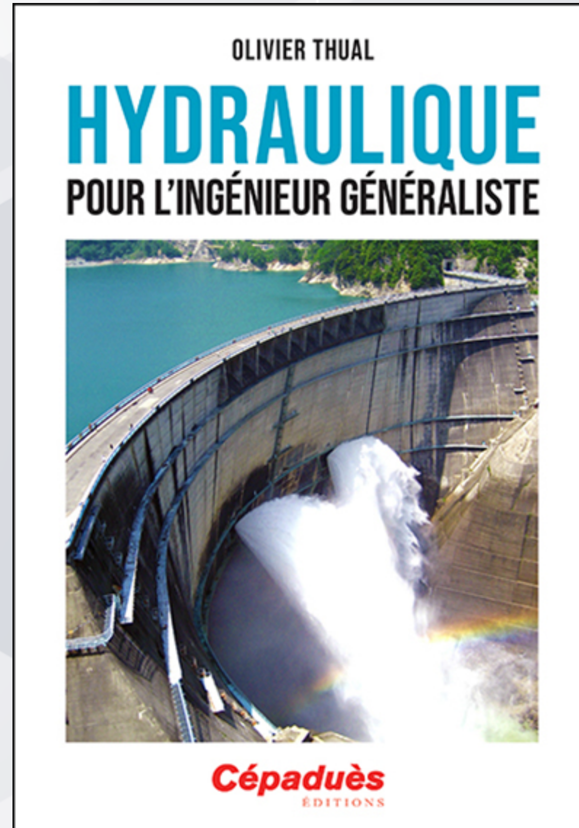
Dans le cadre de la
Formation « Hydraulique Fondamentale »
Unité de Formation pour la Performance Industrielle

en collaboration avec l'INP-ENSEEIHT



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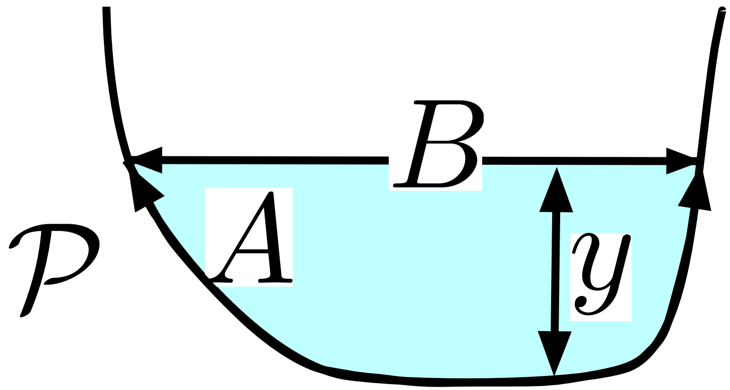
Chapitre 5
Hydraulique à surface libre

Canaux et rivières

Charge hydraulique

$$H = \frac{P_a}{\rho\, g} + Z_f + y + \frac{V^2}{2\, g}$$

- Aire de la section
- Largeur miroir
- Périmètre mouillé
- Profondeur



Rayon et Diamètre hydrauliques

$$R_H = A/\mathcal{P}$$

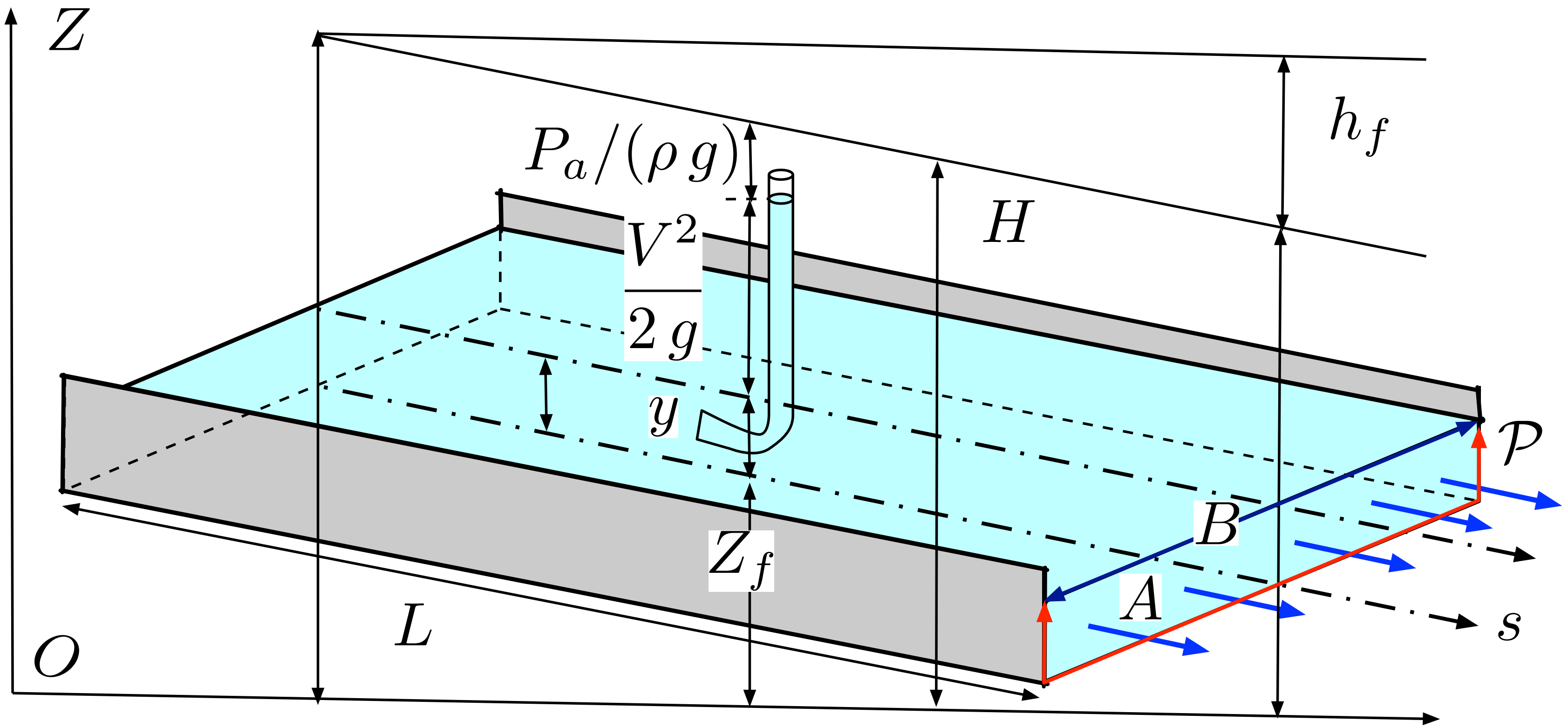
$$D_H = 4\, R_H$$

Pente de frottement

Darcy-Weisbach : $S_f = f(r, Re)\,\dfrac{V^2}{2\,g\,D_H}$

Pente de frottement

$$S_f = -\frac{dH}{ds} = \frac{h_f}{L}$$

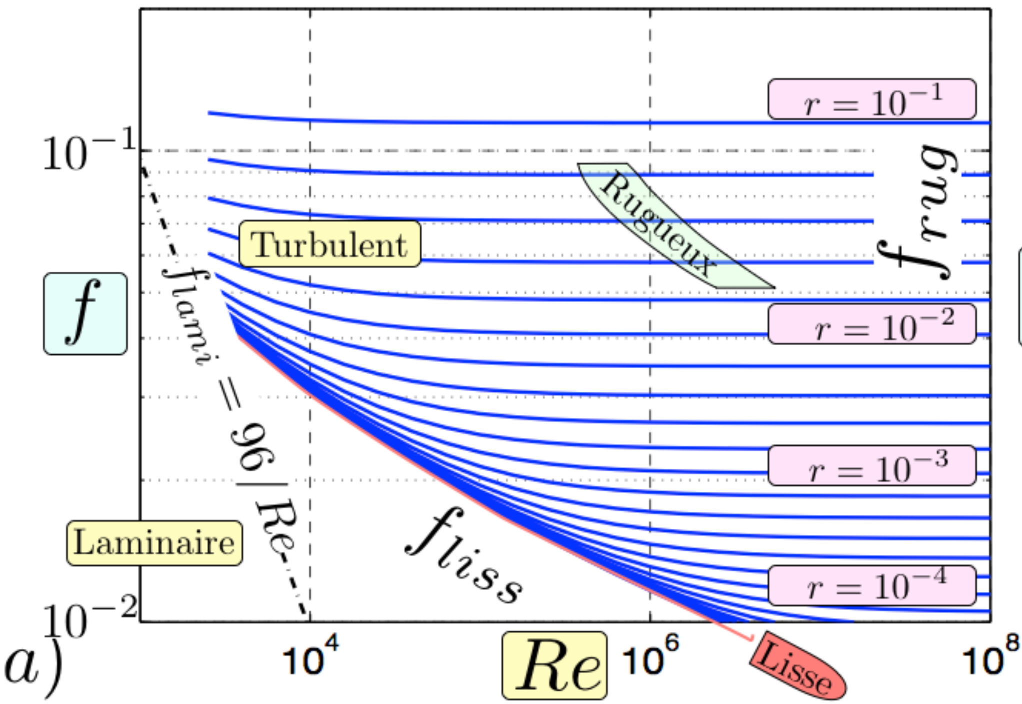


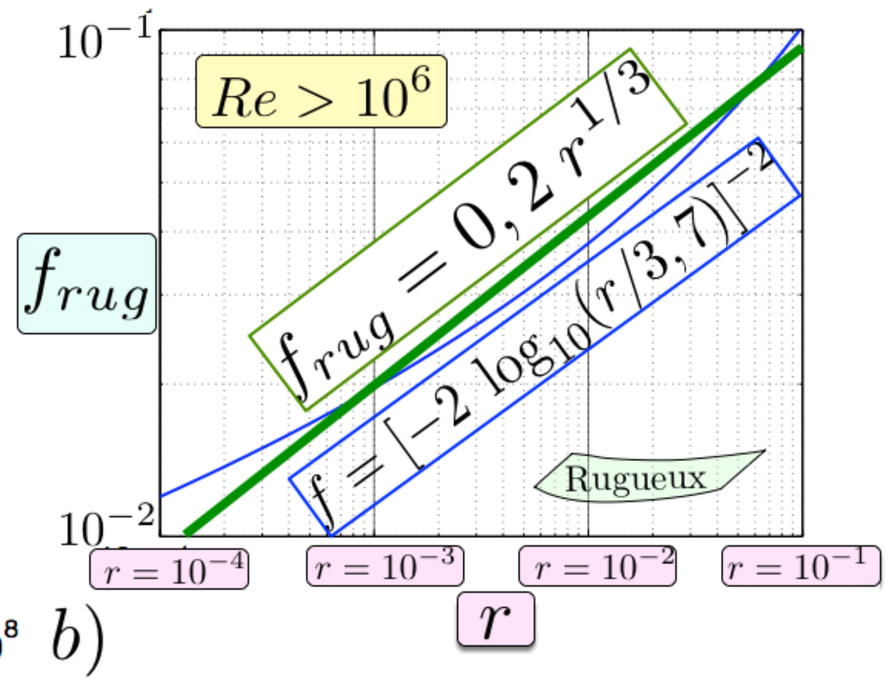
Régime rugueux

$$-\frac{dH}{ds} = S_f = f_{rug}(r)\,\frac{V^2}{2\,g\,D_H}$$

$$r = \frac{\epsilon}{D_H}$$

$$f_{rug}(r) \sim 0,2\,r^{1/3}$$





Formule de Manning-Strickler

$$S_f = f_{rug}(r)\,\frac{V^2}{2\,g\,D_H}$$

$$f_{rug}(r) \sim 0,2\,r^{1/3}$$

$$r = \frac{\epsilon}{D_H}$$

$$\Downarrow$$

$$V = K_s\,\sqrt{S_f}\,R_H^{2/3} \iff S_f = \frac{V^2}{K_s^2\,R_H^{4/3}}$$

Fond	**Strickler** K_s	**Manning** n	**Variations**
Ciment lissé	90	0,011	20%
Béton	40	0,025	30%
Terre	30	0,033	20%
Herbes ou graviers	25	0,040	25%
Pierres ou broussailles	20	0,050	20%
Mauvaises herbes ou crue	10	0,100	40%

Nombre de Froude

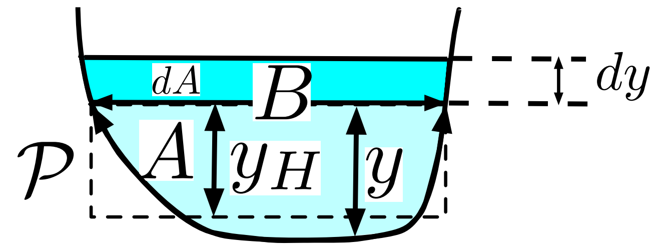
$$dH = -S_f\, ds \quad \text{avec} \quad H = \frac{P_a}{\rho\, g} + Z_f + y + \frac{V^2}{2\, g}$$

$$dA = B\, dy$$

$$d(V^2) = d\left(\frac{Q^2}{A^2}\right) = -2\,\frac{Q^2}{A^3}\, dA = -2\, V^2\, \frac{B}{A}\, dy$$

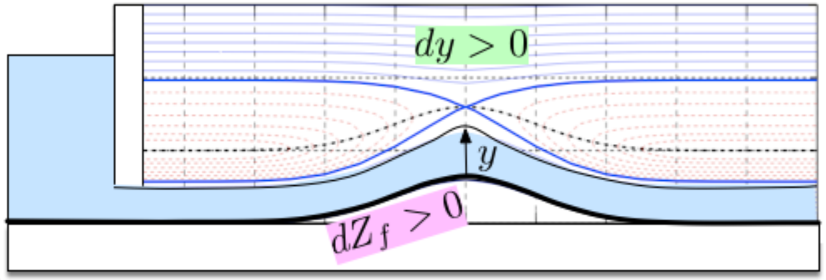
$$y_H = A/B$$

$$d\left(\frac{V^2}{2\, g}\right) = -Fr^2\, dy \quad \text{avec} \quad Fr = \frac{V}{\sqrt{g\, y_H}}$$

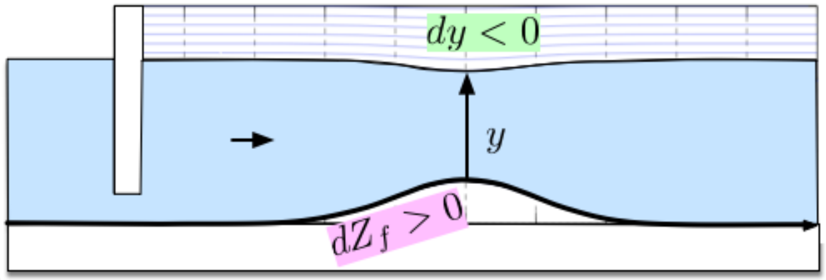


$$(1 - Fr^2)\, dy = -dZ_f + dH$$

Torrentiel : $Fr > 1$



Fluvial : $Fr < 1$

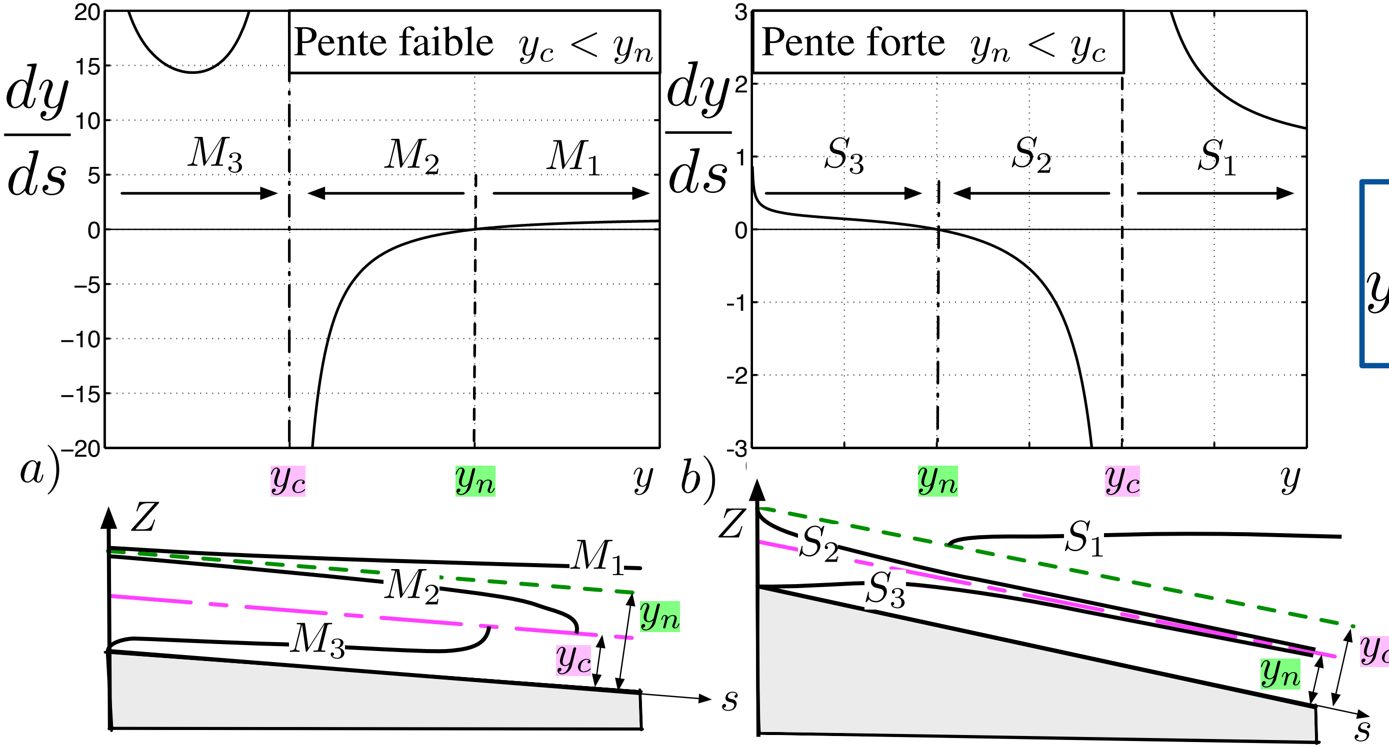


Courbes de remous

$$\frac{dy}{ds} = \frac{S_0 - S_f}{1 - Fr^2} = S_0 \, \frac{1 - (y/y_n)^{-10/3}}{1 - (y/y_c)^{-3}}$$

Large canal : $R_H = y$

Débit linéique : $q = \dfrac{Q}{B}$



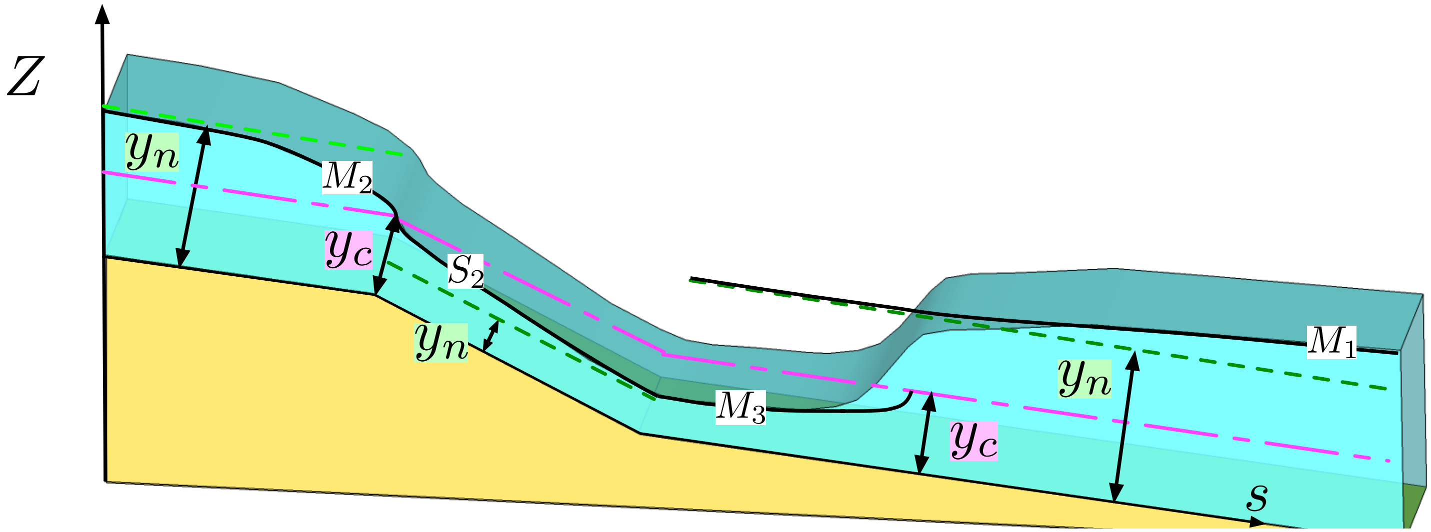
Hauteur normale

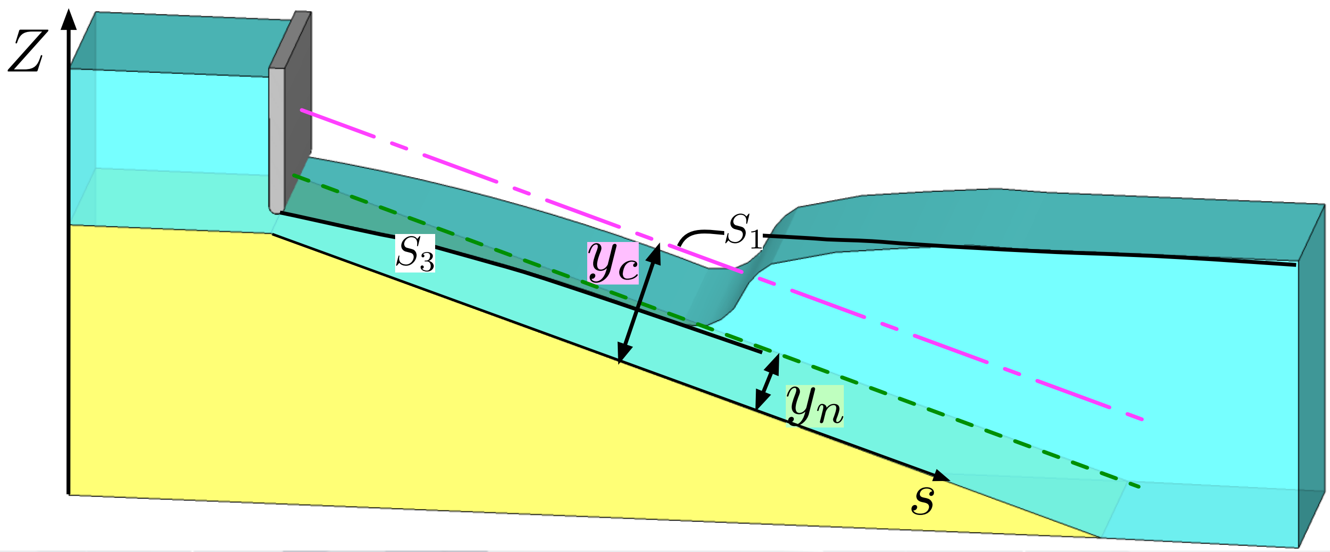
$$y_n = \left(\frac{q^2}{K_s^2 \, S_0} \right)^{3/10}$$

Hauteur critique

$$y_c = \left(\frac{q^2}{g} \right)^{1/3}$$

Ressaut hydraulique





Changement de pente