

**Turbulent Flows**  
Stephen B. Pope  
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**Solution to Exercise 7.12**

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From Ex. 7.11 we know that  $\frac{d\langle p \rangle}{dx} = \frac{dp_w}{dx} = \text{const}$ . Since the pressure drop  $\Delta p$  is defined as a positive quantity, this leads to

$$\frac{\Delta p}{L} = -\frac{dp_w}{dx} \stackrel{(7.101)}{=} 2\frac{\tau_w}{R} = 4\frac{\tau_w}{D},$$

and thus

$$f \stackrel{(7.97)}{=} \frac{\Delta p D}{\frac{1}{2}\rho \bar{U}^2 L} = \frac{4\tau_w}{\frac{1}{2}\rho \bar{U}^2} \stackrel{(7.15)}{=} 4C_f.$$

Using the definition  $u_\tau \equiv \sqrt{\tau_w/\rho}$ , this can be rewritten as

$$f = 8 \left( \frac{u_\tau}{\bar{U}} \right)^2,$$

and thus

$$\frac{u_\tau}{\bar{U}} = \sqrt{\frac{f}{8}}.$$

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