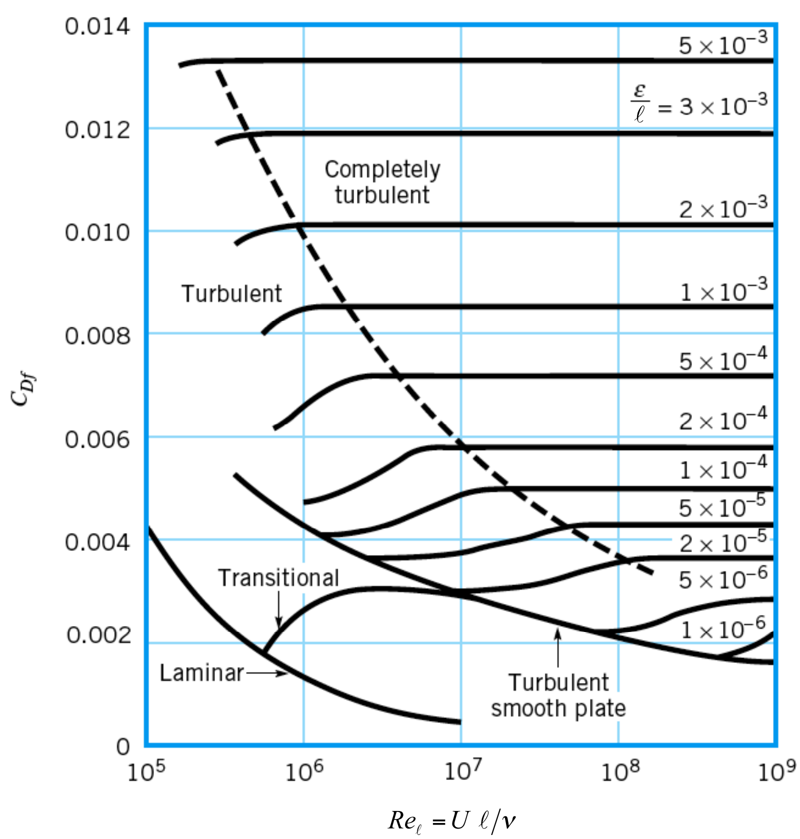
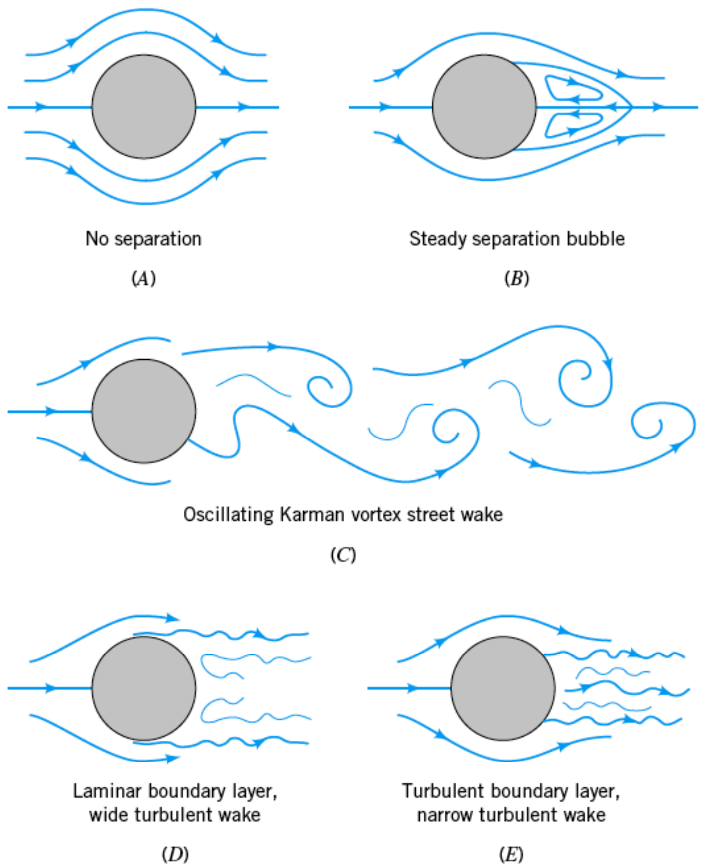
Friction drag coefficient for steady, constant property, 2-D, uniform flow over a flat plate:

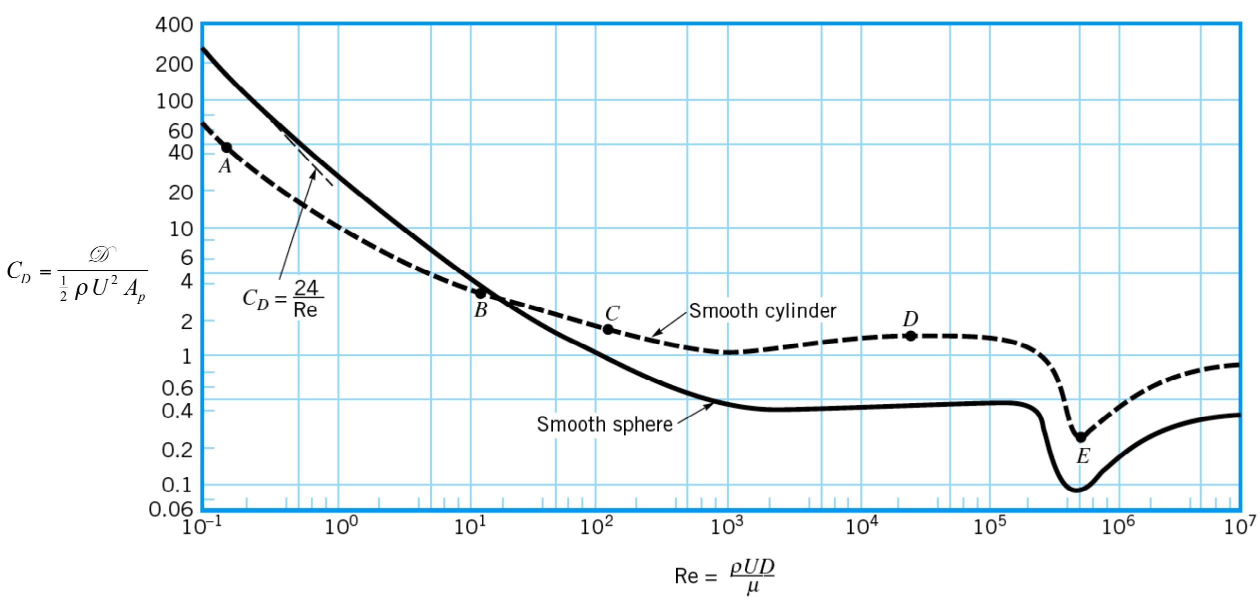
Laminar:	$C_{Df} = 1.328\ Re_\ell^{-1/2}$	$Re_\ell < 5\times10^5$
Mixed or Transitional:	$C_{Df} = 0.0743\ Re_\ell^{-1/5} - \dfrac{1740}{Re_\ell}$	$5\times10^5 < Re_\ell < 10^7$
	$C_{Df} = \dfrac{0.455}{(\log Re_\ell)^{2.58}} - \dfrac{1700}{Re_\ell}$	$5\times10^5 < Re_\ell < 10^9$
Turbulent (smooth plate):	$C_{Df} = 0.0743\ Re_\ell^{-1/5}$	$5\times10^5 < Re_\ell < 10^7$
	$C_{Df} = \dfrac{0.455}{(\log Re_\ell)^{2.58}}$	$5\times10^5 < Re_\ell < 10^9$
Turbulent (completely turbulent):	$C_{Df} = \left[1.89 - 1.62\log\left(\dfrac{\varepsilon}{\ell}\right)\right]^{-2.5}$	see Table 8.1 for ε

where $Re_\ell = U\ell/\nu$ is Reynolds number, U is free stream velocity, ν is kinematic viscosity, ℓ is plate length, b is plate width, ε is plate roughness, and $\mathscr{D}_f$ is drag force due to friction.

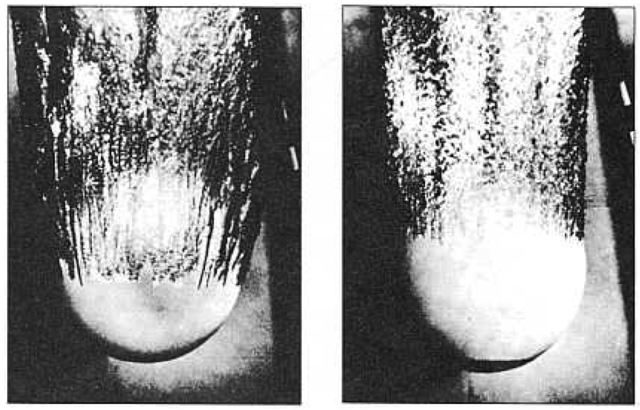


Streamlines for cylinder in uniform cross flow for a range of Reynolds numbers.

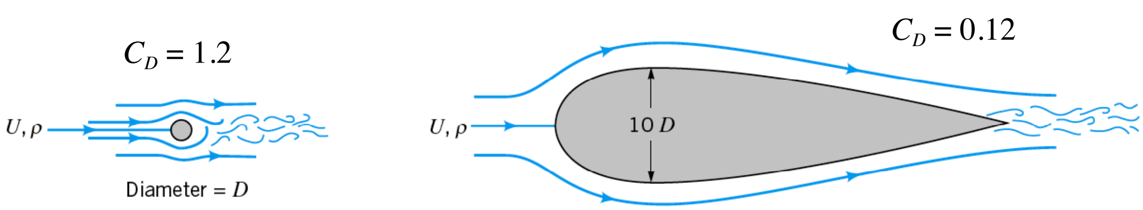




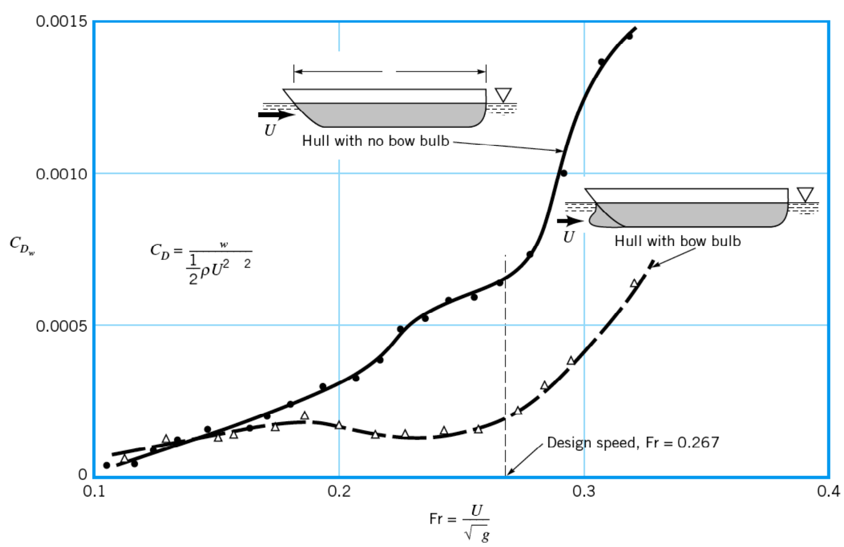
Drag coefficient, C_D, versus Reynolds number, Re, where $\mathscr{D}$ is total drag, U is uniform velocity, D is diameter, A_p is projected frontal area, ρ is density, and μ is viscosity.



Strong differences in laminar and turbulent separation on an 8.5-in. bowling ball entering water at 25 ft/s: (a) smooth ball, laminar boundary layer; (b) same entry, turbulent flow induced by patch of nose-sand roughness (NAVAIR Weapons Division Historical Archives.)

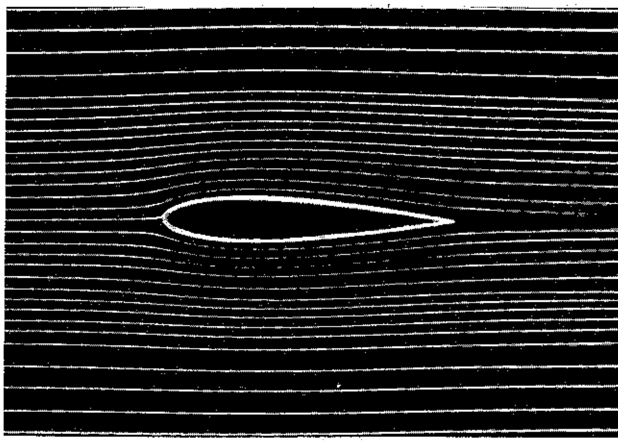


Two objects of considerably different size that have the same drag force.

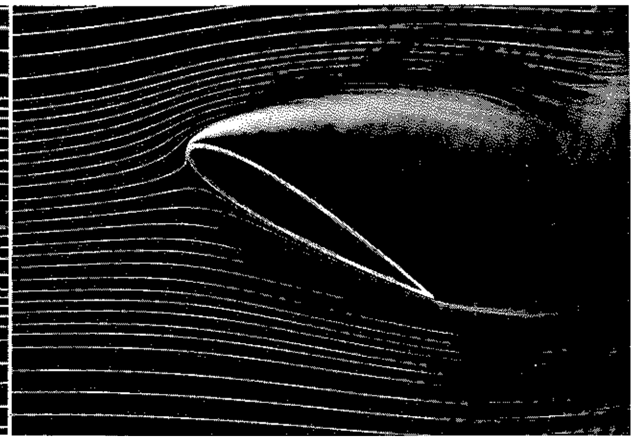


Drag coefficient as a function of Froude number and hull characteristics for that portion of the drag due to the generation of waves (Inui, *Wave Making Resistance of Ships*, 1962).

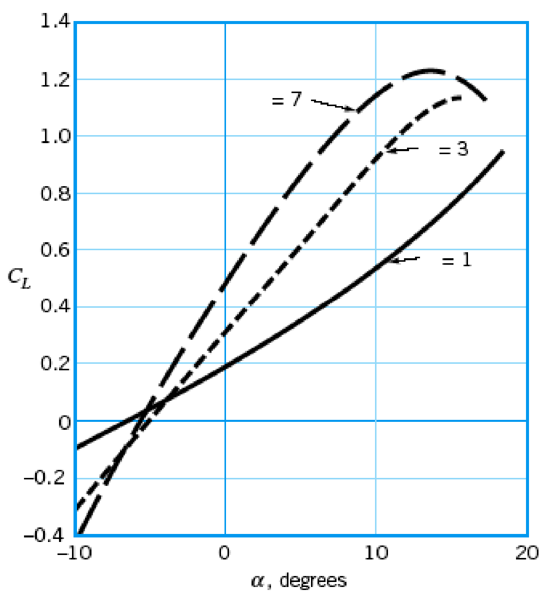
Effect of angle of attack, α, and aspect ratio, $\mathscr{A} = b/c$ where b is span and c is chord length, on lift coefficient, C_L, and drag coefficient, C_D, for typical airfoils.

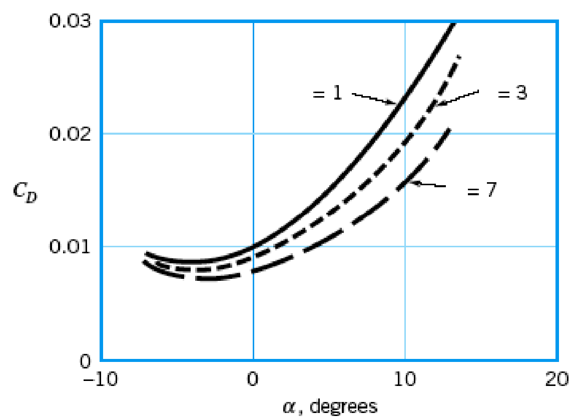


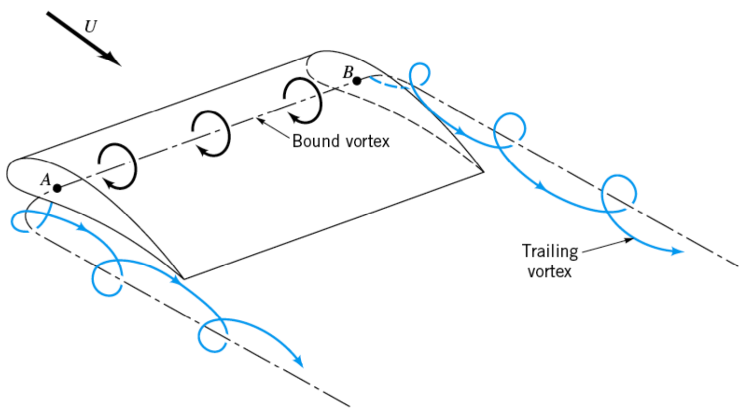
$\alpha = 0°$

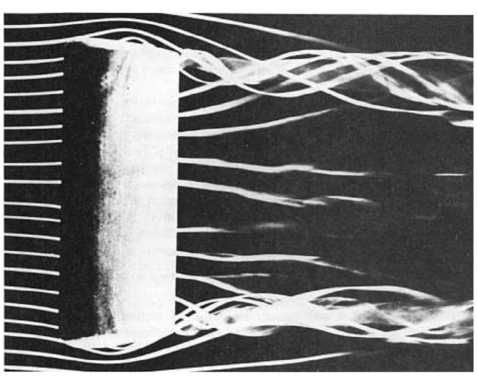


stall at high α

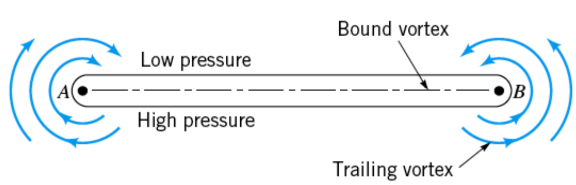




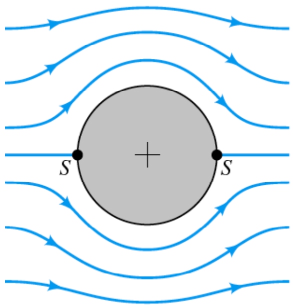




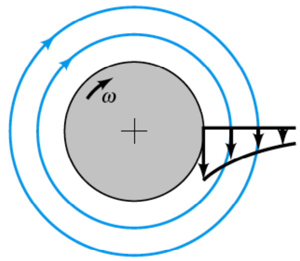
Wing with trailing vortices.



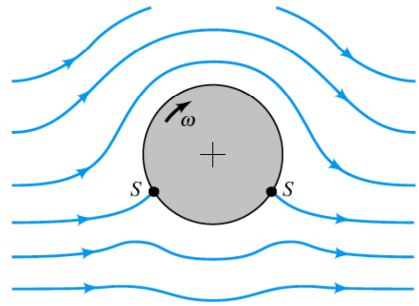
(a) uniform flow past a cylinder



(b) free vortex at center of cylinder

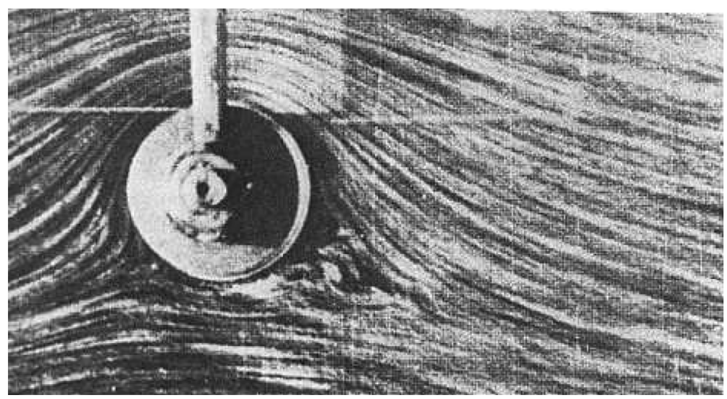


(c) uniform flow past rotating cylinder



S = stagnation point (highest pressure)
"(a) + (b) = (c)"

Rotating cylinder with separation



Lift coefficient, C_L, and drag coefficient, C_D, versus spin ratio, $SR = (\omega D)/(2U)$, for a spinning smooth sphere where:

ω	rate of rotation
D	diameter
U	uniform velocity
Re	Reynolds number
ρ	density
ν	kinematic viscosity
$\mathscr{D}$	drag
$\mathscr{L}$	lift