MODEL TESTING →

13.012
11|18|04 ①

★ Bluff Body : form drag >> friction drag

C_D constant over a range of Reynolds #s for a fixed Regime (laminar or turbulent)

- Measure force on model, calculate c_D ($c_D = F / \frac{1}{2}\rho U_m^2 A_m$)
- Use this c_D for full-scale $F_{fullscale} = C_D \cdot [\frac{1}{2}\rho U_{fs}^2 A_{fs}]$

if the fullscale body operates in a turbulent regime so MUST the model you test

★ Streamlined Body : 

$C_{D_{TOTAL}} = C_f(R_e^{\#}) + C_{D_0}$

- $C_{D_{TOTAL}}$: only slightly dependent overall on Reynolds # as long as in an regime
- $C_f(R_e^{\#})$: frictional drag is Reynolds # dependent (smaller)
- C_{D_0}: profile/form drag due to separation (larger)
- similar to flat plate c_f w/ same wetted Area ← this is an assumption we make (is ok)

EXPERIMENT: (Re model & Reprototype)

- Measure force on model @ $Re_{model} = \frac{U_m L_m}{\nu_m}$
- Determine $C_{D\,model} = F_m / \frac{1}{2}\rho_m U_m^2 A_m$

- Form drag is $C_{Do_m} = C_{D_m} - C_f(Re_m)$

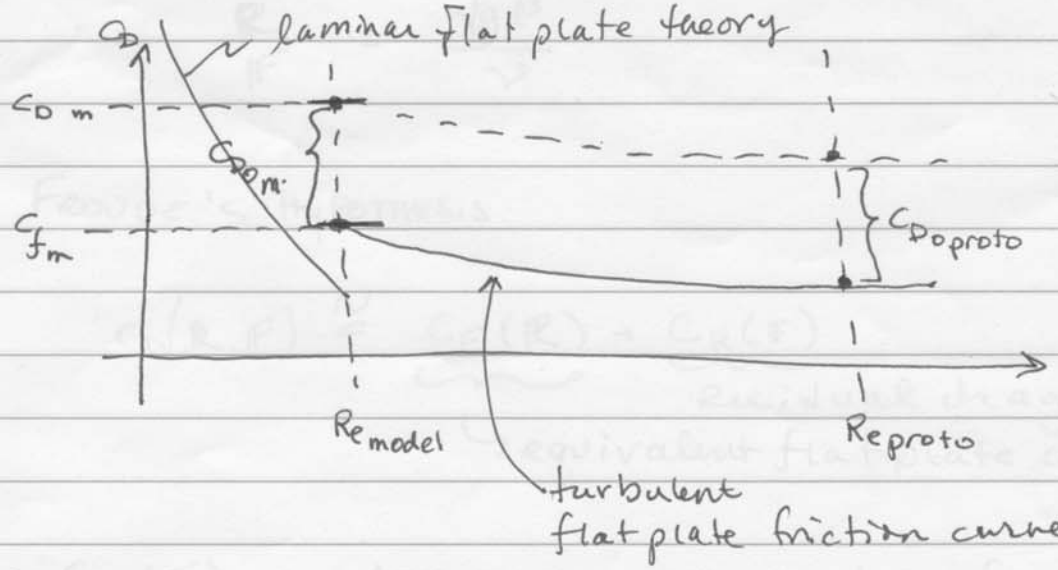
$$C_{Do_m} = C_{Do\ prototype\ full\ scale\ ship}!$$

- Can now predict total C_D on prototype:

$$C_{D\,proto} = C_{Do\,proto} + C_f(Re_{proto})$$

$$= C_{Do_{model}}$$

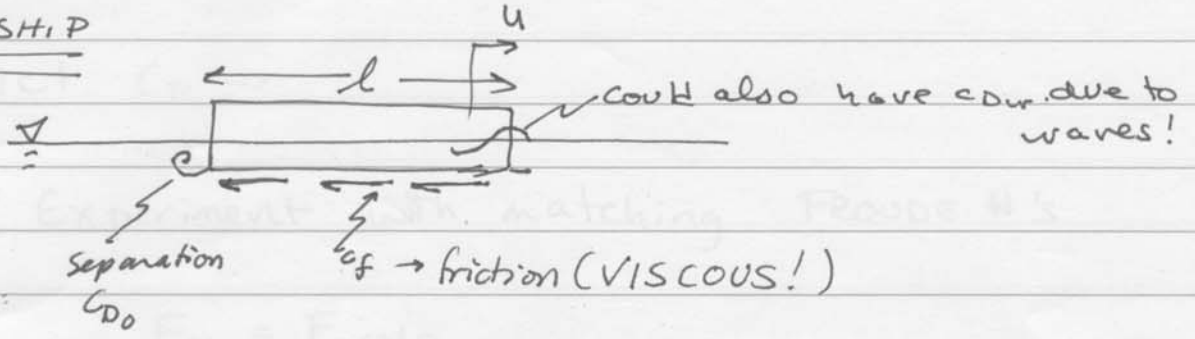
$$\therefore C_{D\,proto} = C_{D_m} - C_f(Re_m) + C_f(Re_{proto})$$



ASIDE:

If Roughness on model is high need to account for this

FOR A SHIP



$C_D = C_D(\mathbb{R}e, \mathbb{F}_R)$ function of both Reynolds # and FROUDE #'s

$$R_e = \frac{Ul}{\nu} \qquad F_e = \frac{U}{\sqrt{gl}}$$

$R_e \sim l$ & $F_n \sim 1/\sqrt{l}$ so

both cannot be scaled together!

$$\frac{\mathbb{R}}{\mathbb{F}} = \frac{\sqrt{gl^3}}{\nu}$$

FROUDE'S HYPOTHESIS

$$C_D(\mathbb{R}, \mathbb{F}) \cong \underbrace{C_F(\mathbb{R})}_{\text{↳ equivalent flat plate drag}} + \underbrace{C_R(\mathbb{F})}_{\text{Residual drag}}$$

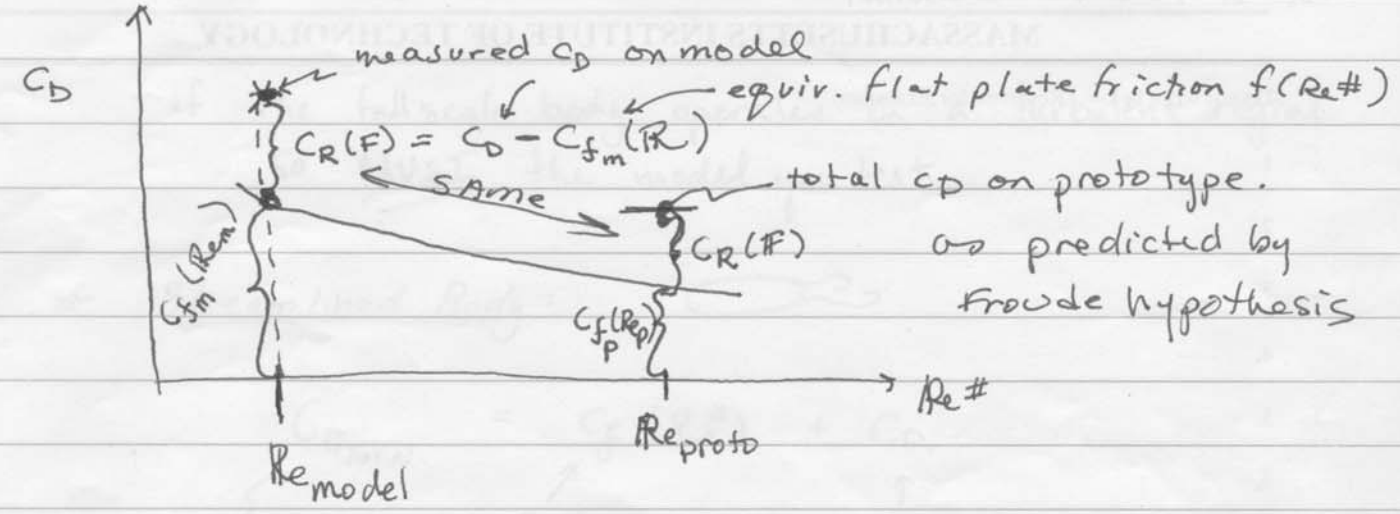
$C_R(\mathbb{F})$ is ASSUMED not to be a function of Reynolds #. Accounts for form drag & separation drag.

Predict $C_R \rightarrow$

Run Experiment with matching FROUDE #'s

$$F_m = F_{proto}$$

Then correct for Reynolds # effects.



Use $C_f = \dfrac{0.075}{(\log_{10} Re - 2)^2}$ ITTC ship curve for friction!