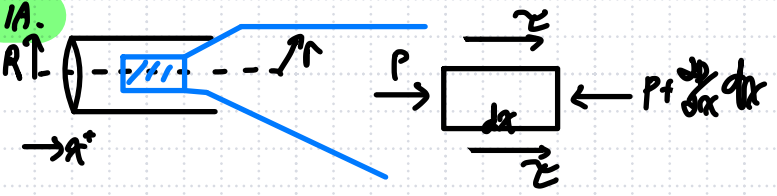


1. 유관 내 층류유에 관한 미방 유도

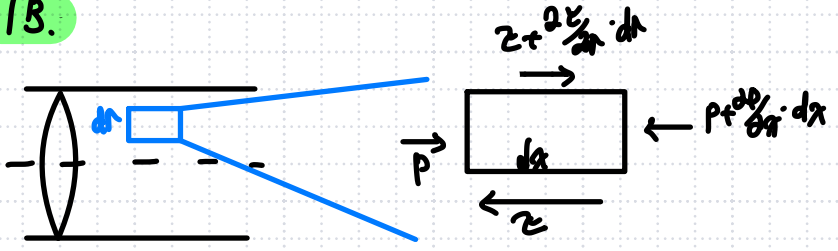


$\sum F_x = 0$ (원천없는 층류유)

$$P(\pi r^2) - (P + \frac{\partial P}{\partial x} dx) \pi r^2 + \tau(2\pi r dx) = 0$$

$$(\frac{\partial P}{\partial x} dx) \pi r^2 = \tau(2\pi r dx) \rightarrow \tau = \frac{r}{2} \left(\frac{\partial P}{\partial x} \right) \quad // \text{Ans.} \dots \textcircled{1}$$

1B.



$\sum F_x = 0$

$$P(\pi dr^2) - (P + \frac{\partial P}{\partial x} dx) \pi dr^2 + (\tau + 2\frac{\partial \tau}{\partial r} \cdot dr) 2\pi r dx - \tau 2\pi r dx = 0$$

$$-\frac{\partial P}{\partial x} dr^2 + 2\tau \frac{\partial r}{\partial r} \cdot dr \cdot 2 = 0, \quad \frac{\partial \tau}{\partial r} = \frac{1}{2} \frac{\partial P}{\partial x}$$

$$\int 2\tau = \frac{1}{2} \left(\frac{\partial P}{\partial x} \right) dr \quad \leftarrow \text{원천없는 층류유 반경방향 속도 분포. } \frac{\partial P}{\partial x} \text{의 함수가 아님}$$

$$\therefore \tau = \frac{r}{2} \left(\frac{\partial P}{\partial x} \right) \quad // \text{Ans.} \dots \textcircled{2}$$

①, ② 동일.