· Difficulties in matching similarities

[FINAL 12/15 (목) 11:00 –]

to match more than two non-dimensional parameters together ⇒ very hard.

① hydraulic model test w/ a free surface. ⇒ Re, Fr

$$\begin{cases} Re_m = \dfrac{V_m L_m}{\nu_m} = Re_p = \dfrac{V_p L_p}{\nu_p} \\ Fr_m = \dfrac{V_m^2}{g L_m} = Fr_p = \dfrac{V_p^2}{g L_p} \end{cases}$$

if $L_m = \alpha \cdot L_p \Rightarrow V_m = \sqrt{\alpha} V_p$ (Fr) $\Rightarrow \dfrac{\nu_m}{\nu_p} = \alpha^{\frac{3}{2}}$

ν_p : water $\rightarrow \nu_m = \alpha^{\frac{3}{2}} \nu_p$ ← impossible, No!!

⇒ drop Re!

② compressible aerodynamic model test → Re, Ma.

$$Re_m = \frac{V_m L_m}{\nu_m} = Re_p = \frac{V_p L_p}{\nu_p}$$

$$Ma_m = \frac{V_m}{a_m} = Ma_p = \frac{V_p}{a_p}$$

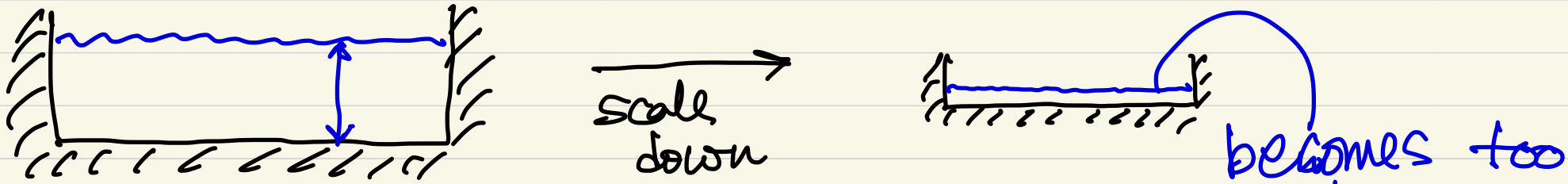
$$\frac{\nu_m}{\nu_p} = \frac{L_m}{L_p} \cdot \frac{a_m}{a_p}$$

air

low ν_m
high a_m. → expensive

→ drop Re!

③ Hydraulic model of natural flow system.



drop geometric similarity !

surface tension affects.

Ch.6. Viscous Flow in Ducts. (Internal flow)

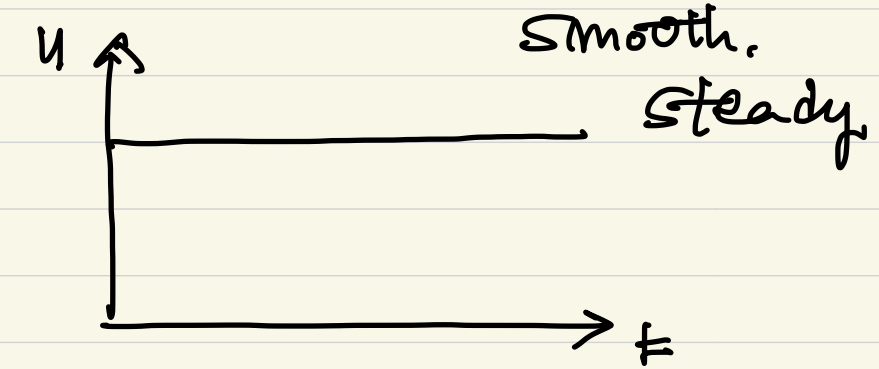
6.1. Reynolds number regimes.

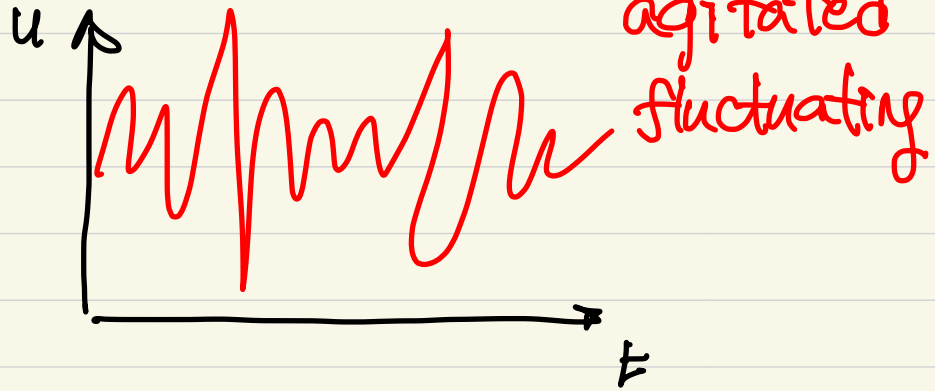
Laminar flow (층류)

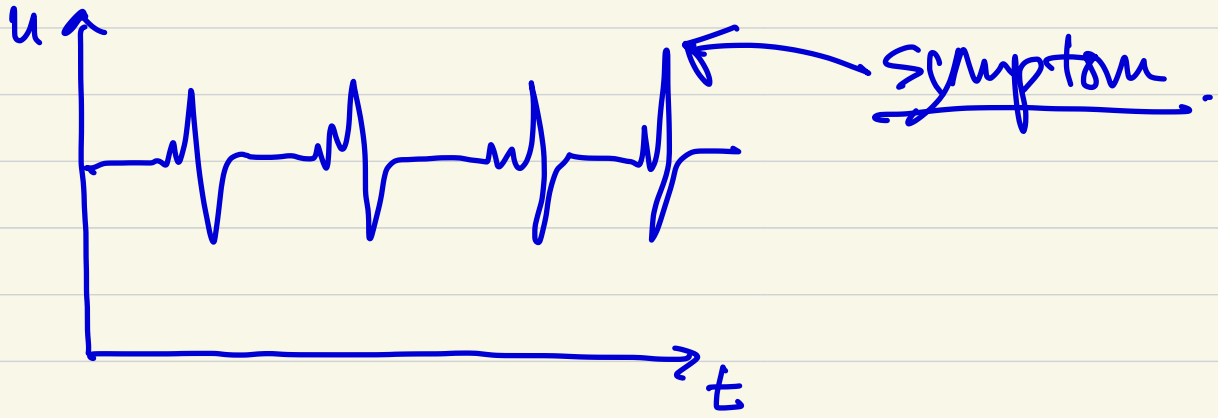
$Re_f = \frac{UL}{\nu}$

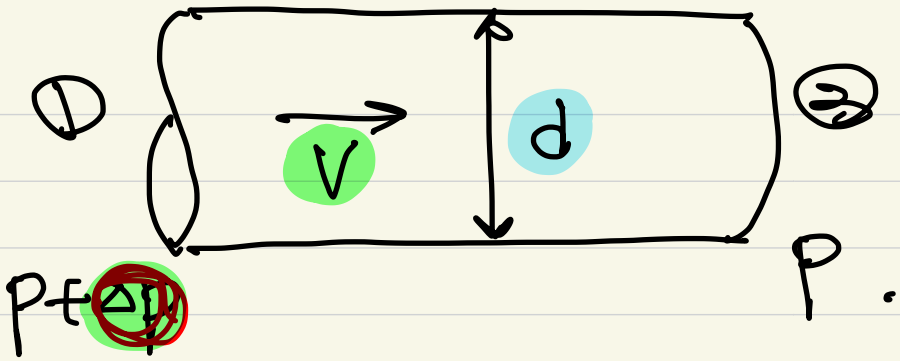
Transition (천이)

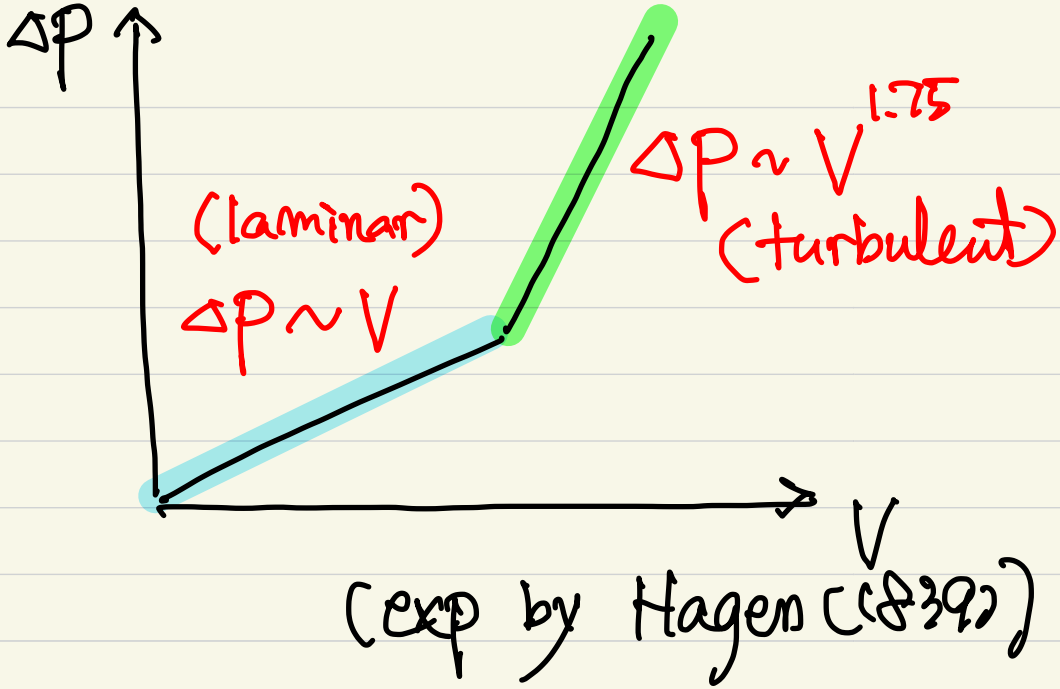
Turbulent flow (난류)





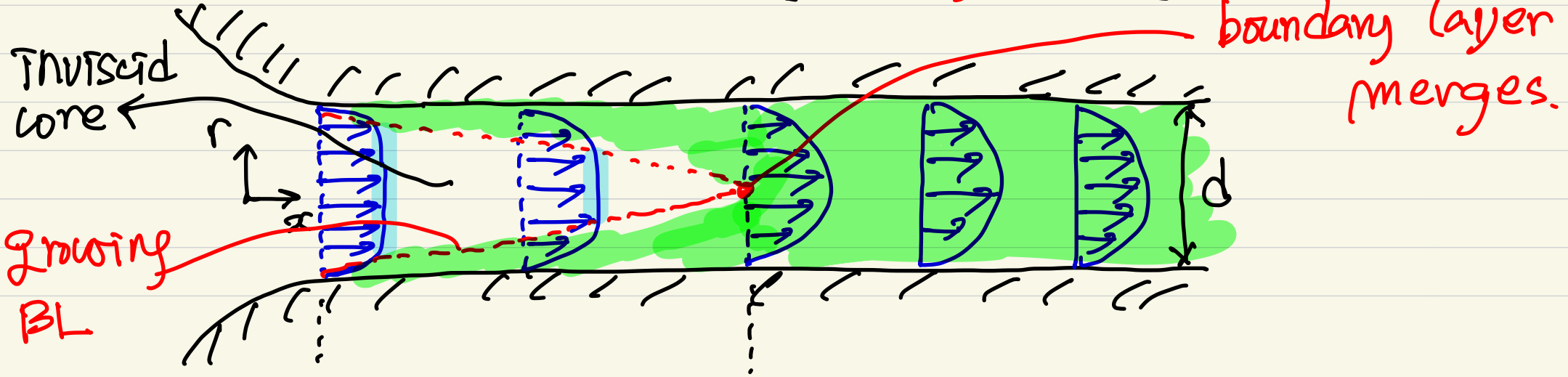


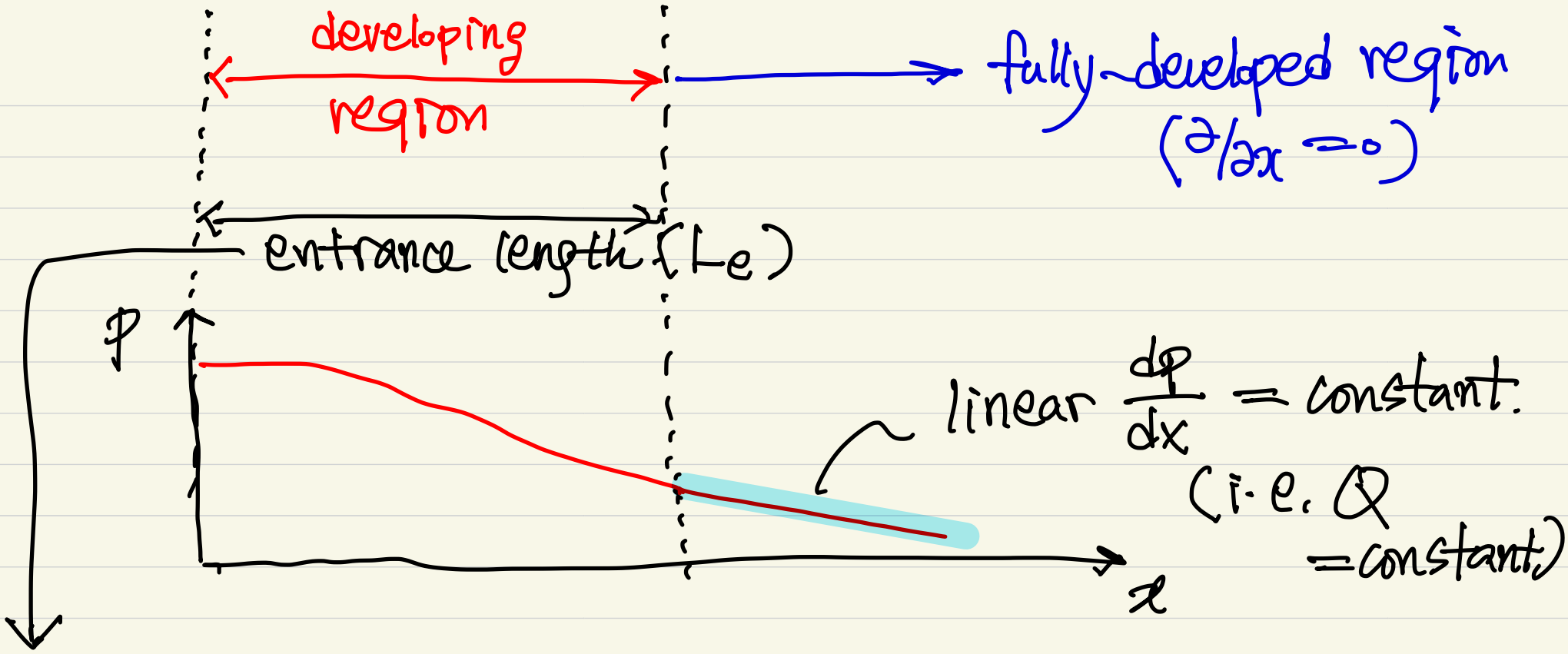




6.2. Internal vs external viscous flows.

↓ constrained by the bounding walls.





$$L_e = f(d, V, \rho, \mu)$$

↳ bulk velocity ($V = Q/A$)

↓ dimensional analysis

$$\frac{L_e}{d} = g\left(\frac{\rho V d}{\mu}\right) = g(Re_d)$$

$\frac{L_e}{d} \simeq 0.06\, Re_d$ for laminar flow

$\simeq 4.4\, Re^{1/6}$ for turbulent flow

(or $1.6 Re^{1/4}$)

$Re_{crit} \doteqdot 2300$

$\Downarrow$

$L_{e,crit} \doteqdot 13 d$

$\Downarrow$

$Re = 4000, \; L_e \simeq 13d.$

$= 10^7, \; L_e \simeq 90d.$

6.3. Head loss – the friction factor (practical point of view)

– CV analysis, Bernoulli eq w/ loss

- flow driven by pressure gradient or gravity