y^+ Calculation, Example 6D

Example 6D: Consider a high-velocity fluid over a flat plate. It is desired to find the thickness of the viscous sublayer at $y^+=1$. The fluid is H_2O at 395 K and 1 MPa. Its free stream velocity is 700 m/s, and has a boundary layer δ=0.1 m.

Solutions :

1) Use the "Yplus_LIKE_Eddy_Scales_Book_Version.m" application found in my CFD/turbulence book, "Applied Computational Fluid Dynamics and Turbulence Modeling", Springer International Publishing, 1st Ed., ISBN 978 – 3 – 030 – 28690 – 3, 2019, DOI : 10.1007 / 978 – 3 – 030 – 28691 – 0.

or

2) Get a free copy of "Yplus_LIKE_Eddy_Scales_Book_Version.m" at www.cfdturbulence.com, or email me at tayloreddydk1@gmail.com.

or

3) Use the free y^+ estimation GUI tool offered by cfd-online, which is at http : / / www.cfd – online.com / Tools / yplus.php

or

4) Follow the step-by-step solution shown in the next slide.

y^+ Calculation, Example 6D

From P and T, $\rho = 942$ kg/m^3 and μ=2.28x10^{-4} kg/m-s.

$$\nu = \frac{\mu}{\rho} = \frac{2.28\text{x}10^{-4}}{942} = 2.43\text{x}10^{-7}\ \text{m}^2/\text{s}$$

$$Re_x = \frac{U_\infty \delta(x)}{\nu} = \frac{700 * 0.1}{2.43\text{x}10^{-7}} = 2.87\text{x}10^{8}\ ,< 10^9$$

$$C_f = \left[2\log_{10}\left(Re_x\right) - 0.65\right]^{-2.3} = \left[2\log_{10}\left(2.87\text{x}10^{8}\right) - 0.65\right]^{-2.3} = 1.60\text{x}10^{-3}$$

$$\tau_\text{w} = C_f \frac{\rho U_\infty^2}{2} = 1.60\text{x}10^{-3} \frac{942 * 700^2}{2} = 3.78\text{x}10^{5}$$

$$u_* = \sqrt{\frac{\tau_\text{w}}{\rho}} = \sqrt{\frac{3.78\text{x}10^{5}}{942}} = 20.0$$

$$y\left(\text{at } y^+ = 1\right) = \frac{y^+ \nu}{u_*} = \frac{1 * 2.43\text{x}10^{-7}}{20} = 1.22\text{x}10^{-8}\ \text{m}$$

y^+ Calculation, Example 6D Solutions

Approach 1 and 2 (the Matlab script, Yplus_LIKE_Eddy_Scales_Book_Version.m)

$$Re_x = 2.89\text{x}10^8$$

$$y\left(\text{at } y^+ = 1\right) = 1.23\text{x}10^{-8} \text{ m}$$

Approach 4 (previous slide)

$$Re_x = 2.87\text{x}10^8$$

$$y\left(\text{at } y^+ = 1\right) = 1.22\text{x}10^{-8} \text{ m}$$

Approach 3 (cfd-online tool)