

Problem 9.30 (In Excel)

Consider flow of air over a flat plate. On one graph, plot the laminar boundary-layer thickness as a function of distance along the plate (up to transition) for freestream speeds $U = 1$ m/s, 2 m/s, 3 m/s, 4 m/s, 5 m/s, and 10 m/s.

Solution

Governing equations:

$$\frac{\nu}{x} \approx \frac{5.48}{\sqrt{Re_x}} \quad (9.21) \quad \text{and} \quad Re_x \approx \frac{U x}{\nu} \quad \text{so} \quad \nu \approx 5.48 \sqrt{\frac{\nu x}{U}}$$

The critical Reynolds number is $Re_{crit} \approx 500000$

Hence, for velocity U the critical length x_{crit} is $x_{crit} \approx 500000 \frac{\nu}{U}$

Tabulated or graphical data:

$$\nu = 1.50E-05 \text{ m}^2/\text{s}$$

(Table A.10, 20°C)

Computed results:

U (m/s)	1	2	3	4	5	10
x_{crit} (m)	7.5	3.8	2.5	1.9	1.5	0.75

x (m)	δ (mm)	δ (mm)	δ (mm)	δ (mm)	δ (mm)	δ (mm)
0.000	0.00	0.00	0.00	0.00	0.00	0.00
0.025	3.36	2.37	1.94	1.68	1.50	1.06
0.050	4.75	3.36	2.74	2.37	2.12	1.50
0.075	5.81	4.11	3.36	2.91	2.60	1.84
0.100	6.71	4.75	3.87	3.36	3.00	
0.2	9.49	6.71	5.48	4.75	4.24	
0.5	15.01	10.61	8.66	7.50	6.71	
1.5	25.99	18.38	15.01	13.00	11.62	
1.9	29.26	20.69	16.89	14.63		
2.5	33.56	23.73	19.37			
3.8	41.37	29.26				
5.0	47.46					
6.0	51.99					
7.5	58.12					

