PROBLEMS FOR CHAPTER 5

5-7

For stagnation boundary layer flow, $U = kx$, estimate the position Re_x where instability first occurs.

TABLE 4-2
Numerical values of the streamwise velocity $f'(\eta)$ for Falkner–Skan similarity flows

	β	−0.19884	−0.18	0.0	0.3	1.0	2.0	10.0
	f_0''	0.0	0.12864	0.46960	0.77476	1.23259	1.68722	3.67523
	η^*	2.35885	1.87157	1.21678	0.91099	0.64790	0.49743	0.24077
η	θ^*	0.58544	0.56771	0.46960	0.38574	0.29235	0.23079	0.11523
0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.1		0.00099	0.01376	0.04696	0.07597	0.11826	0.15876	0.31843
0.2		0.00398	0.02933	0.09391	0.14894	0.22661	0.29794	0.54730
0.3		0.00895	0.04668	0.14081	0.21886	0.32524	0.41854	0.70496
0.4		0.01591	0.06582	0.18761	0.28569	0.41446	0.52190	0.81043
0.5		0.02485	0.08673	0.23423	0.34938	0.49465	0.60964	0.87954
0.6		0.03578	0.10937	0.28058	0.40988	0.56628	0.68343	0.92414
0.7		0.04868	0.13373	0.32653	0.46713	0.62986	0.74496	0.95259
0.8		0.06355	0.15975	0.37196	0.52107	0.68594	0.79587	0.97057
0.9		0.08038	0.18737	0.41672	0.57167	0.73508	0.83767	0.98185
1.0		0.09913	0.21651	0.46063	0.61890	0.77787	0.87172	0.98888
1.2		0.14232	0.27899	0.54525	0.70322	0.84667	0.92142	0.99591
1.4		0.19274	0.34622	0.62439	0.77425	0.89681	0.95308	0.99856
1.6		0.24982	0.41691	0.69670	0.83254	0.93235	0.97269	0.99957
1.8		0.31271	0.48946	0.76106	0.87906	0.95683	0.98452	0.99998
2.0		0.38026	0.56205	0.81669	0.91509	0.97322	0.99146	0.99999
2.2		0.45097	0.63269	0.86330	0.94211	0.98385	0.99542	
2.4		0.52308	0.69942	0.90107	0.96173	0.99055	0.99761	
2.6		0.59460	0.76048	0.93060	0.97548	0.99463	0.99879	
2.8		0.66348	0.81449	0.95288	0.98480	0.99705	0.99940	
3.0		0.72776	0.86061	0.96905	0.99088	0.99842	0.99972	
3.2		0.78578	0.89853	0.98037	0.99471	0.99919	0.99987	
3.4		0.83635	0.92854	0.98797	0.99704	0.99959	0.99995	
3.6		0.87882	0.95138	0.99289	0.99840	0.99980	0.99998	
3.8		0.91315	0.96805	0.99594	0.99916	0.99991	0.99999	
4.0		0.93982	0.97975	0.99777	0.99958	0.99996		
4.5		0.97940	0.99449	0.99957	0.99994	0.99999		
5.0		0.99439	0.99997	0.99994	0.99999			

TABLE 5-1
Spatial stability parameters for Falkner–Skan profiles

β	$Re_{\delta^*,\,crit}$	$Re_{\theta,\,crit}$	$c_{i,\,max}$	$\left(-\frac{\alpha\delta^*}{Re_{\delta^*}}\right)_{max} \times 10^7$
+1.0	12,490	5,636	0.0065	1.14
0.8	10,920	4,874	0.0070	1.35
0.6	8,890	3,909	0.0075	1.67
0.5	7,680	3,344	0.0080	1.92
0.4	6,230	2,679	0.0085	2.42
0.3	4,550	1,927	0.0095	3.45
0.2	2,830	1,174	0.0104	6.0
0.1	1,380	556	0.0129	15.7
0.05	865	342	0.0154	32
0.0	520	201	0.0196	74
−0.05	318	119	0.0275	186
−0.1	199	71	0.0388	450
−0.14	138	47	0.0525	963
−0.1988	67	17	0.12	5,600

Source: Computations by Wazzan et al. (1968*b*).

5-8

For the separating Falkner-Skan wedge-flow boundary layer, $\beta = -0.19884$, estimate the point $\left(\frac{x}{L}\right)$ where boundary layer instability first occurs. Assume a low subsonic Mach number.

5-14

For stagnation boundary layer flow, $U = kx$, estimate the position Re_x where transition first occurs, using the method of Michel, Eq.5-38.

5-15

For the separating Falkner-Skan wedge flow boundary layer, $\beta = -0.19884$, use any appropriate correlation to estimate the position Re_x where transition first occurs. Neglect free stream turbulence. Compare your result with Fig.5-32.

5-19

Air at 20°C and 1 atm flows quietly towards a wedge of half angle 36°, resulting in a power-law free-stream and a laminar boundary layer along the surface. Use Wazzan's method (Eq.5-42) to estimate the transition Reynolds number, (Re_{x-tr})

5-20

Modify Problem 5-14 for a free stream turbulence level of 1-percent.

Problem 5-14

For stagnation boundary layer flow, $U = kx$, estimate the position Re_x where transition first occurs, using the method of Michel, Eq.5-38.

5-21

Modify Problem 5-15 for a free stream turbulence level of 1-percent.

Problem 5-15

For the separating Falkner-Skan wedge flow boundary layer, $\beta = -0.19884$, use any appropriate correlation to estimate the position Re_x where transition first occurs. Neglect free stream turbulence.

5-25

Effect of surface roughness on transition (pg. 387)

Air at 20°C and 1 atm flows at $U = 12\ m/s$ past a smooth flat plate. It is desired to trip the boundary layer to turbulence by stretching a 1mm diameter wire across the plate at the wall. Where will transition occur if the wire is placed at $x = 1\ m$? What wire location, x, will cause the earliest transition?

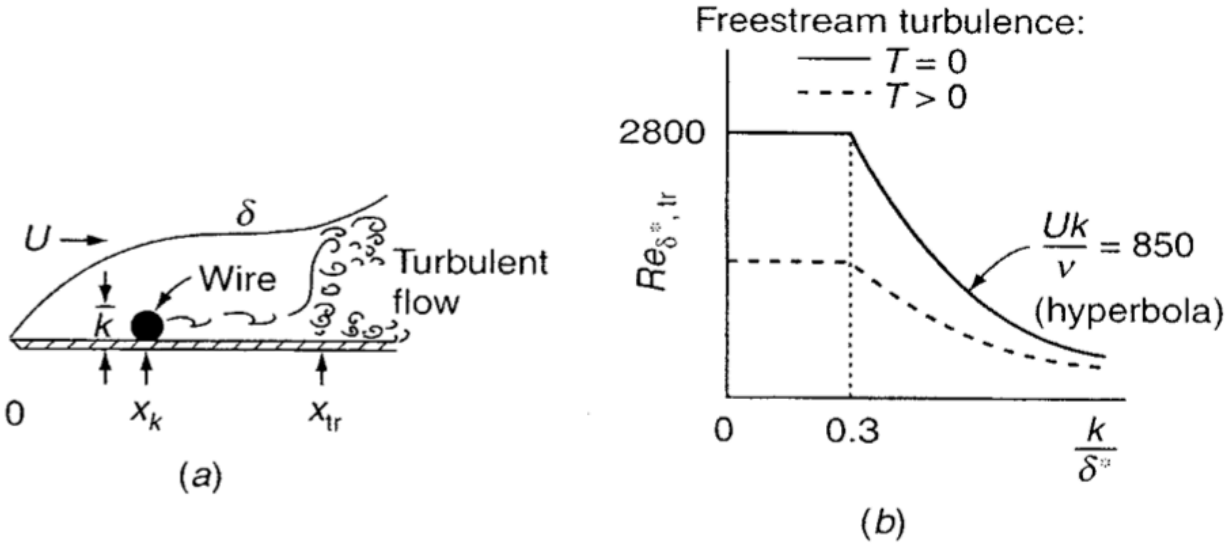

FIGURE 5-35
Idealized effect of two-dimensional roughness on transition: (*a*) flat plate with trip wire; (*b*) transition data.

5-26

Repeat Problem 5-25 if the free stream turbulence level is 1-percent.

Problem 5-25

Air at 20°C and 1 atm flows at $U = 12\ m/s$ past a smooth flat plate. It is desired to trip the boundary layer to turbulence by stretching a 1mm diameter wire across the plate at the wall. Where will transition occur if the wire is placed at $x = 1\ m$? What wire location x will cause the earliest transition?

5-28

Repeat Problem 5-19 if the free stream has a turbulence level of 4-percent. Find the estimated transition Reynolds number, $Re_{x,tr}$ by two different methods and compare.

Problem 5-19

Air at 20°C and 1 atm flows quietly towards a wedge of half angle 36°, resulting in a power-law free-stream and a laminar boundary layer along the surface. Use Wazzan's method (Eq.5-42) to estimate the transition Reynolds number, $Re_{x,tr}$