Flat-Plate Boundary Layer: Thickness and Skin-Friction Drag

Reynolds number, boundary layer thickness at the trailing edge, mean skin-friction coefficient and drag of a flat plate in laminar or turbulent flow.

Method: Blasius and one-seventh-power flat-plate results

Input parameters

Unit system: SI

Parameter	Value	Unit
Free-stream velocity	10.000	m/s
Plate length (in the flow direction)	2.0000	m
Plate width	1.0000	m
Kinematic viscosity	15.000	mm²/s
Fluid density	1.2000	kg/m³
Transition Reynolds number	500,000	

Calculated results

Parameter	Value	Unit
Reynolds number at the trailing edge	1,333,333	
Transition position from the leading edge	0.75000	m
Boundary layer thickness at the trailing edge	44.080	mm
Average skin-friction coefficient	0.003101	
Drag on one side	0.37214	N

Notes for this case

• Below the transition Reynolds number the Blasius similarity solution gives $\delta_{99} = 4.91x/\sqrt{Re_x}$ and an average skin-friction coefficient $1.328/\sqrt{Re_L}$. Above it the plate is taken as turbulent from the leading edge with Prandtl's one-seventh-power law, C_D = 0.074Re_L^−0.2 and δ = 0.37x·Re_x^−0.2, less a laminar-run correction A/Re_L with A = Re_cr(0.074Re_cr^−0.2 − 1.328/√Re_cr) (1,742 for Re_cr = 5 × 10⁵). Valid for smooth plates up to about Re = 10⁷; roughness, pressure gradients and free-stream turbulence move transition and raise drag.

Formula and method

$$\delta = \frac{4.91x}{\sqrt{Re_x}}, \quad C_D = \frac{1.328}{\sqrt{Re_L}}; \quad C_D = \frac{0.074}{Re_L^{0.2}} - \frac{A}{Re_L}$$

Variables

U	Free-stream velocity	m/s
L	Plate length (in the flow direction)	m
b	Plate width	m
ν	Kinematic viscosity	m²/s
ρ	Fluid density	kg/m³
Re_{cr}	Transition Reynolds number	-
Re_L	Reynolds number at the trailing edge	-
x_{tr}	Transition position from the leading edge	m
δ_L	Boundary layer thickness at the trailing edge	m
C_D	Average skin-friction coefficient	-
F_D	Drag on one side	N

Method and standards

Boundary layer.

Assumptions and limits

- Smooth flat plate; zero pressure gradient; incompressible flow.

References

Blasius and one-seventh-power flat-plate results

Report details

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Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/mechanical/fluid-mechanics/flat-plate-boundary-layer

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Reopens the calculator with the inputs of this report.