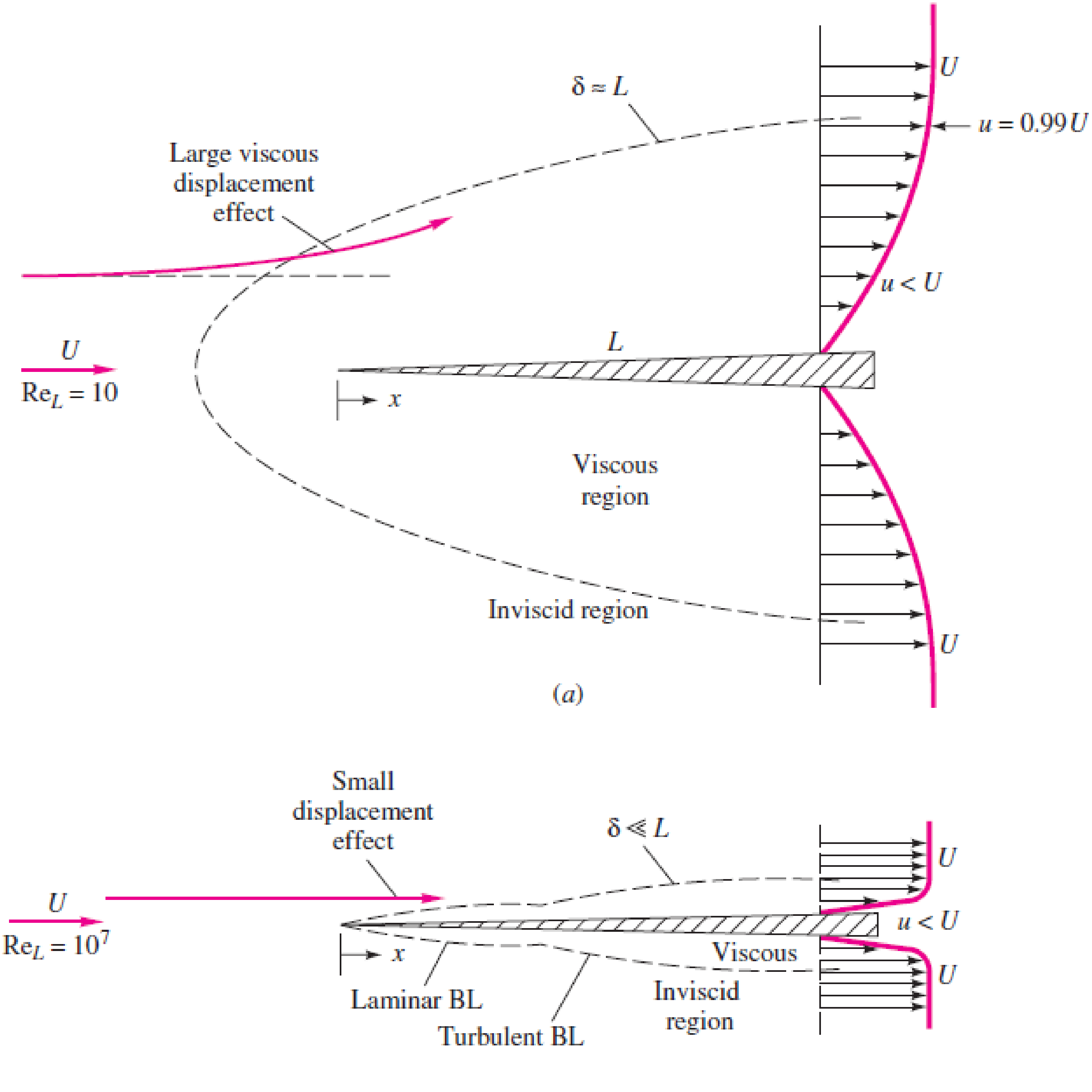
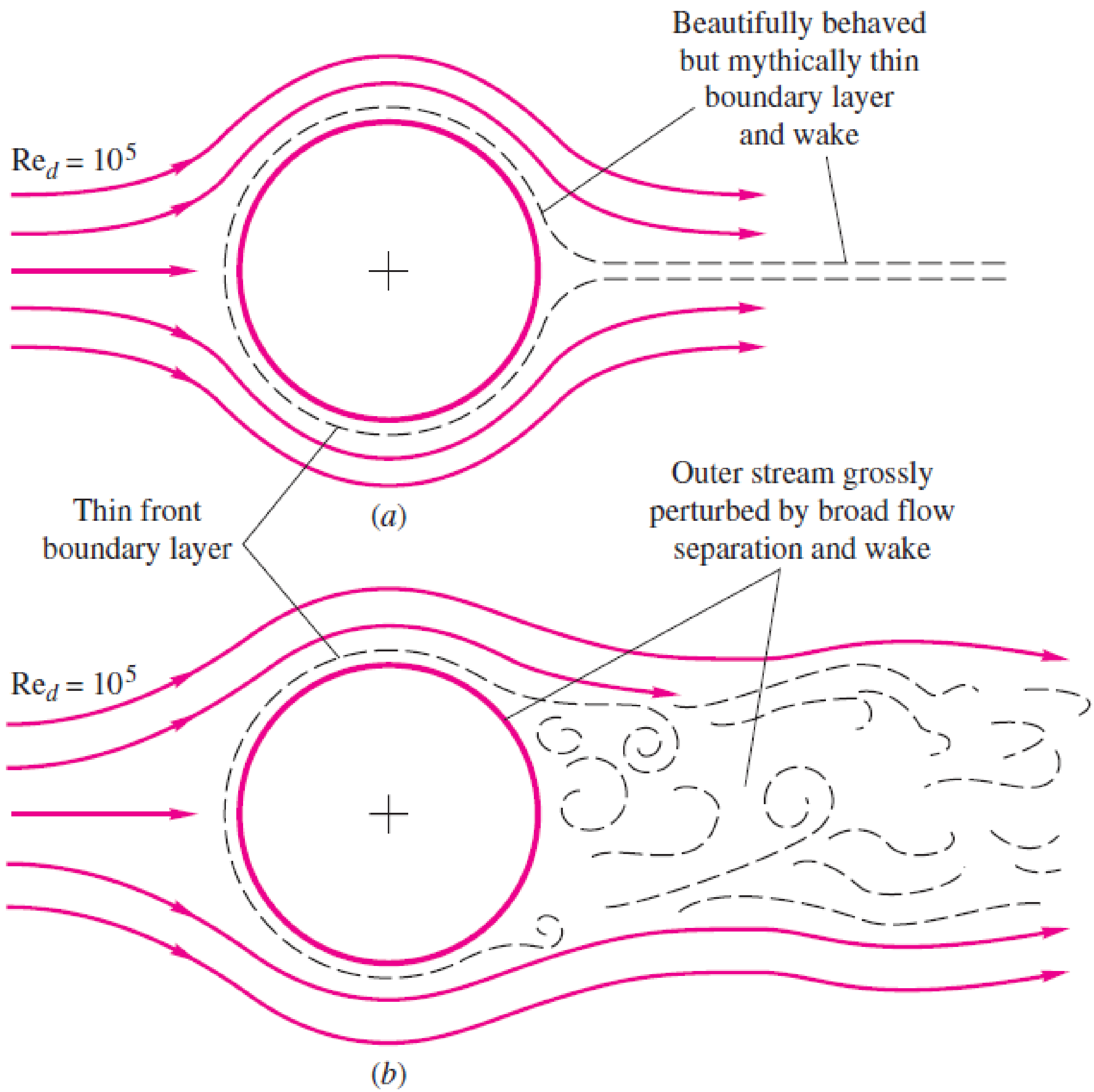
Noções de Escoamentos Externos

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)

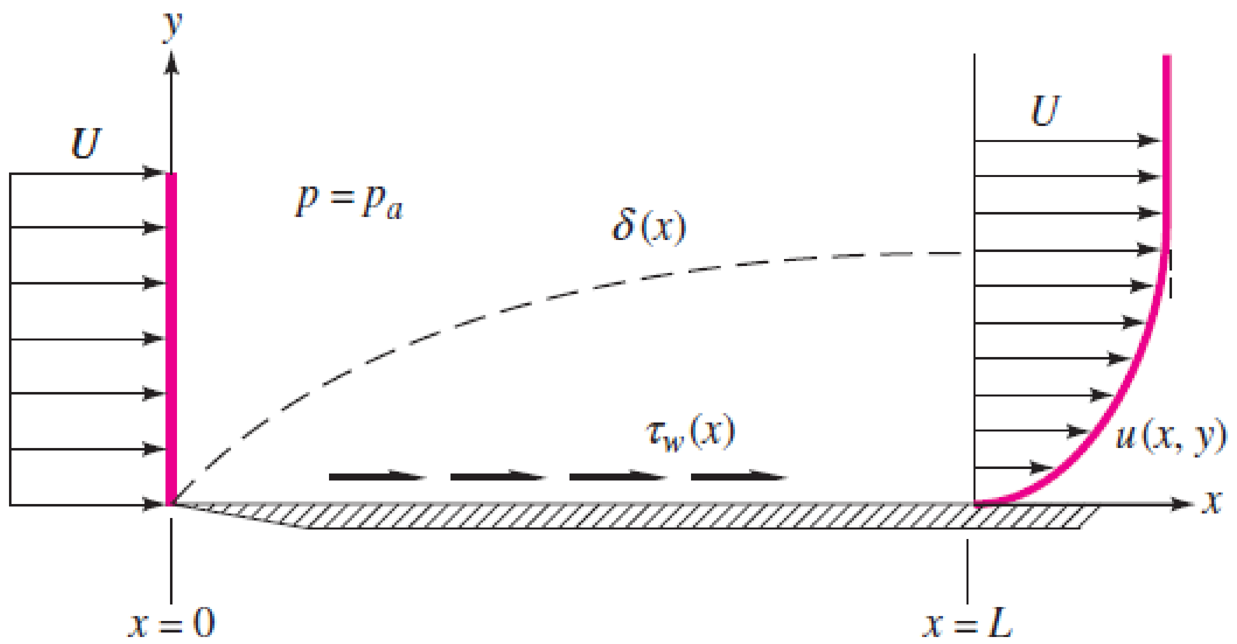

δ ≈ L
U
u = 0.99U
Large viscous
displacement
effect
u < U
U
L
Re_L = 10
x
Viscous
region
Inviscid region
U
(a)
Small
displacement
effect
δ ≪ L
U
U
Re_L = 10^7
u < U
x
Viscous
U
Laminar BL
Inviscid
region
Turbulent BL
(b)



Exemplo: https://youtu.be/SiOiVHUEYao?si=6p0tPmCcYb4cGPFC

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



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

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

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

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

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

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

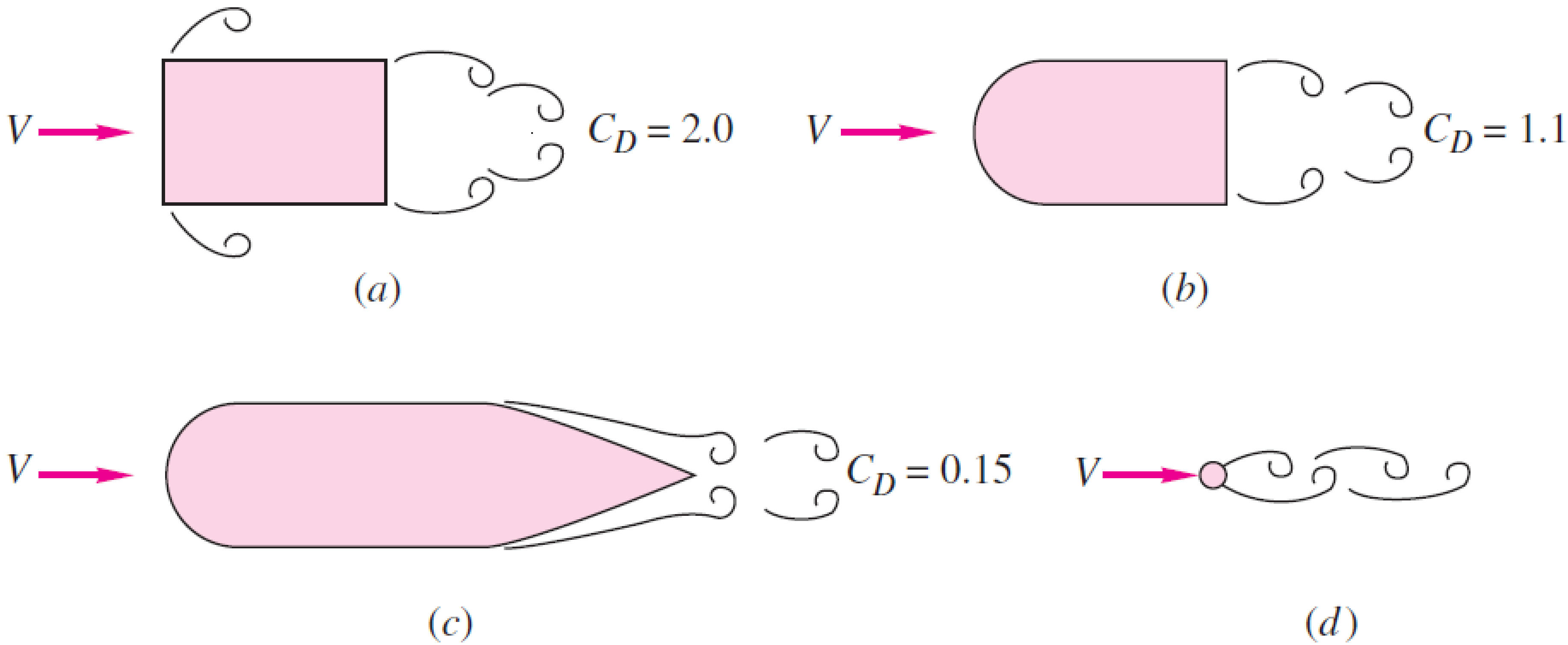
→ ARRASTO

Corpo rombudo

- Há arrasto viscoso e arrasto de pressão

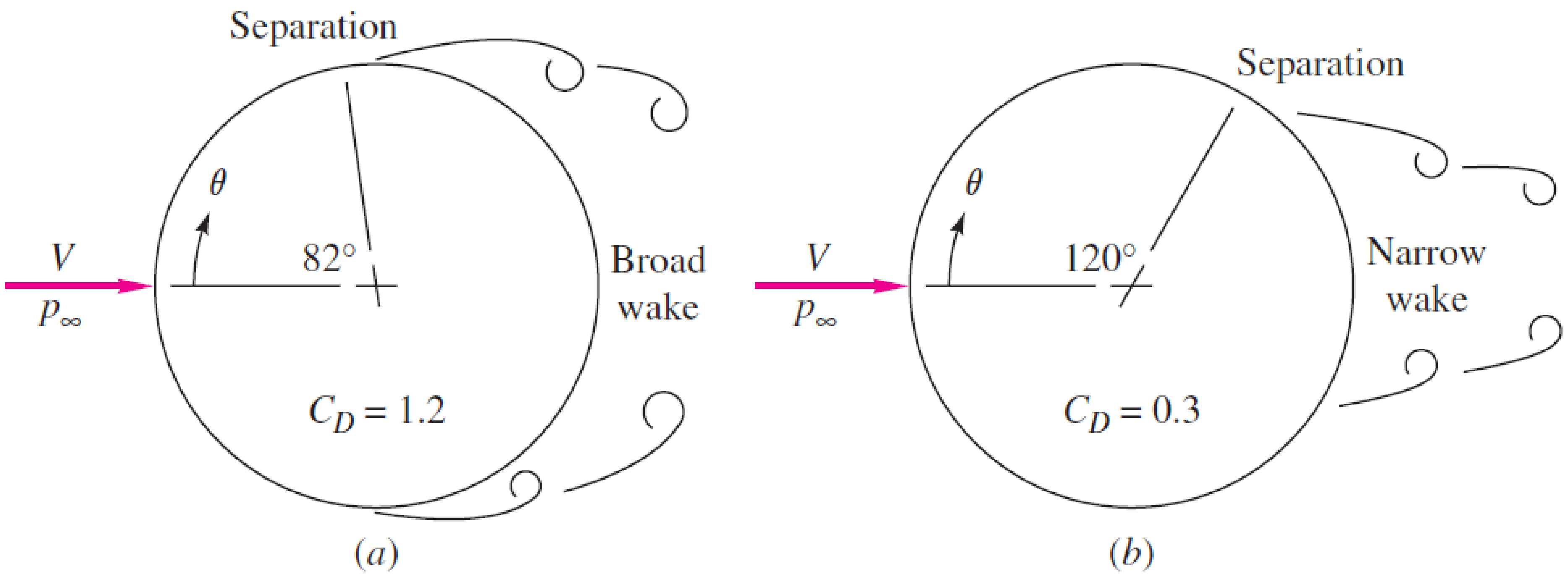
$$C_D = C_{D,\text{press}} + C_{D,\text{fric}}$$

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

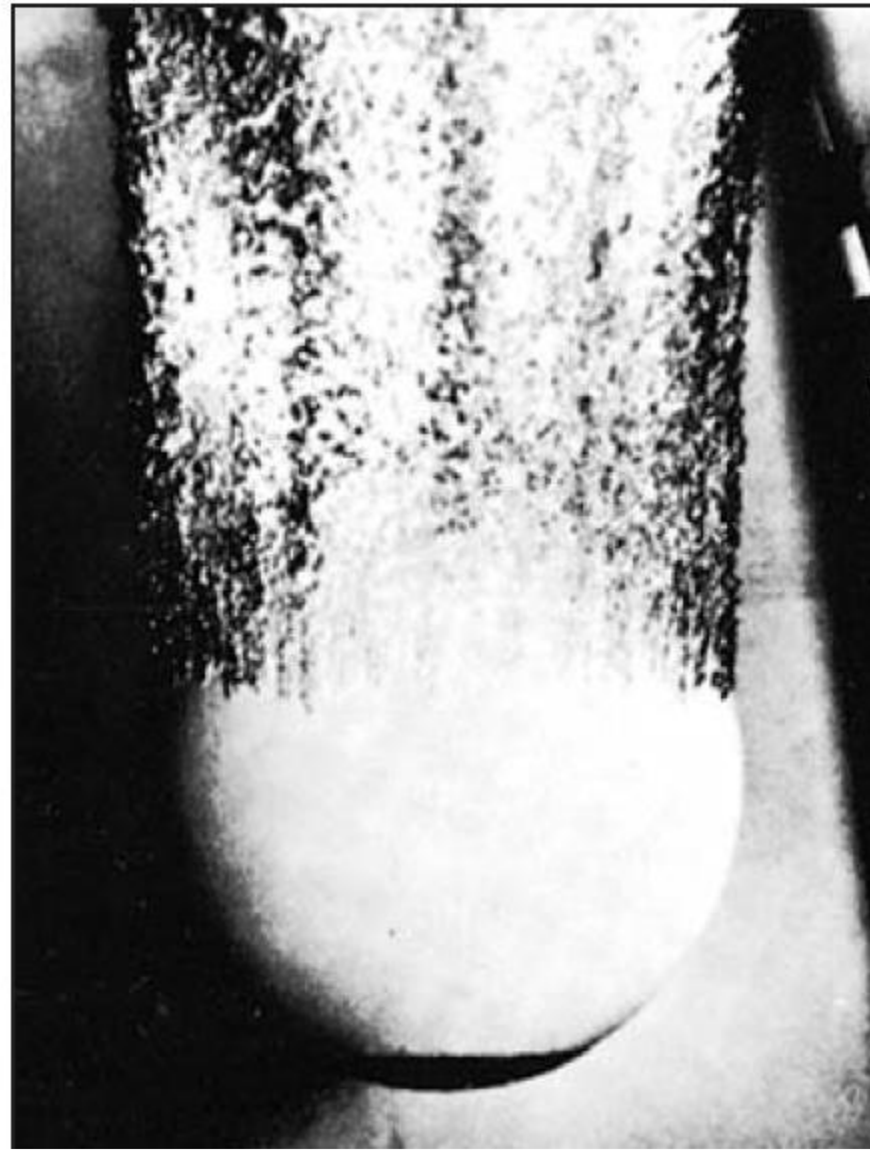


Exemplo (escoamentos externos em corpos rombudos)

https://youtu.be/bJX8fVsq5oQ?si=-C7cKez1mU8PBQug



Exemplo: https://youtu.be/B2jz4MJAtSw?si=ZGu-YVcGKoIb0F2K

C_D Placa Plana

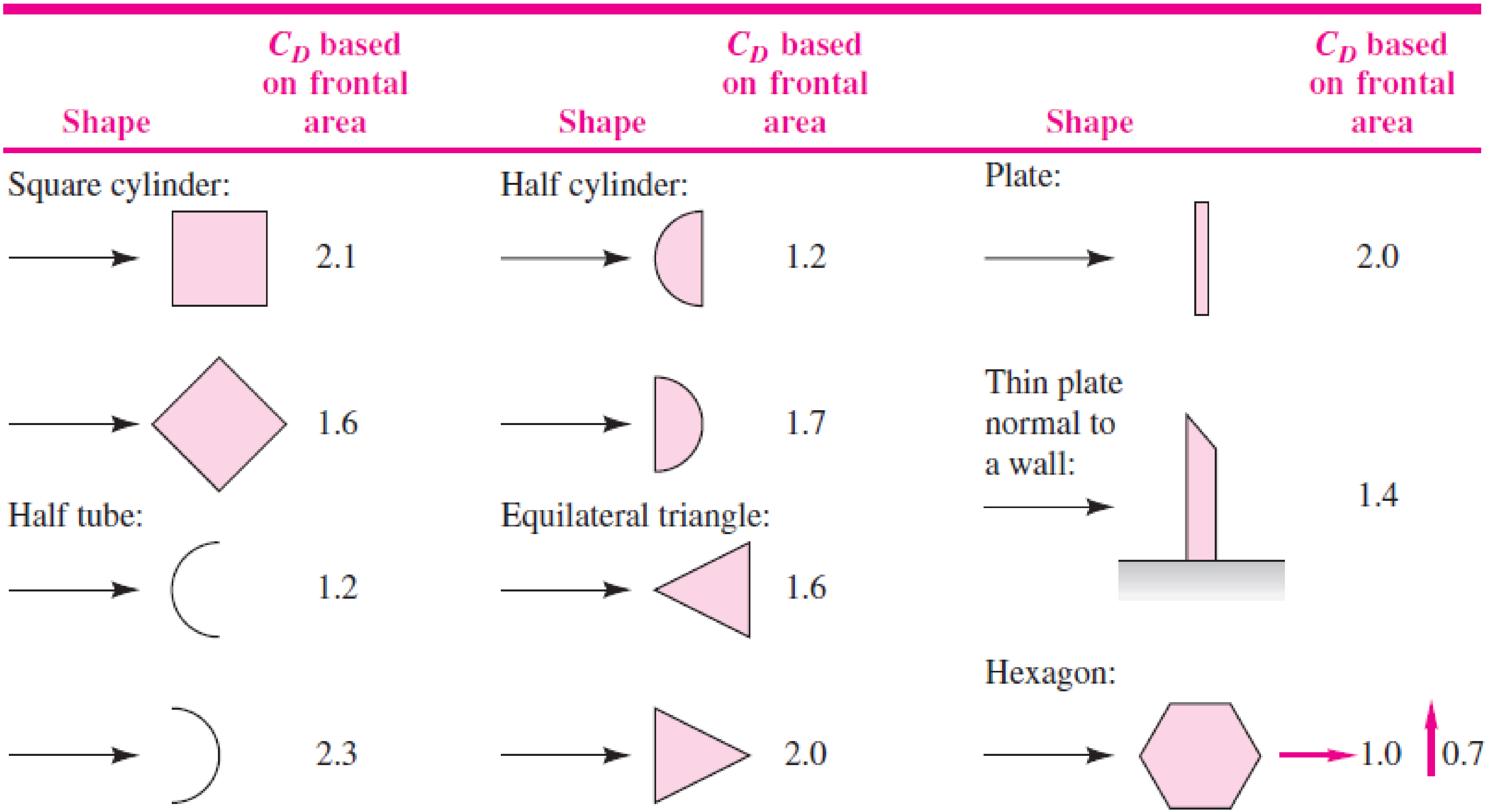
Laminar

$$C_D = \frac{1.328}{\mathrm{Re}_L^{1/2}}$$

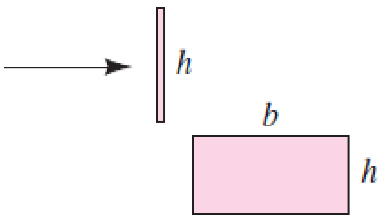
Turbulento

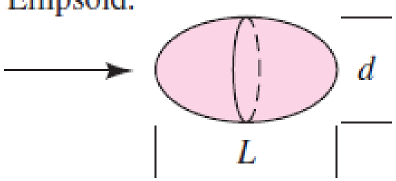
$$C_D \approx \begin{cases} \dfrac{0.031}{\mathrm{Re}_L^{1/7}} - \dfrac{1440}{\mathrm{Re}_L} & \mathrm{Re}_{\mathrm{trans}} = 5 \times 10^5 \\ \dfrac{0.031}{\mathrm{Re}_L^{1/7}} - \dfrac{8700}{\mathrm{Re}_L} & \mathrm{Re}_{\mathrm{trans}} = 3 \times 10^6 \end{cases}$$

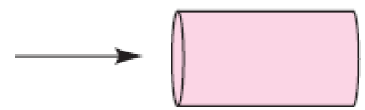
C_D Corpo Rombudo



C_D Corpo Rombudo

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	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], $135 < Re_d < 1E5$	$C_D \approx 0.95$	