) = 0.86$ m/yr

$Q = Av = 1\text{ha} \times 0.86$ m/yr

$= 0.86$ ha-m/yr

CONSTANT HEAD PERMEAMETER



permeameter

$v = ki = kh_L/L$

$A = \pi d^2/4$

d = diameter of permeameter

$Q = Av = Akh_L/L$

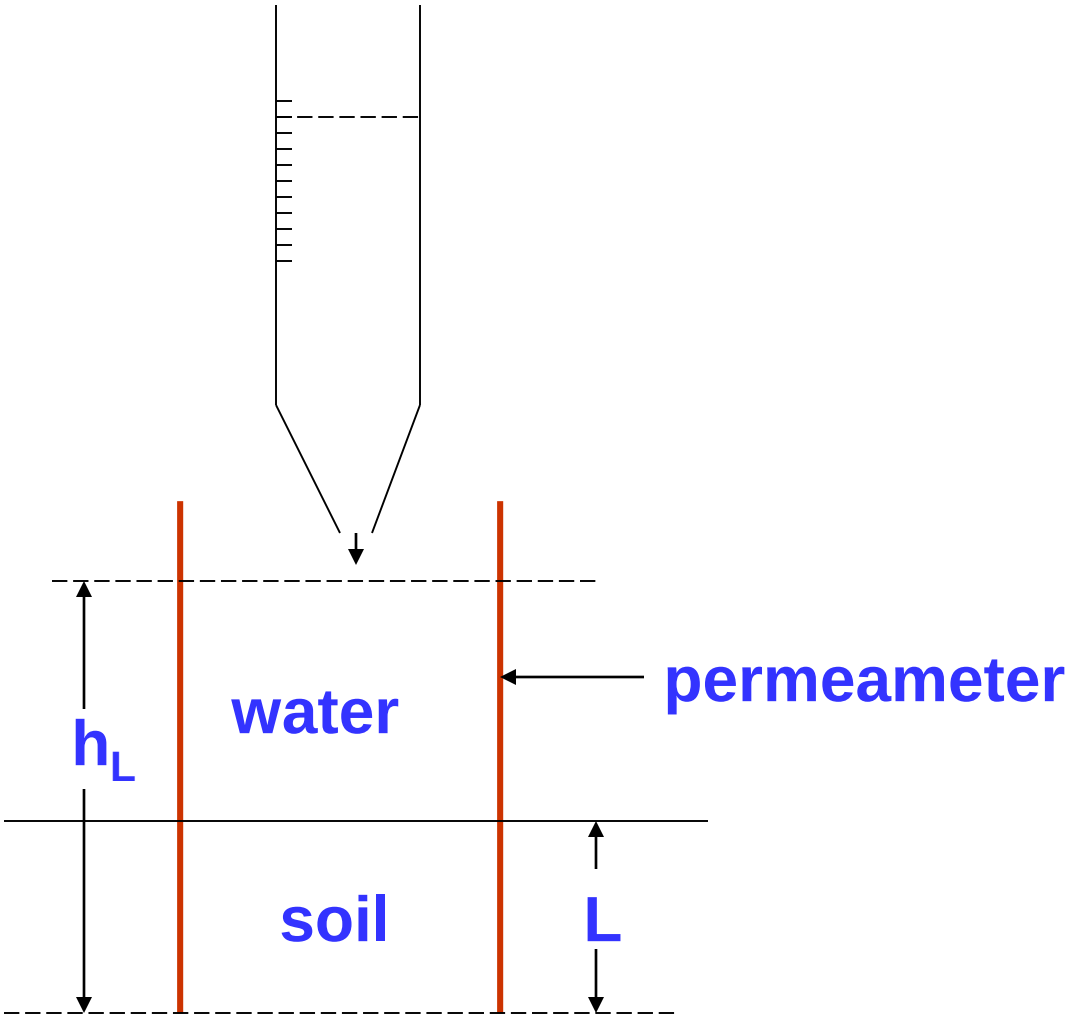
$k = QL/(Ah_L)$

Example: h_L = 73 cm, L = 30 cm, Vol of water in the graduated cylinder = 9.5 li., time to fill the 9.5 li. Volume = 0.4 hr, permeameter x-sectional area = 1070 cm^2. Find permeability, k.

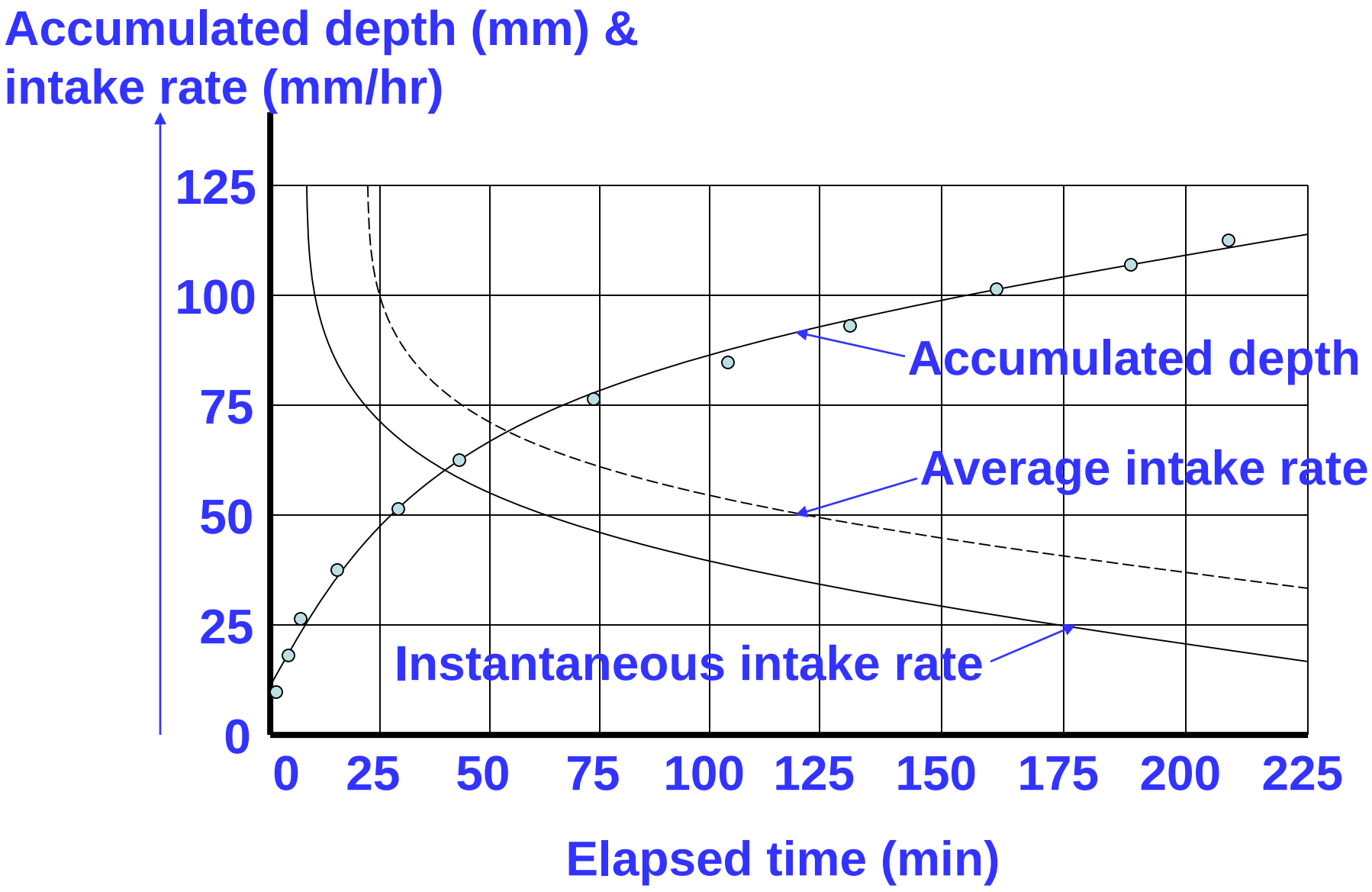
$k = QL/(Ah_L) = (9.5/0.4)x30/(1070x73)$

$= 9.1$ cm/hr

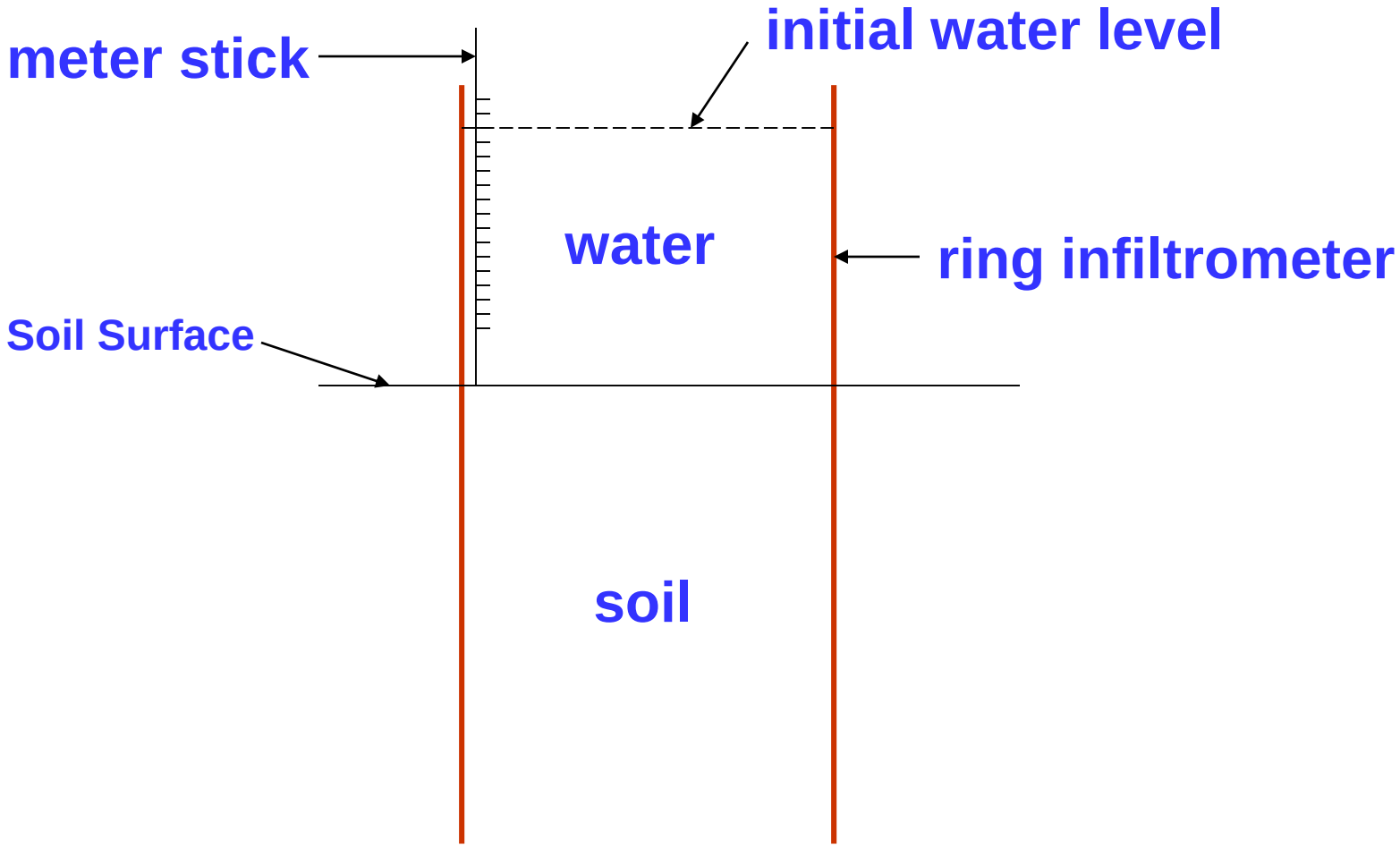
FALLING HEAD PERMEAMETER



Time (min)		Intake Depth (mm)	
Difference	Cumulative	Depth	Cumulative
1	1	11	11
2	3	7	18
4	7	8	26
8	15	11	37
18	33	14	51
14	47	8	59
27	74	14	73
31	105	10	83
29	134	11	94
28	162	9	103


Accumulated depth (mm) &
intake rate (mm/hr)
125
100
75
50
25
0
0
25
50
75
100
125
150
175
200
225
Elapsed time (min)
Accumulated depth
Average intake rate
Instantaneous intake rate

Measurement of the permeability of a 15-meter stratum of saturated clay soil overlying a water-bearing gravel shows that k = 0.5 mm/hr. If the pressure head in the gravel is 25 meters of water (as measured at the lower surface of the clay) and 0 meter near the soil surface, water is flowing vertically upward through the clay. Compute the flow in ft^3/sec through a block of clay 15 meters thick and 250 hectares in area.


meter stick
initial water level
water
ring infiltrometer
Soil Surface
soil