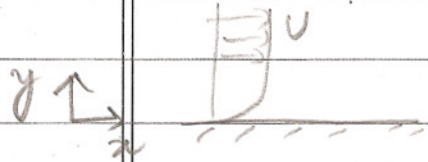
ESO 212 QUIZ 3 paper A Solution key

① Within a boundary layer, the velocity gradient can be estimated as



$$\frac{dV_x}{dy} \sim \frac{U}{\delta} \frac{d\tilde{V}_x}{d\tilde{y}}$$

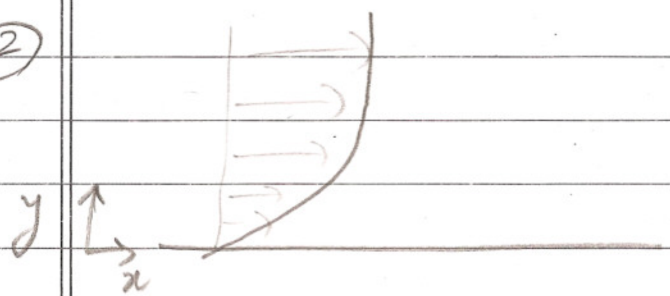
where $\frac{\delta}{L} \sim Re^{-1/2}$

So $$\frac{dV_x}{dy} \sim \frac{U}{L} Re^{1/2} \frac{d\tilde{V}_x}{d\tilde{y}}$$

$\Rightarrow \frac{dV_x}{dy}$ will increase with Re.

Correct answer: B.

②



$$c_f = \frac{0.73}{\sqrt{Re_x}} = \frac{0.73}{\sqrt{\frac{\rho U}{\mu}}\, x^{1/2}}$$

Wall shear stress.

$$\tau_w = \frac{1}{2} \rho U^2 c_f$$

$$\tau_w = \frac{1}{2} \rho U^2 \frac{0.73}{\sqrt{\frac{\rho U}{\mu}}} x^{-1/2}$$

$$F = W \int_0^L \tau_w \, dx = \frac{W}{2} \rho U^2 \frac{0.73}{\sqrt{\frac{\rho U}{\mu}}} \int_0^L x^{-1/2} \, dx$$

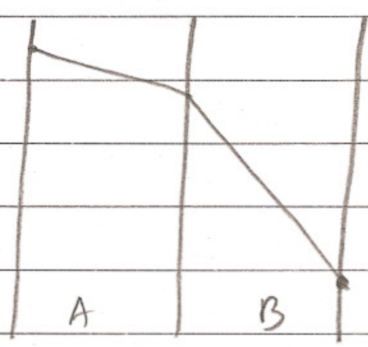
$$= \frac{W}{2} \rho U^2 \frac{0.73}{\sqrt{\frac{\rho U}{\mu}}} \left[\frac{x^{1/2}}{1/2} \right]_0^L$$

$$F = \rho U^2 \frac{0.73}{\sqrt{\frac{\rho U}{\mu}}} L^{1/2}$$

$$\frac{F_{new}}{F_{old}} = \frac{(4L)^{1/2}}{L^{1/2}} = 2$$

Correct answer: D

(3)



at the interface

$$-k_A \frac{dT_A}{dx} = -k_B \frac{dT_B}{dx}$$

$$\frac{dT_A}{dx} < \frac{dT_B}{dx}$$

$$\Rightarrow \quad k_A > k_B.$$

Correct answer A

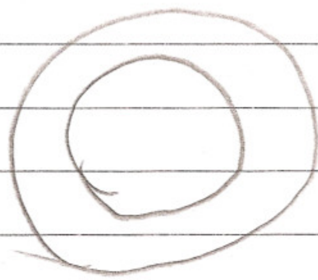
(4)

$$Bi = \frac{hL}{k} = \frac{\frac{L}{kA}}{\frac{1}{hA}}$$

Correct answer: (C)

$$= \frac{\text{resistance to conduction in the solid}}{\text{resistance to convection in the fluid}}.$$

(5)



$$Q = \frac{T_1 - T_2}{\ln R_2/R_1} (2\pi k L)$$

$$\frac{Q_{new}}{Q_{old}} = \frac{\frac{T_1 - T_2}{\ln 8}}{\frac{T_1 - T_2}{\ln 2}} \; \frac{\cancel{2\pi k L}}{\cancel{2\pi k L}} = \frac{\ln 2}{\ln 8}$$

$$= \frac{\ln 2}{\ln 2^3}$$

$$\frac{Q_{new}}{Q_{old}} = \frac{1}{3}$$

Correct answer (D)