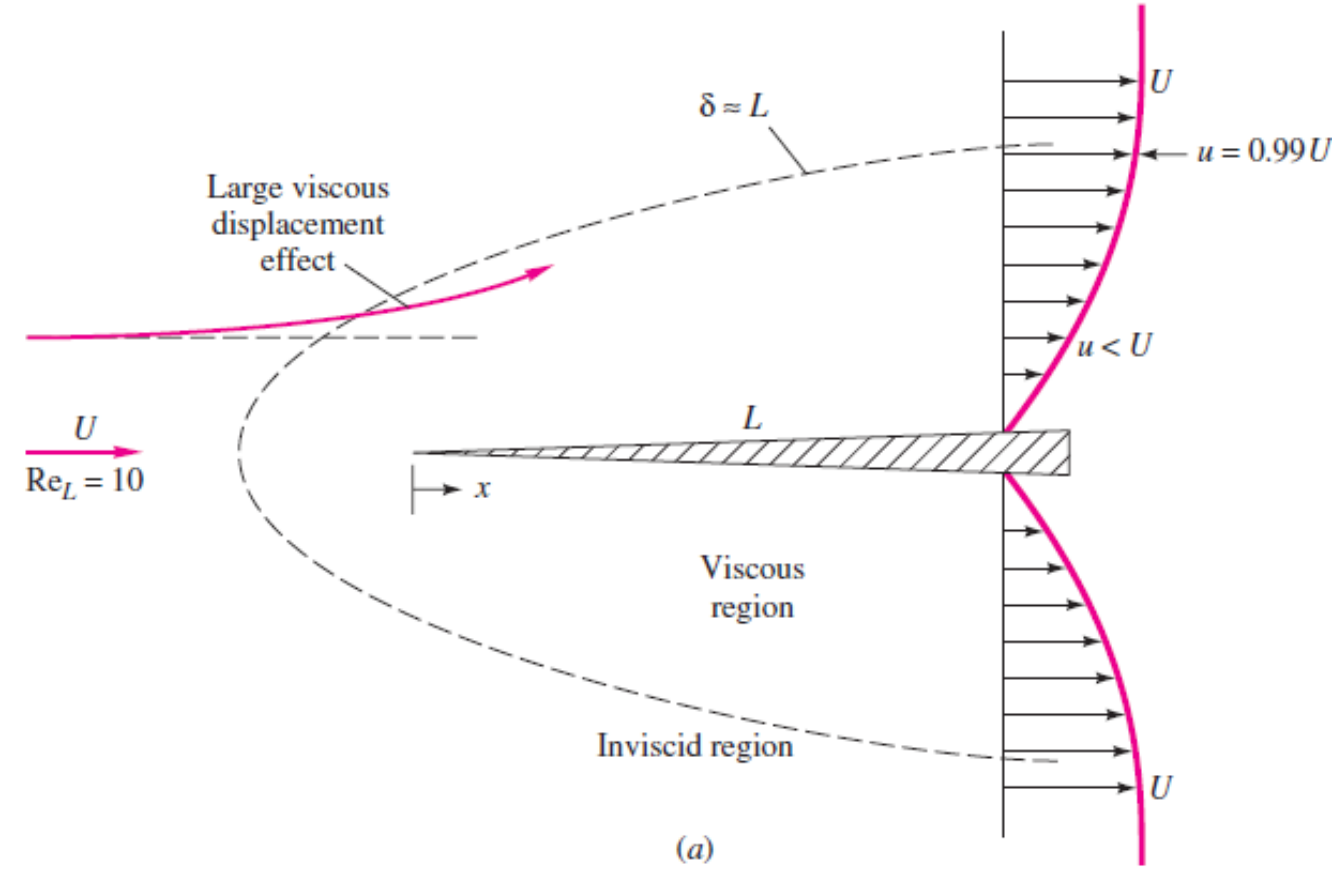
Noções de Escoamentos Externos

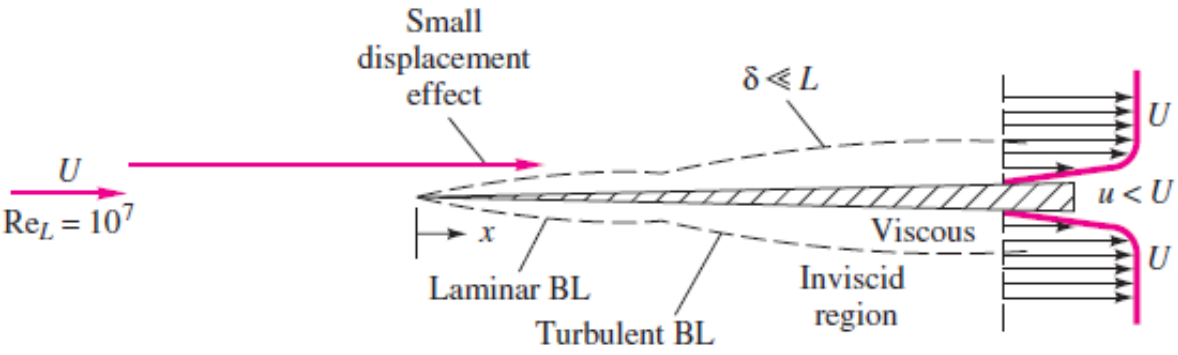
Ref: White F.M., Mecânica dos Fluidos

Introdução

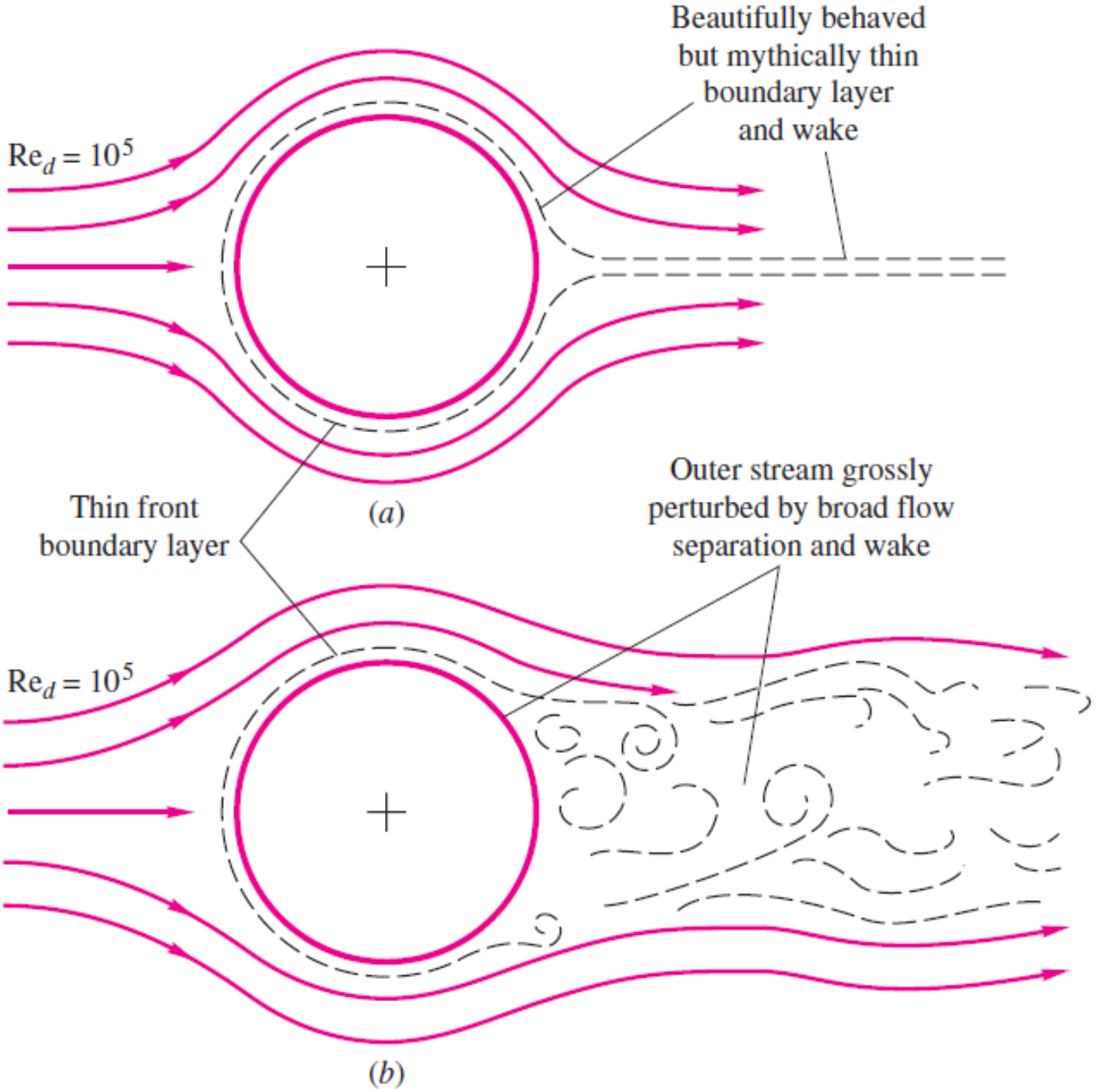
- Veremos aqui apenas algumas noções
  - Como de costume, maior ver notas de aula (lousa)
- Veremos escoamentos externos mais a fundo em Mecânica dos Fluidos II (EM561)


δ ≈ L
U
u = 0.99U
Large viscous
displacement
effect
u < U
U
Re_L = 10
L
x
Viscous
region
Inviscid region
U

(a)

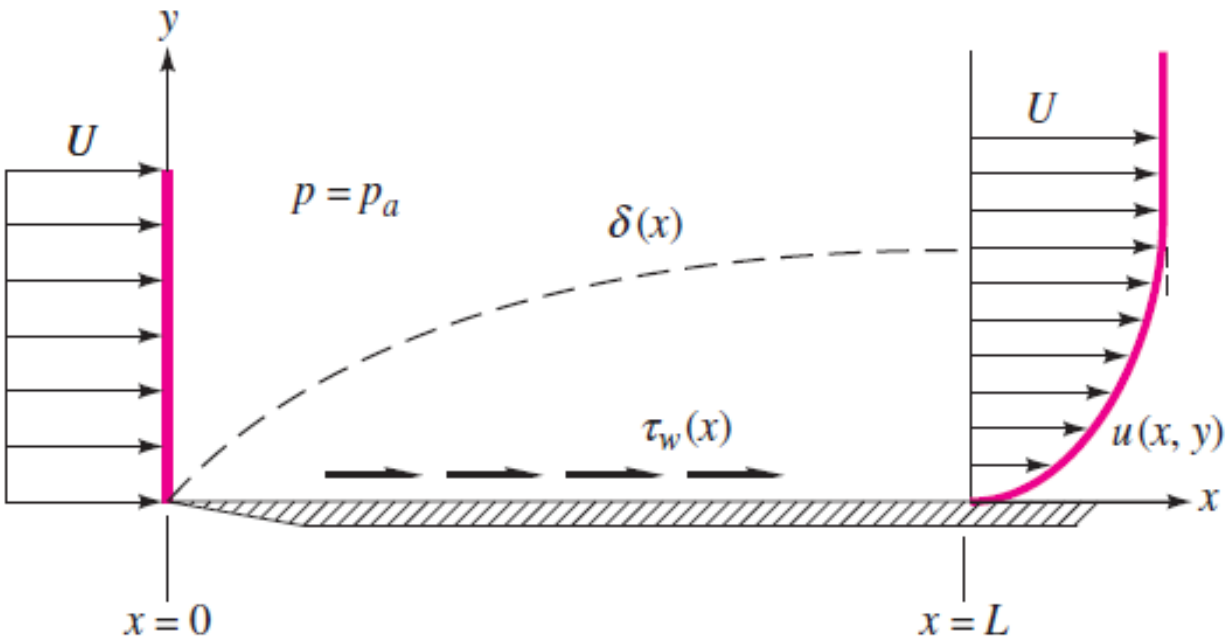

Small
displacement
effect
δ ≪ L
U
U
Re_L = 10^7
u < U
x
Viscous
Laminar BL
Inviscid
region
Turbulent BL
U

(b)


Beautifully behaved
but mythically thin
boundary layer
and wake
$Re_d = 10^5$
(a)
Thin front
boundary layer
Outer stream grossly
perturbed by broad flow
separation and wake
$Re_d = 10^5$
(b)

Placa plana

- Obtemos a seguir as seguintes expressões para placa plana, utilizando o V.C. mostrado em aula:
  - Força de arrasto
  - Tensão na parede
  - Coeficiente de fricção
  - Coeficiente de arrasto



$$D(x) = \rho b \int_0^{\delta(x)} u(U - u)\, dy$$

$$D(x) = \rho b U^2 \theta \qquad \theta = \int_0^{\delta} \frac{u}{U}\left(1 - \frac{u}{U}\right) dy$$

$$\tau_w = \rho U^2 \frac{d\theta}{dx}$$

$$c_f = \frac{2\tau_w}{\rho U^2} = 2\frac{d\theta}{dx}$$

$$C_D = \frac{2D(L)}{\rho U^2 bL} = 2\frac{\theta}{L}$$

$$D = \frac{1}{2} C_D \rho U^2 bL$$

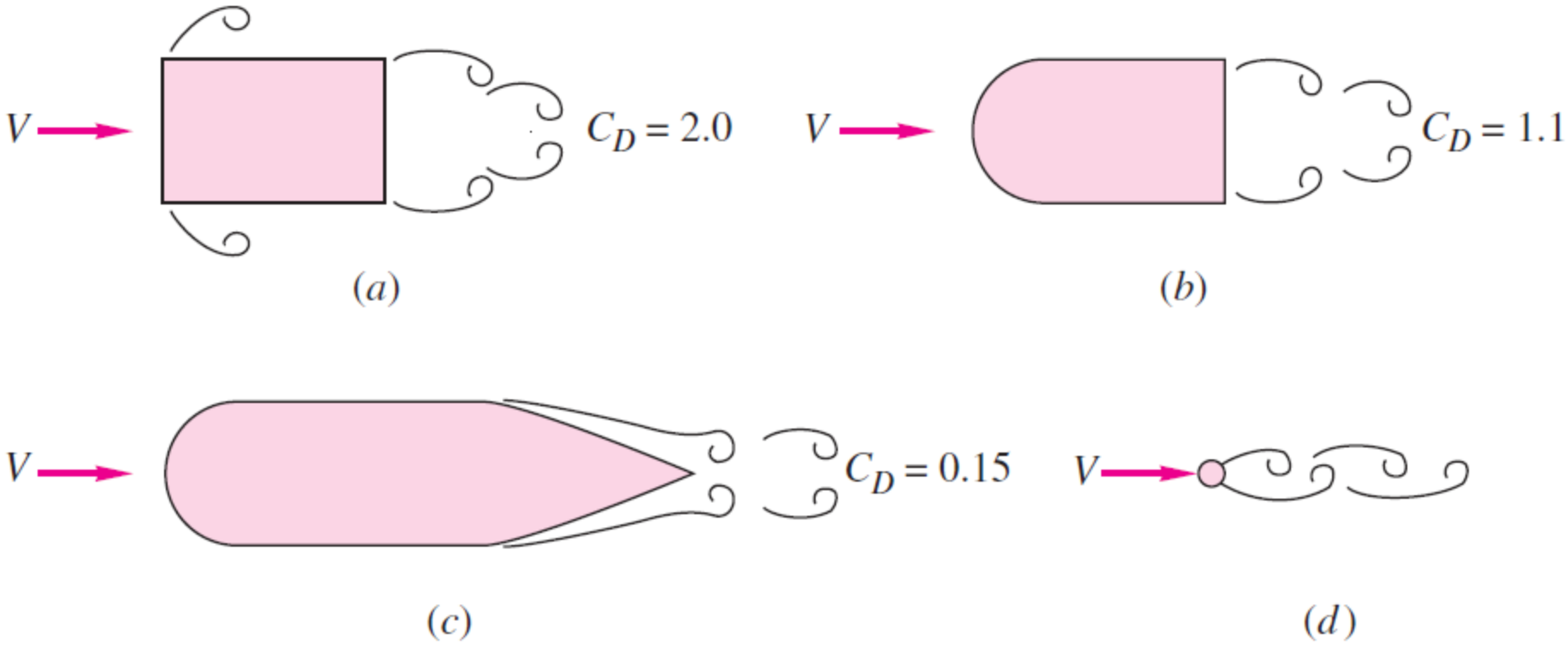
→ ARRASTO

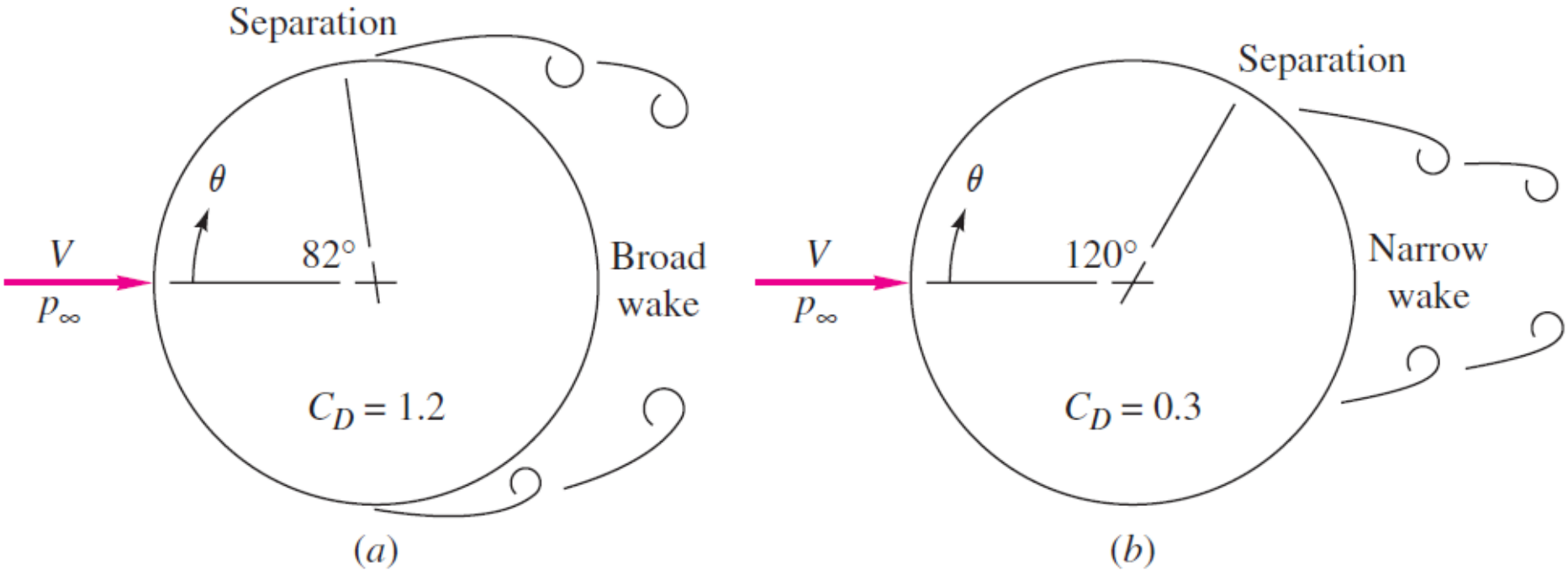
Corpo rombudo

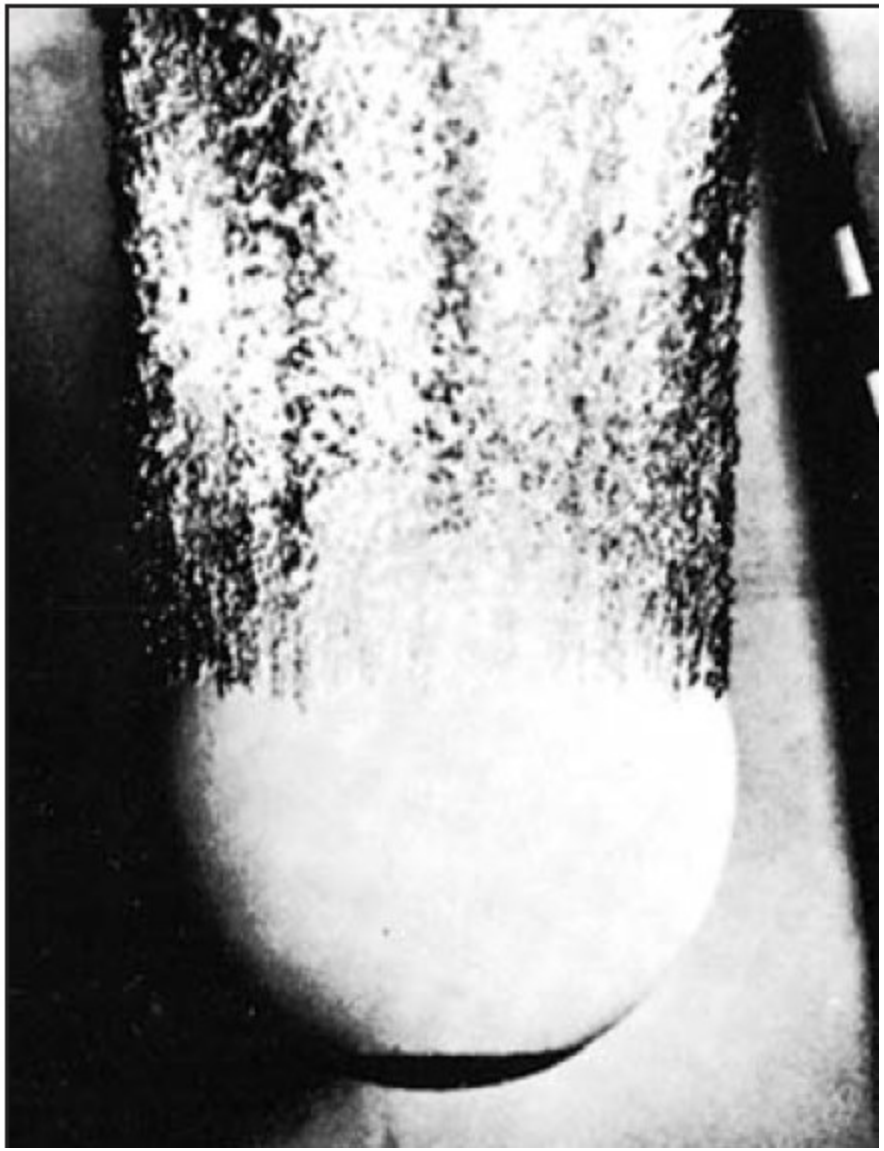
- Há arrasto viscoso e arrasto de pressão

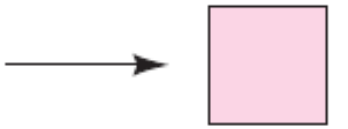
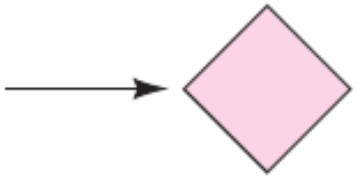
$$C_D = C_{D,\text{press}} + C_{D,\text{fric}}$$

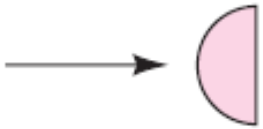
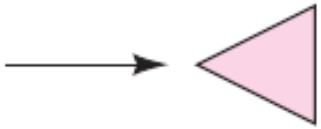
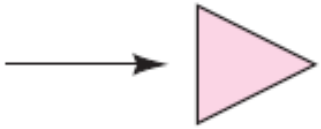
- Em geral o arrasto de pressão é muito maior
  - Nestes casos, nos preocupamos apenas com o arrasto de pressão.

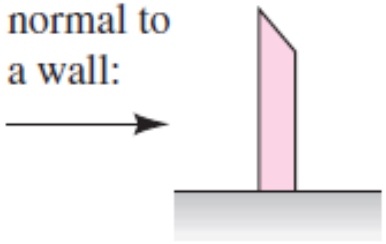
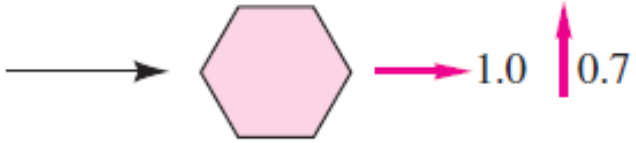

V
$C_D = 2.0$
(a)
V
$C_D = 1.1$
(b)
V
$C_D = 0.15$
(c)
V
(d)


Separation
θ
V
p∞
82°
Broad
wake
CD = 1.2
(a)
Separation
θ
V
p∞
120°
Narrow
wake
CD = 0.3
(b)

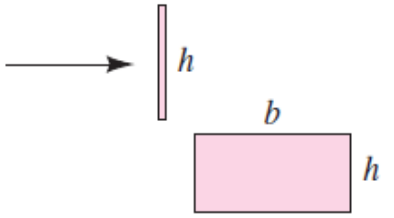


Shape	C_D based on frontal area
Square cylinder: 	2.1
	1.6
Half tube: 	1.2
	2.3

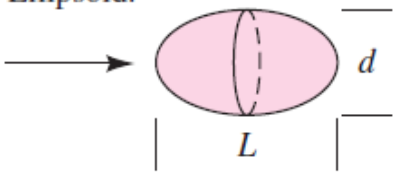
Shape	C_D based on frontal area
Half cylinder: 	1.2
	1.7
Equilateral triangle: 	1.6
	2.0

Shape	C_D based on frontal area
Plate: 	2.0
Thin plate normal to a wall: 	1.4
Hexagon: 	

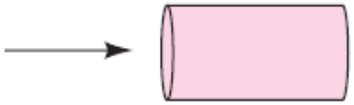
Body	Ratio	C_D based on frontal area
Rectangular plate:	b/h 1	1.18
	5	1.2
	10	1.3
	20	1.5
	∞	2.0



Body	Ratio	C_D based on frontal area	
		Laminar	Turbulent
Ellipsoid:	L/d 0.75	0.5	0.2
	1	0.47	0.2
	2	0.27	0.13
	4	0.25	0.1
	8	0.2	0.08



Body	Ratio	C_D based on frontal area
Flat-faced cylinder:	L/d 0.5	1.15
	1	0.90
	2	0.85
	4	0.87
	8	0.99



Buoyant rising sphere [50],	$C_D \approx 0.95$
$135 < \mathrm{Re}_d < 1\mathrm{E}5$	