

# $y^+$ 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  $\delta = 0.1$  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, 1<sup>st</sup>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](http://www.cfdturbulence.com), or email me at [taylorreddydk1@gmail.com](mailto:taylorreddydk1@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  $T$ ,  $\rho = 942 \text{ kg/m}^3$  and  $\mu = 2.28 \times 10^{-4} \text{ kg/m-s}$ .

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

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

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

$$\tau_w = C_f \frac{\rho U_\infty^2}{2} = 1.60 \times 10^{-3} \frac{942 * 700^2}{2} = 3.78 \times 10^5$$

$$u_* = \sqrt{\frac{\tau_w}{\rho}} = \sqrt{\frac{3.78 \times 10^5}{942}} = 20.0$$

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

# $y^+$ Calculation, Example 6D Solutions

*Approach 1 and 2 (the Matlab script,  
Yplus\_LIKE\_Eddy\_Scales\_Book\_Version.m)*

$$Re_x = 2.89 \times 10^8$$

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

*Approach 4 (previous slide)*

$$Re_x = 2.87 \times 10^8$$

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

*Approach 3 (cfd-online tool)*

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## Y+ Wall Distance Estimation

**Input**

Freestream velocity:	<input type="text" value="700"/>	[m/s]
Density:	<input type="text" value="942"/>	[kg/m3]
Dynamic viscosity:	<input type="text" value="2.32e-4"/>	[kg/ms]
Boundary layer length:	<input type="text" value="0.1"/>	[m]
Desired Y+ value:	<input type="text" value="1.0"/>	[]

**Output**

Reynolds number:	<input type="text" value="2.8e+8"/>	[]
Estimated wall distance:	<input type="text" value="1.2e-8"/>	[m]

Estimate Wall Distance