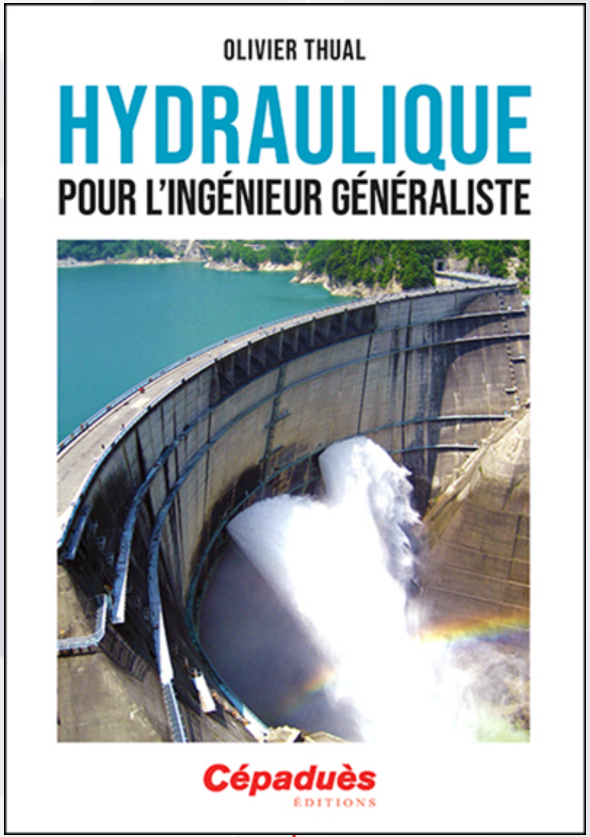
Dans le cadre de la
Formation « Hydraulique Fondamentale »
Unité de Formation pour la Performance Industrielle

en collaboration avec l'INP-ENSEEIHT

Olivier THUAL
Toulouse INP
ENSEEIHT

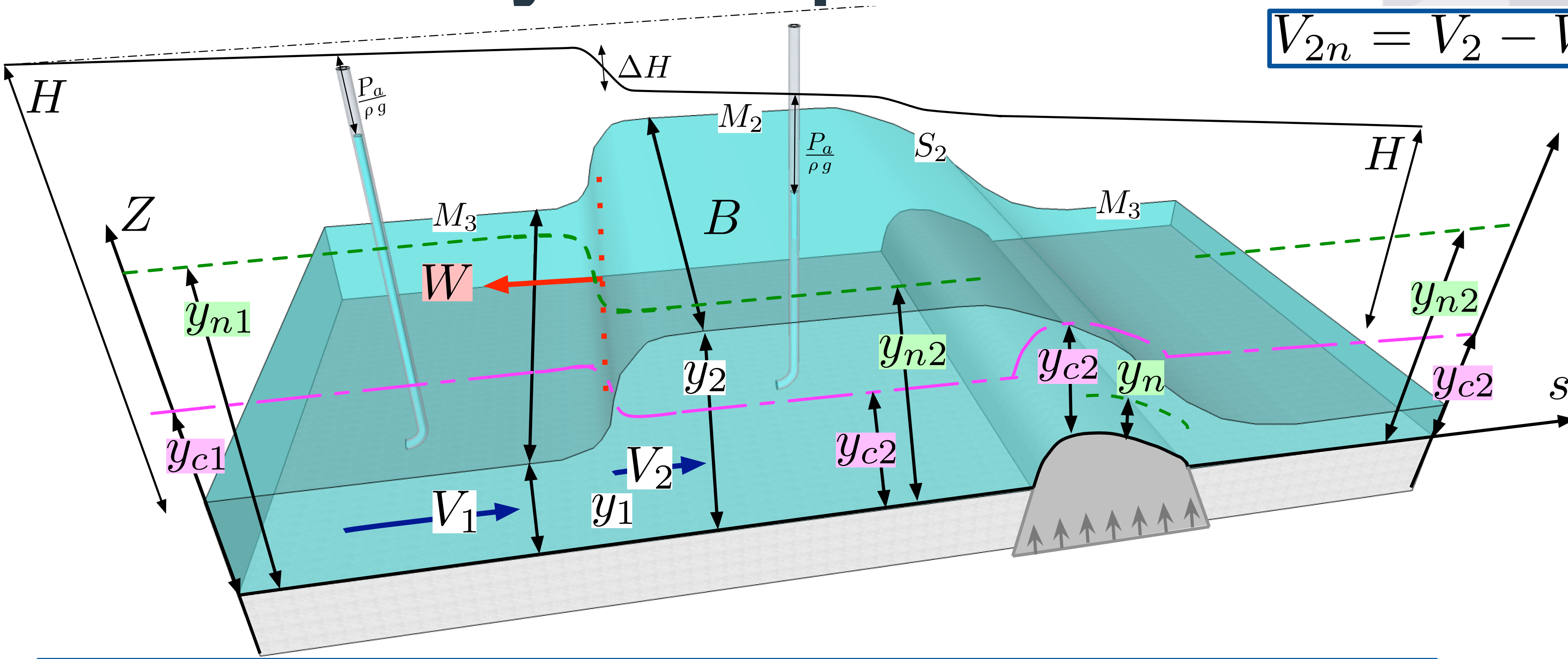


Chapitre 6
Régimes instationnaires

Ressaut hydraulique mobile

$$V_{1n} = V_1 - W$$

$$V_{2n} = V_2 - W$$



$$y_1\, V_{1n} = y_2\, V_{2n} \qquad \text{et} \qquad y_1\, V_{1n}^2 + \frac{1}{2}\, g\, y_1^2 = y_2\, V_{2n}^2 + \frac{1}{2}\, g\, y_2^2 \quad \Longrightarrow$$

$$V_{1n} = \frac{q_n}{y_1}\;, \qquad V_{2n} = \frac{q_n}{y_2} \quad \text{et} \quad q_n = \epsilon \sqrt{g\, y_1\, y_2\, \frac{y_1 + y_2}{2}} \quad \text{avec } \epsilon = \pm 1$$

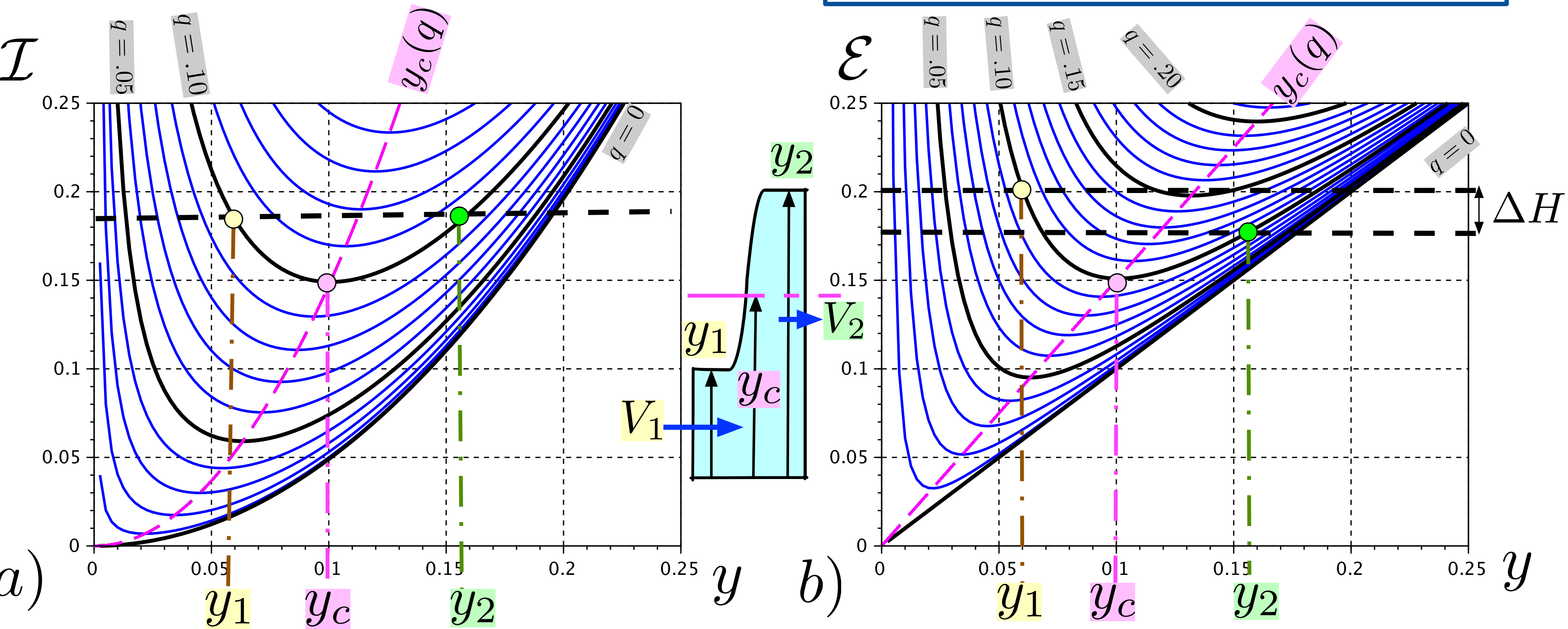
Ressaut immobile

Impulsion

$$\mathcal{I}(q,y) = \frac{q^2}{y} + \frac{1}{2}\, g\, y^2$$

Charge spécifique

$$\mathcal{E}(q,y) = y + \frac{V^2}{2\,g} = y + \frac{q^2}{2\,g\,y^2}$$

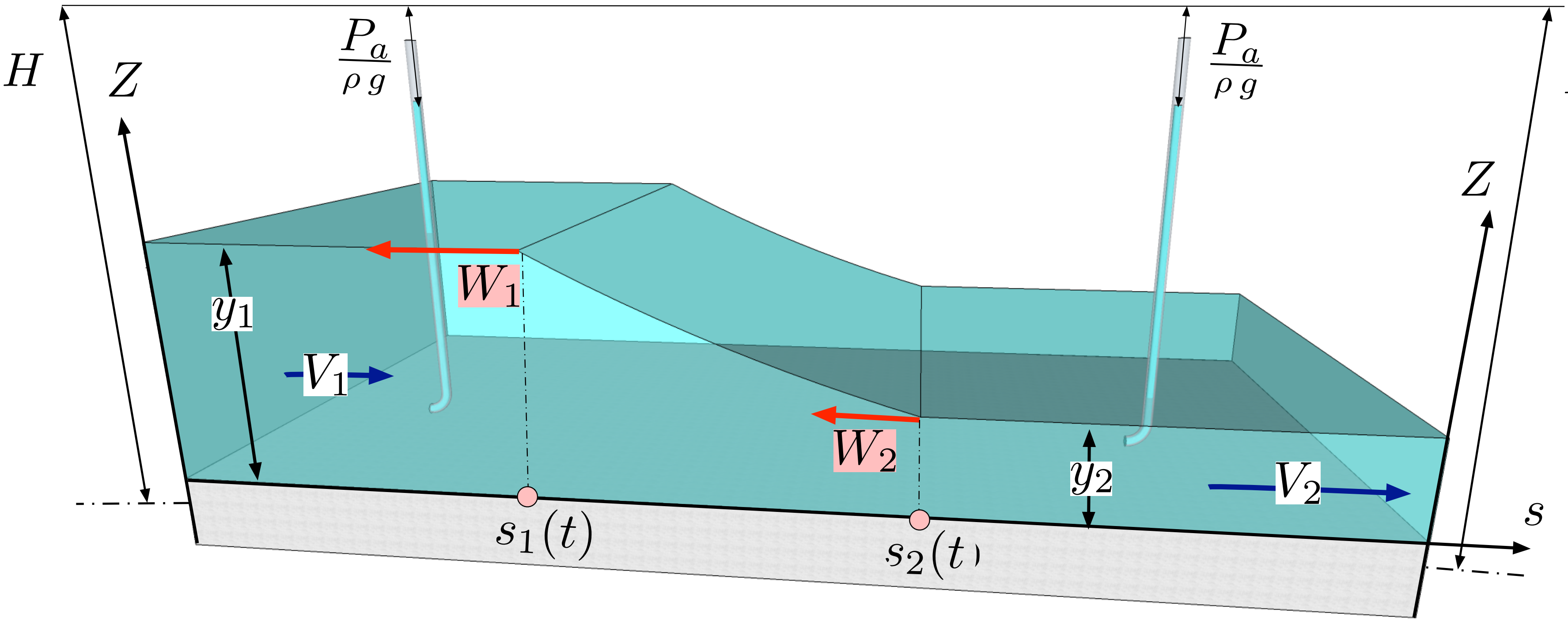


Petite onde de détente

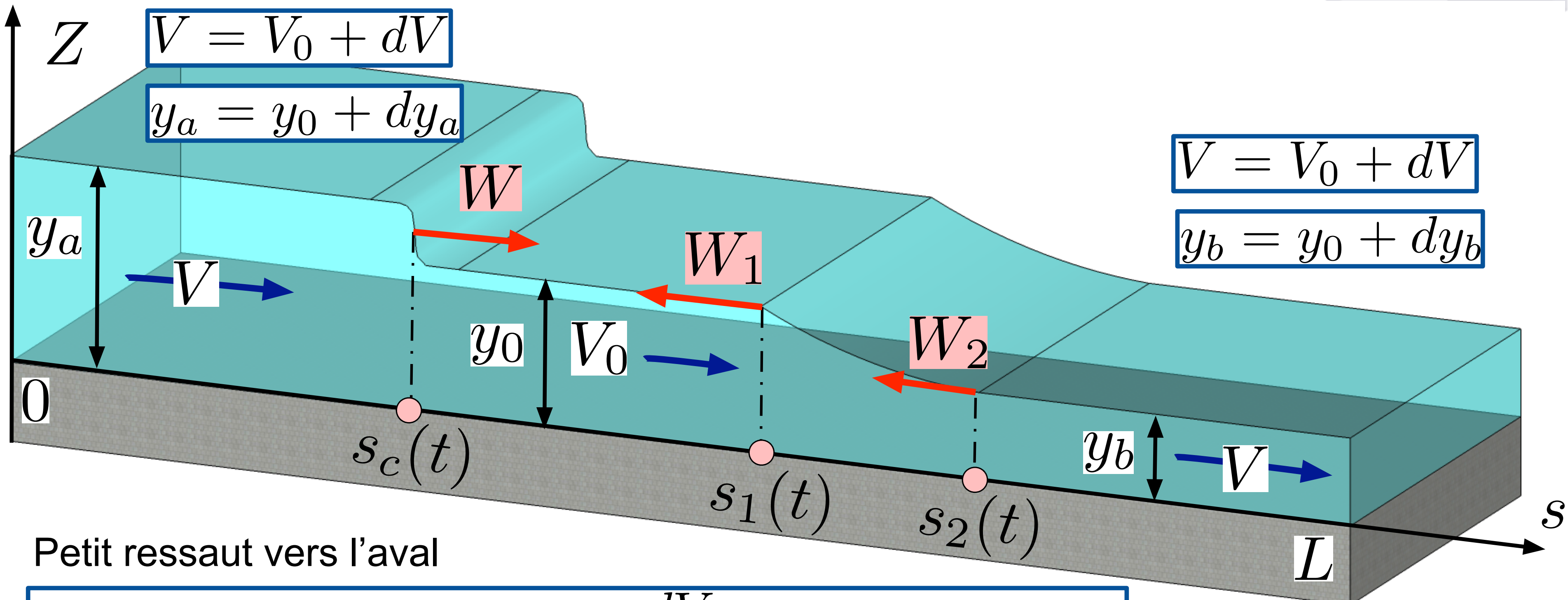
$$W_1 = V_1 - \epsilon \sqrt{g\, y_1}\ , \qquad W_2 = V_2 - \epsilon \sqrt{g\, y_2}$$

et $\quad V_1 + 2\,\epsilon \sqrt{g\, y_1} = V_2 + 2\,\epsilon \sqrt{g\, y_2} \qquad$ avec $\epsilon = \pm 1$

$y_1 \sim y_2 \sim y$ et $V_1 \sim V_2 \sim V \Longrightarrow W_1 \sim W_2 \sim V - \epsilon \sqrt{g\, h}$



Accroissements de vitesse



Petit ressaut vers l'aval

$$W \sim V_0 + c \quad \text{et} \quad dy_a \sim y_0 \frac{dV}{c} \quad \text{avec} \quad c = \sqrt{g\, y_0}$$

Petite onde de détente vers l'amont

$$W_1 \sim W_2 \sim V_0 - c \quad \text{et} \quad dy_b \sim -y_0 \frac{dV}{c} \quad \text{avec} \quad c = \sqrt{g\, y_0}$$

Point de basculement

$c = \sqrt{g\, y_0}$

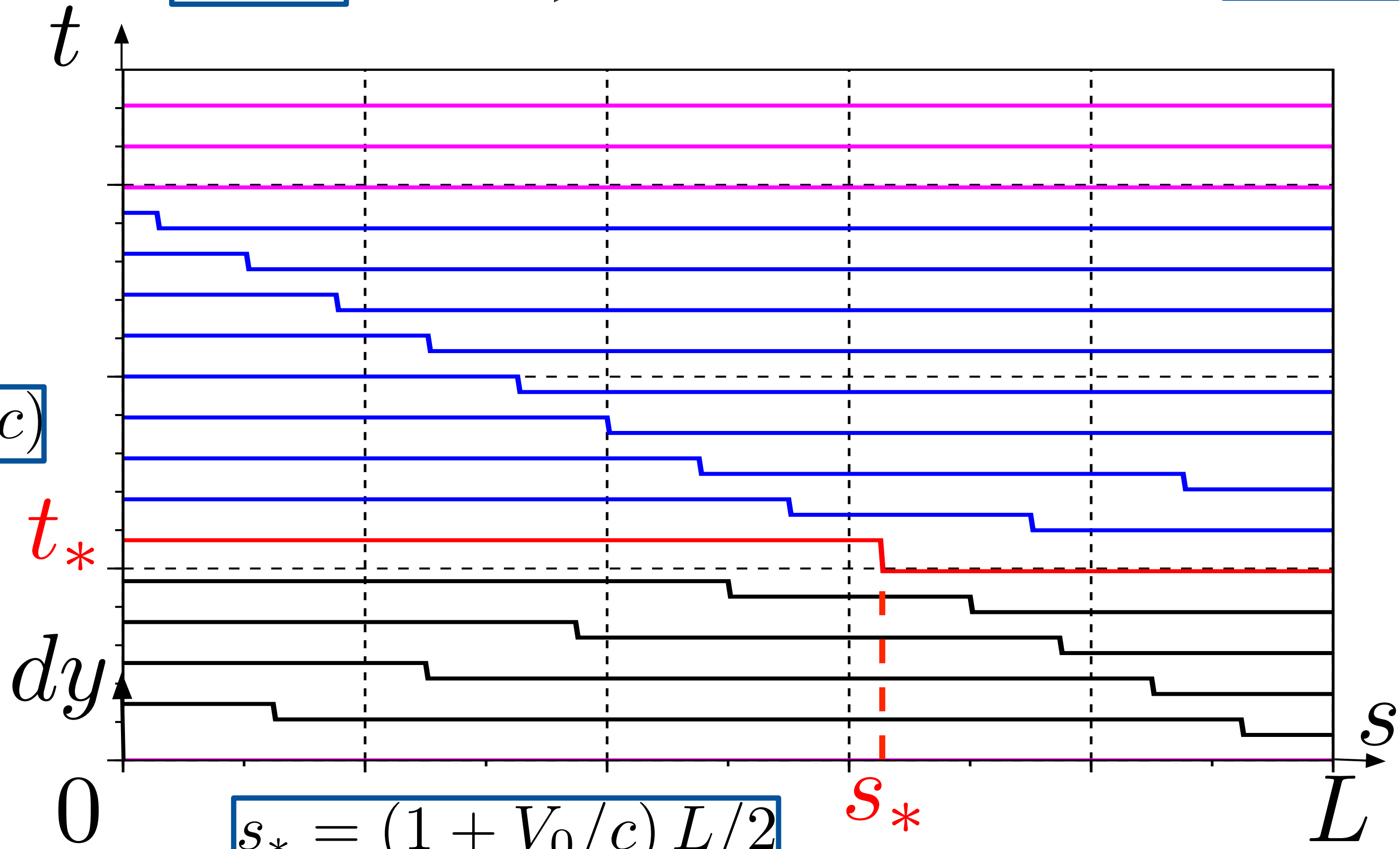
$(y_0 + dy, V_0 + dV)$

$dy = y_0\, dV/c$

$(y_0 - dy, V_0 + dV)$

$V_0 + c$

$V_0 - c$

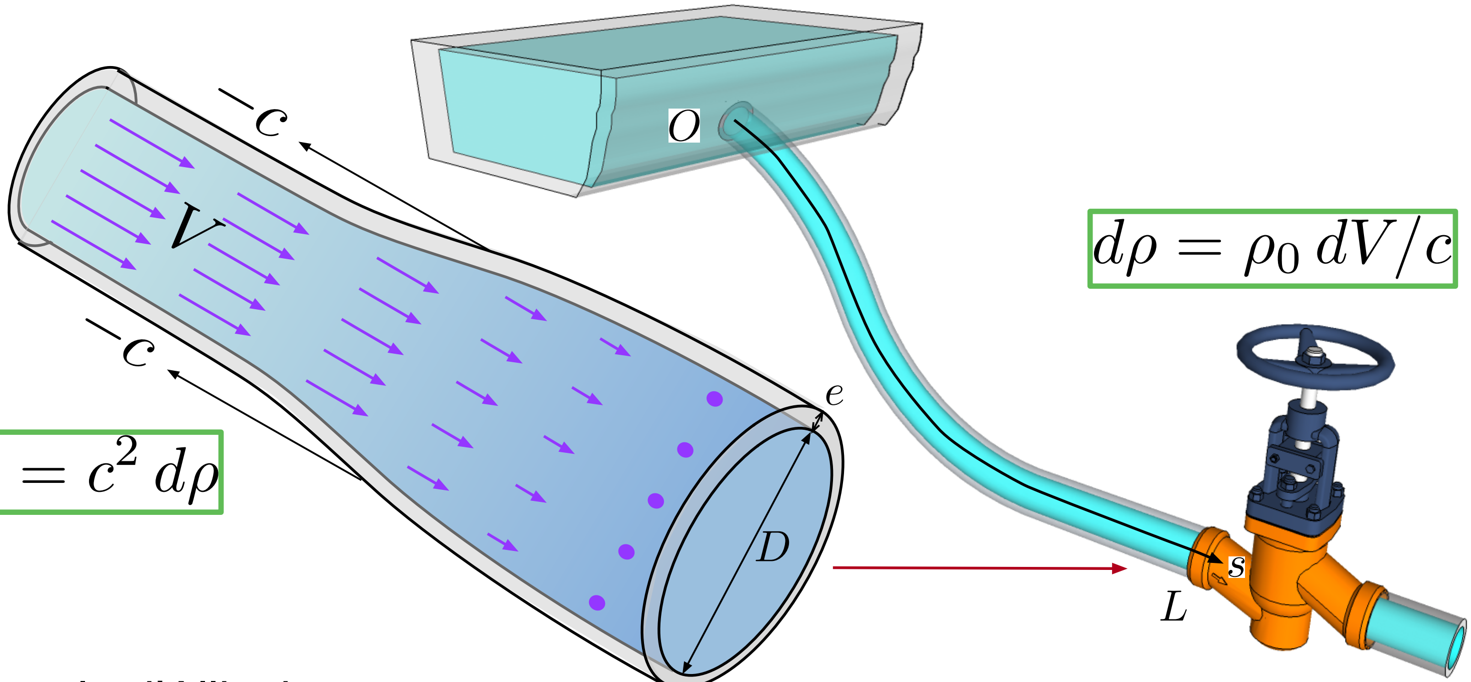


$t_* = L/(2\,c)$

$s_* = (1 + V_0/c)\, L/2$

Coup de bélier

$$c = \left(\frac{E_c}{\rho_0}\right)^{1/2} \qquad \text{avec} \qquad \frac{1}{E_c} = \frac{1}{E_f} + \frac{k\,D}{e\,E_m}$$



$$d\rho = \rho_0\, dV/c$$

$$dP = c^2\, d\rho$$

Formule d'Allievi

$$c = 9990\,(48,3 + r\,D/e)^{-1/2} \text{ m/s où } r \in \{0,5; 1,0; 4,4; 5\}$$

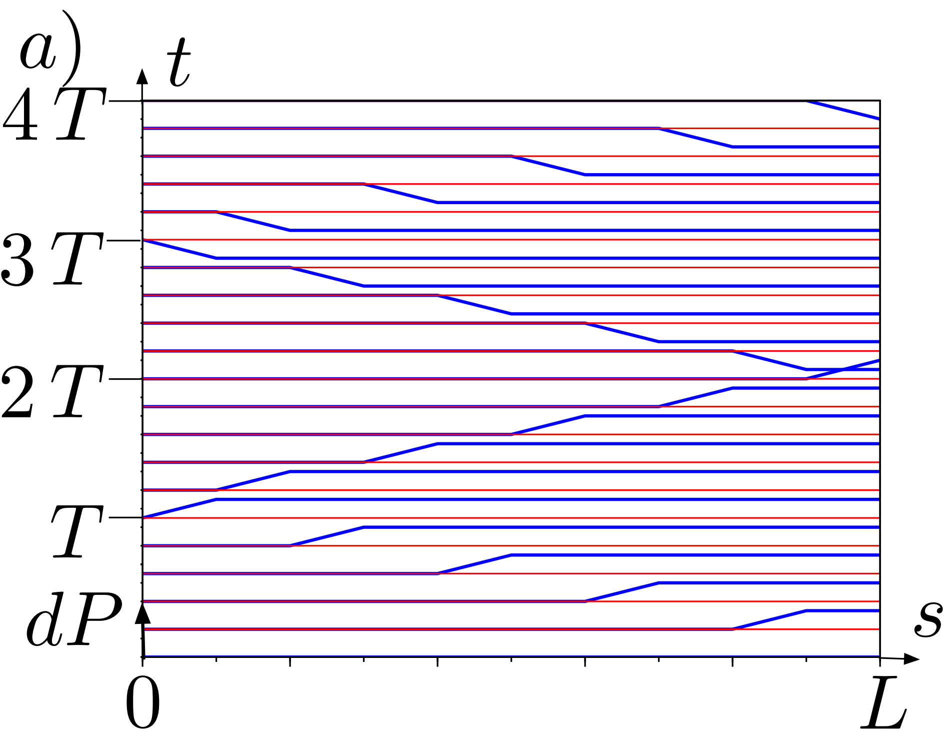
Variation brusque

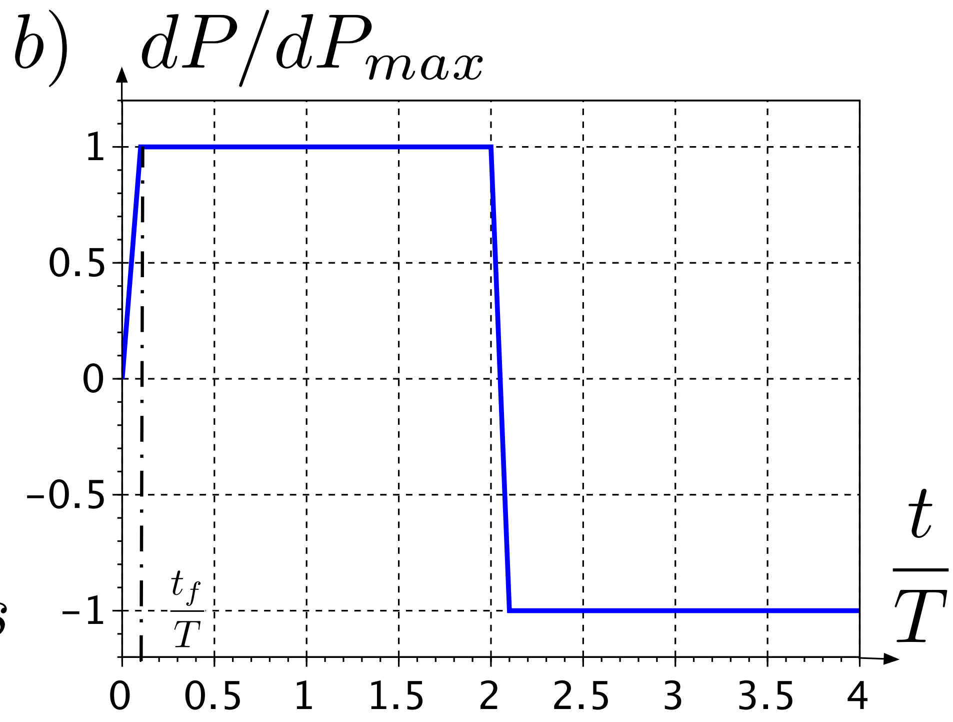
$$t_f < 2\,T = 2\,L/c$$

Coup de bélier non amorti (d'onde)

Formule de Joukovski

$$dH_{max} = dP_{max}/(\rho_0\, g) = c\, dV_{max}/g$$





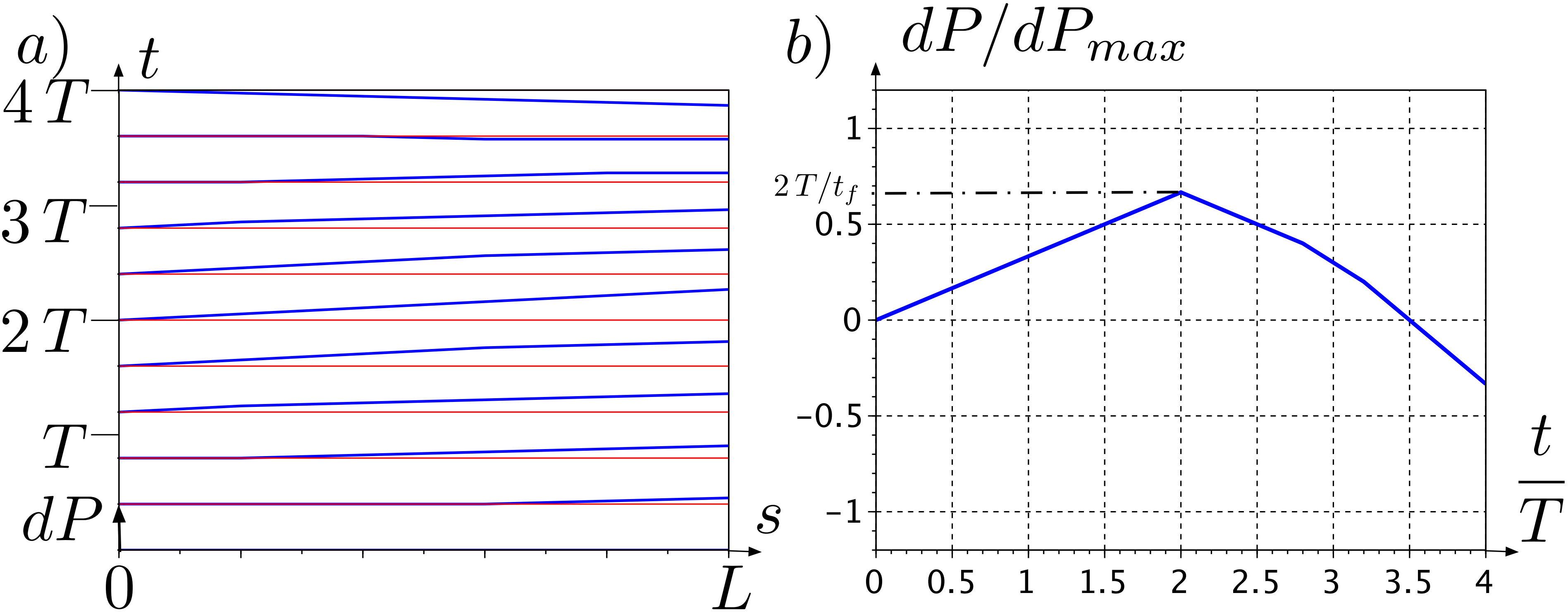
Variation progressive

$$t_f > 2\,T = 2\,L/c$$

Coup de bélier amorti (de masse)

Formule de Michaud

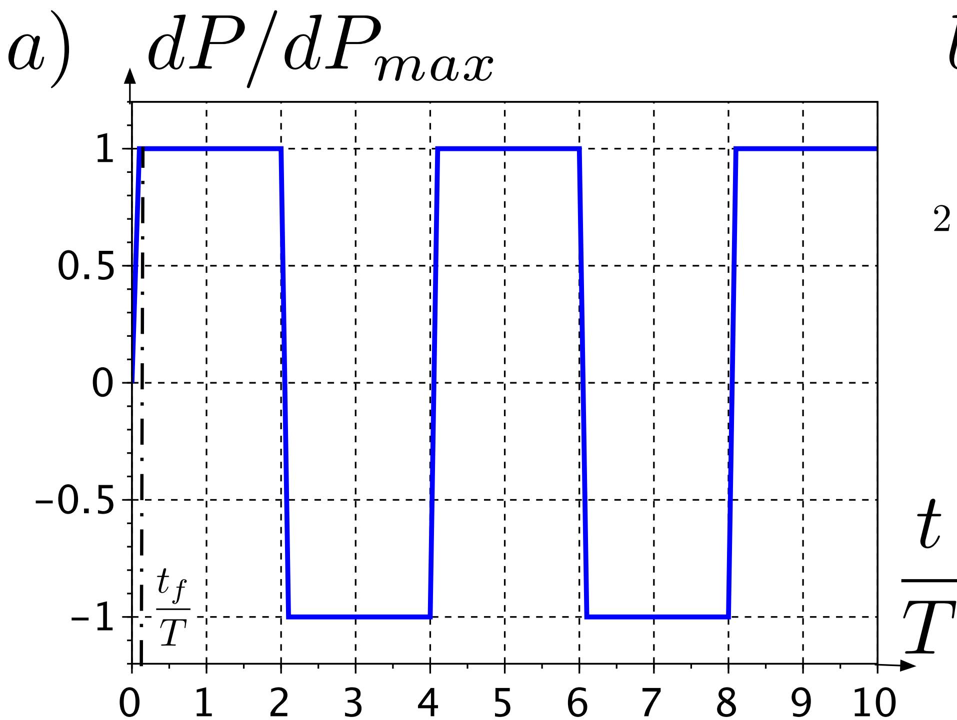
$$dH_* = dP_*/(\rho_0\, g) = (2\,L/t_f)\; dV_{max}/g$$



Oscillation de pression

Danger : possibilité de résonance

Variation brusque



Variation progressive