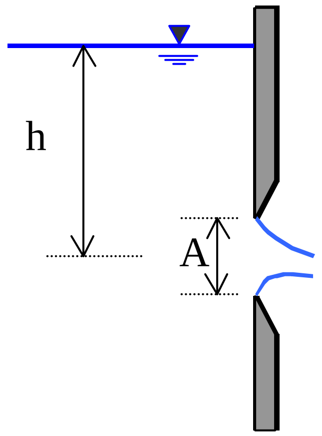
FORONOMIA

LUCI A BATTENTE

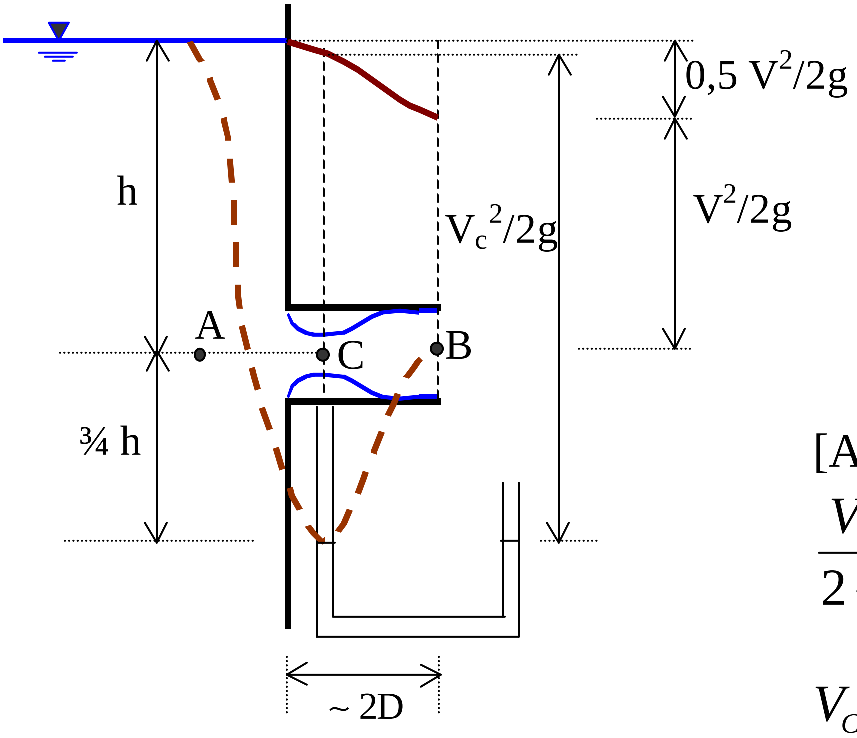
1) A spigolo vivo



$$Q = m \cdot A \cdot \sqrt{2 \cdot g \cdot h}$$

$$m = 0.6$$

2) L. di Venturi (tubo addiz. esterno)



- bocca piena
- $J \cdot L = 0$
- $\frac{p_B}{g} = -\frac{3}{4} \cdot h$

[A-C]

$$\frac{V_C^2}{2 \cdot g} \cong h + \frac{3}{4} \cdot h = \frac{7}{4} \cdot h$$

$$V_C = \sqrt{2 \cdot g \cdot \frac{7}{4} \cdot h}$$

$$Q = C_V \cdot A_C \cdot \sqrt{2 \cdot g \cdot \frac{7}{4} \cdot h} = 0.98 \cdot 0.61 \cdot A \cdot \sqrt{2 \cdot g \cdot \frac{7}{4} \cdot h}$$

$$Q = m \cdot A \cdot \sqrt{2 \cdot g \cdot h} \qquad m = 0.8$$

[A–B] $$h = 1.5 \cdot \frac{V^2}{2 \cdot g} = \frac{3}{2} \cdot \frac{V^2}{2 \cdot g}$$

$$Q = A \cdot \sqrt{2 \cdot g \cdot \frac{2}{3} \cdot h} \cong 0.8 \cdot A \cdot \sqrt{2 \cdot g \cdot h}$$

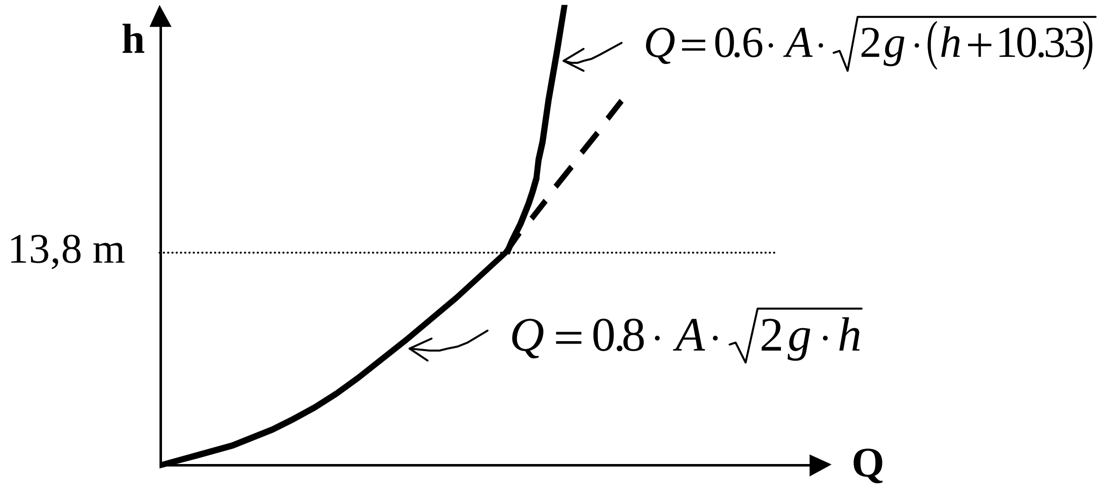
CONDIZIONE: $$\frac{3}{4} h \le \frac{p_a^*}{g}$$

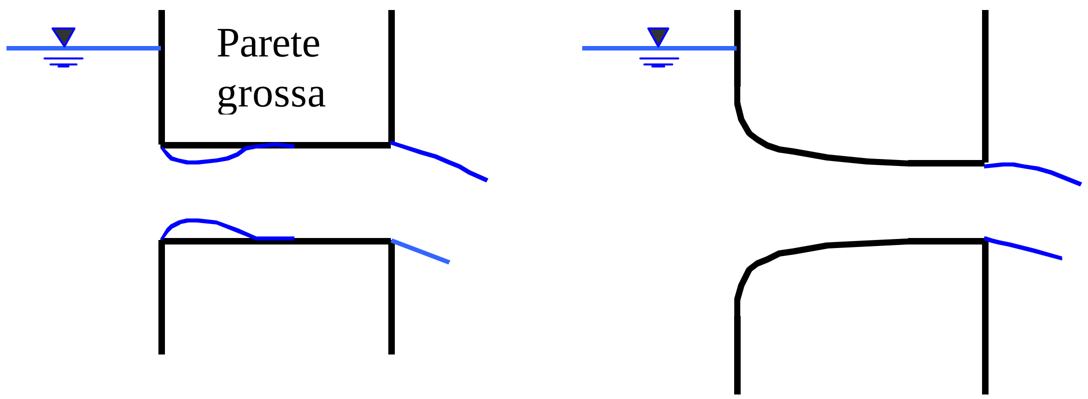
$$h \le \frac{4}{3} \cdot 10.33 \cong 13.8m$$

SE $h \ge 13.8m$

$$V_C = \sqrt{2 \cdot g \cdot (h + 10.33)}$$

$$Q = 0.6 \cdot A \cdot \sqrt{2g \cdot (h + 10.33)}$$

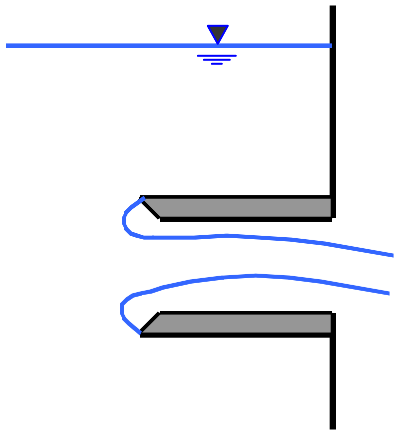




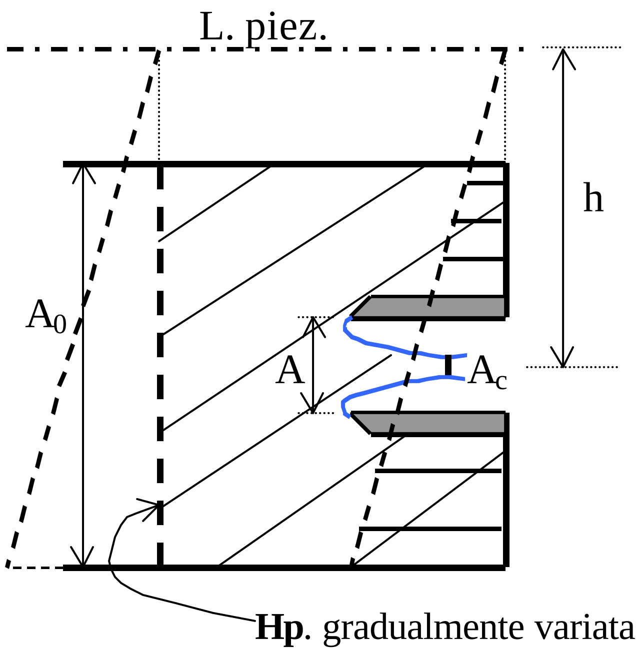
$$Q = 0.8 \cdot A \cdot \sqrt{2g \cdot h}$$

$$Q = C_V \cdot A \cdot \sqrt{2g \cdot h}$$

3) Bocca di Borda (tubo addizionale interno)



$$\boxed{C_C \geq 0.5}$$



$$A_0 >> A$$

$$\frac{V_0^2}{2 \cdot g} \cong 0 \qquad (<< h)$$

$$\frac{V_C^2}{2 \cdot g} = h$$

$$V_C = \sqrt{2 \cdot g \cdot h}$$

EQ. GLOBALE IN ORIZZONTALE

$$\begin{cases} g \cdot h \cdot A_0 + r \cdot A_0 \cdot V_0^2 = g \cdot h \cdot (A_0 - A) + r \cdot A_C \cdot V_c^2 \\ A_0 \cdot V_0 = A_C \cdot V_C \end{cases}$$

$$\frac{r \cdot A_C \cdot V_C^2}{r \cdot A \cdot V_C^2} = \frac{g \cdot h \cdot A}{r \cdot A \cdot V_C^2} + \frac{r \cdot A_C \cdot V_C \cdot V_0}{r \cdot A \cdot V_C^2}$$

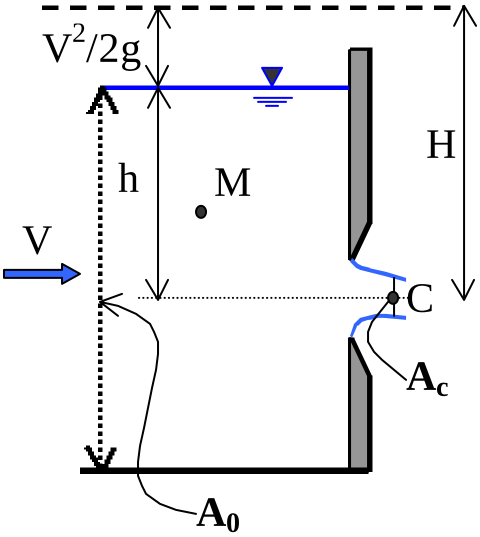
$$C_C = \frac{A_C}{A} = \frac{g \cdot h}{r \cdot V_C^2} + \frac{V_0 \cdot A_C}{V_C \cdot A} = \frac{g \cdot h}{r \cdot 2 \cdot g \cdot h} + \frac{V_0 \cdot A_C}{V_C \cdot A} =$$

$$= \frac{1}{2} + \frac{V_0 \cdot A_C}{V_C \cdot A} \geq \frac{1}{2}$$

$$Q = 0.5 \cdot A \cdot \sqrt{2 \cdot g \cdot h}$$

$$\boxed{m = 0.5}$$

4) Velocità in arrivo ¹ 0



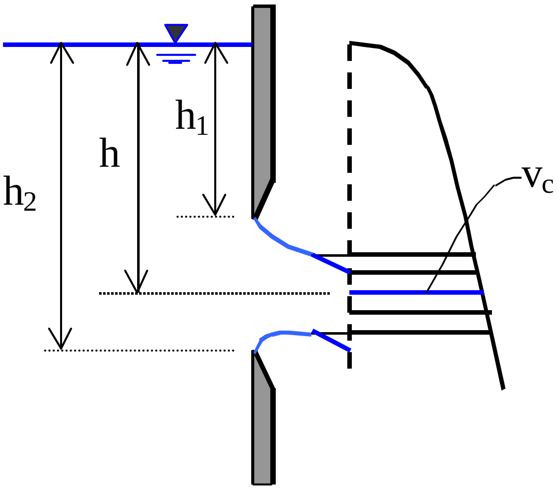
[M-C]

$$z_M + \frac{p_M}{g} + \frac{V^2}{2 \cdot g} = z_C + \frac{V_C^2}{2 \cdot g}$$

$$h = z_M + \frac{p_M}{g} - z_C = \frac{Q^2}{2 \cdot g} \cdot \left(\frac{1}{A_C^2} - \frac{1}{A_0^2} \right)$$

$$Q = \underbrace{\frac{A_C \cdot A_0}{\sqrt{A_0^2 - A_C^2}} \cdot \sqrt{2 \cdot g \cdot h} \cdot C_V}_{\text{come per venturimetro}}$$

5) Luci grandi



$$v \neq V_{media}$$

$$v_C = \sqrt{2 \cdot g \cdot h}$$

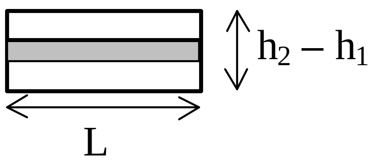
$$Q = \int_{A_C} \sqrt{2 \cdot g \cdot h} \cdot dA$$

ma A_C *è poco nota*

Hp. discutibile μ=cost

$$Q = m \cdot \int_A \sqrt{2 \cdot g \cdot h} \cdot dA$$

<u>Caso di luce rettangolare</u>

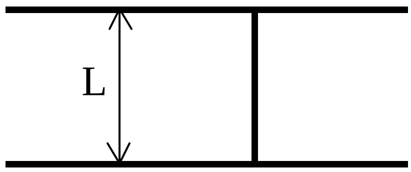


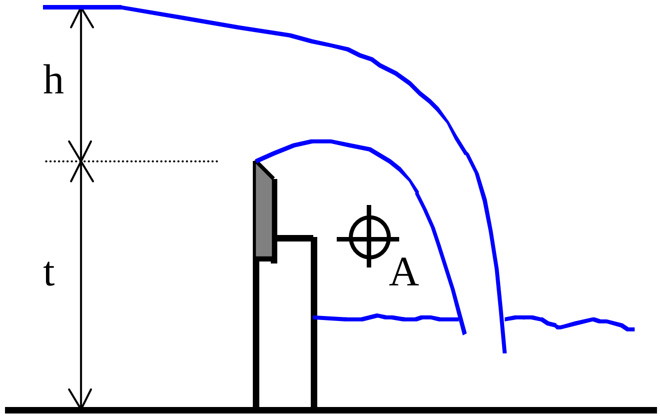
$$Q = m \cdot L \cdot \int_{h_1}^{h_2} \sqrt{2 \cdot g \cdot h} \cdot dh = \frac{2}{3} \cdot m \cdot L \cdot \sqrt{2g} \cdot \left(h_2^{3/2} - h_1^{3/2} \right)$$

ricavata in modo discutibile però l'esperienza dice OK

Luci a stramazzo (battente nullo)

1) Bazin





vena depressa
vena aderente } **Q >**

h = carico
t = petto

Q = Q(h) equazione dello stramazzo

Non applicab. Bernoulli → *non ∃ sez. contratta*
→ *forti curvature*

Arbitrario ⇒ Stramazzo ≡ Luce grande con battente nullo

$$Q = \frac{2}{3} \cdot m \cdot L \cdot \sqrt{2 \cdot g} \cdot \left(h_2^{3/2} - h_1^{3/2}\right)$$

$$h_1 = 0 \qquad\qquad h_2 = h$$

$$Q = \frac{2}{3} \cdot m \cdot L \cdot \sqrt{2 \cdot g} \cdot h^{3/2}$$

$Q = m_S \cdot L \cdot h \cdot \sqrt{2 \cdot g \cdot h}$ di POLENI   (vero f($h^{3/2}$) , μ=0.4)

$m_S = f\left(V_0 = \dfrac{Q}{L(h+t)}\right) \rightarrow$ quindi c'è $h_V = \dfrac{V_0^2}{2 \cdot g}$

e quindi $Q = \dfrac{2}{3} \cdot m \cdot L \cdot \sqrt{2 \cdot g} \cdot \left[(h + h_V)^{3/2} - h_V^{3/2}\right]$

h_V = f(Q)   disagevole   (Bazin fece uno sviluppo in serie)

formula di REHBOCK

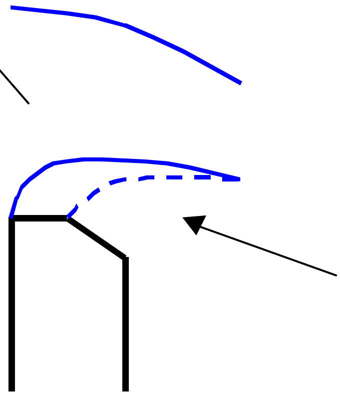
$$Q = m_S \cdot L \cdot h_e \cdot \sqrt{2 \cdot g \cdot h_e}$$

$$h_e = h + 0.0011(m)$$

$$m_S = 0.402 + 0.054 \cdot \frac{h_e}{t}$$

* 0.0011 m = f(tens.superfic.)

carichi piccoli → forte curvatura e quindi riduzione di pressione all'interno della vena

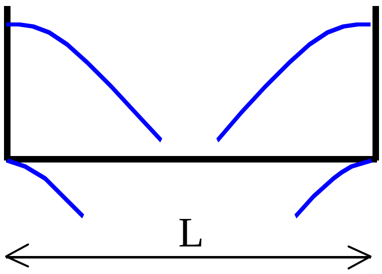


si stacca da valle (con > sezione)

* μ_s : ↑ per h_e ↑ per V_0 d'arrivo

($\frac{h_e}{t}$ = adimensionale : rispetta la similitudine)

2) Hègly



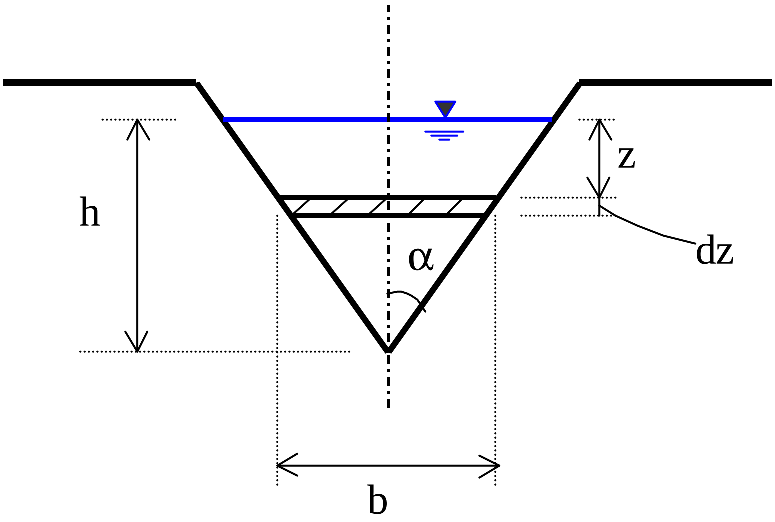
vasca di calma

contrazione sui fianchi

$$Q = m_s \cdot L' \cdot h \cdot \sqrt{2 \cdot g \cdot h}$$

$$L' = L - 0.2 \cdot h$$

3) Stramazzo triangolare



$$Q = m \cdot \sqrt{2 \cdot g} \cdot \int_0^h b \cdot \sqrt{z} \cdot dz = m \cdot \sqrt{2 \cdot g} \cdot \int_0^h 2 \cdot (h - z) \cdot tg\alpha \cdot \sqrt{z} \cdot dz$$

$$Q = 2 \cdot m \cdot tg\alpha \cdot \sqrt{2 \cdot g} \cdot \int_0^h (h - z) \cdot z^{1/2} \cdot dz$$

$$Q = 2 \cdot m \cdot tg\alpha \cdot \sqrt{2 \cdot g} \cdot \left[\frac{2}{3} \cdot h^{3/2} \cdot h - \frac{2}{5} \cdot h^{5/2} \right] =$$

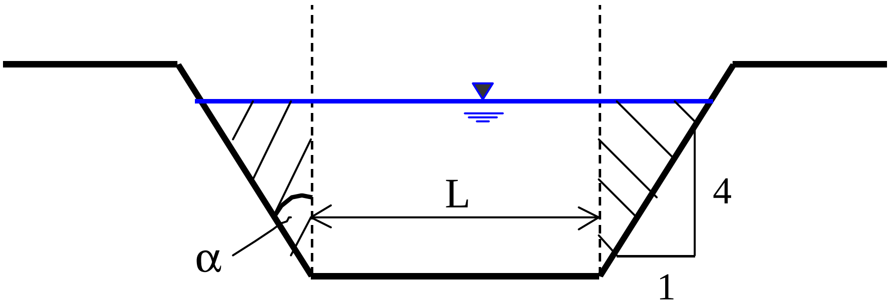
$$= \frac{8}{15} \cdot m \cdot tg\alpha \cdot \sqrt{2 \cdot g} \cdot h^{5/2} \qquad m = 0.6$$

TARATURA PER MISURE PRECISE

<u>Stramazzo THOMSON</u> $\alpha = 45^\circ$

$$Q = \frac{8}{15} \cdot m \cdot h^2 \cdot \sqrt{2 \cdot g \cdot h}$$

4) Stramazzo Cipolletti



secondo Hègly *(riduzione di portata dovuta alla contrazione sui fianchi)*

$$\Delta Q = f\left(\Delta L = 0.2 \cdot h\right)$$

$$\Delta Q = \frac{2}{3} \cdot m \cdot 0.2 \cdot h \cdot h \cdot \sqrt{2 \cdot g \cdot h} = \underbrace{\frac{8}{15} \cdot m \cdot tg\alpha \cdot \sqrt{2 \cdot g \cdot h} \cdot h^2}$$

↳ triangolare

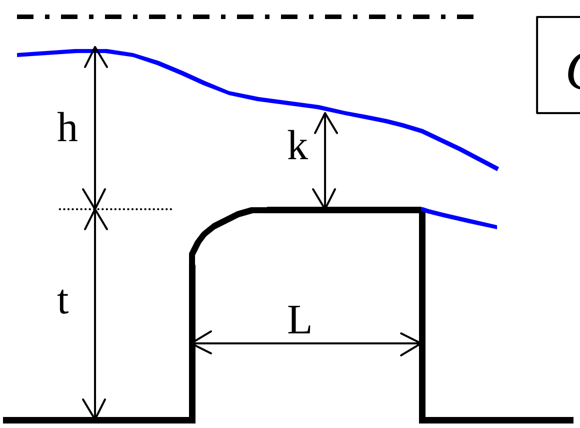
$$\boxed{tg\alpha = \frac{1}{4}}$$

Usare perciò formula tipo Str. Bazin con $m_s = \cos t$ *essendoci una vasca di calma*

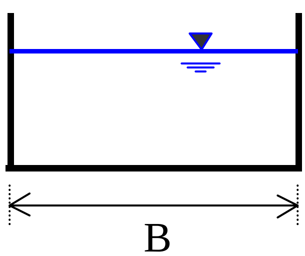
Sperimentalmente :

$$Q = 0.415 \cdot L \cdot h \cdot \sqrt{2 \cdot g \cdot h}$$

5) A larga soglia

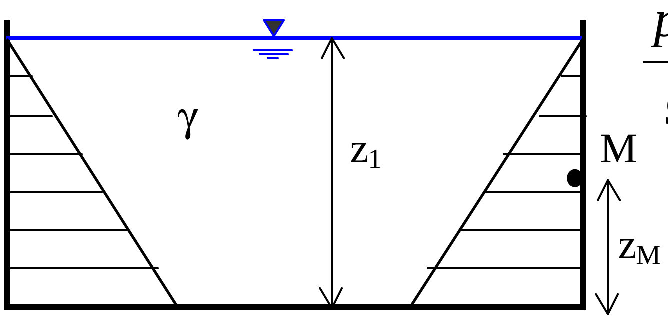


$$\boxed{Q = q \cdot B = 0.385 \cdot h \cdot \sqrt{2 \cdot g \cdot h} \cdot B}$$



REAZIONE D'EFFLUSSO

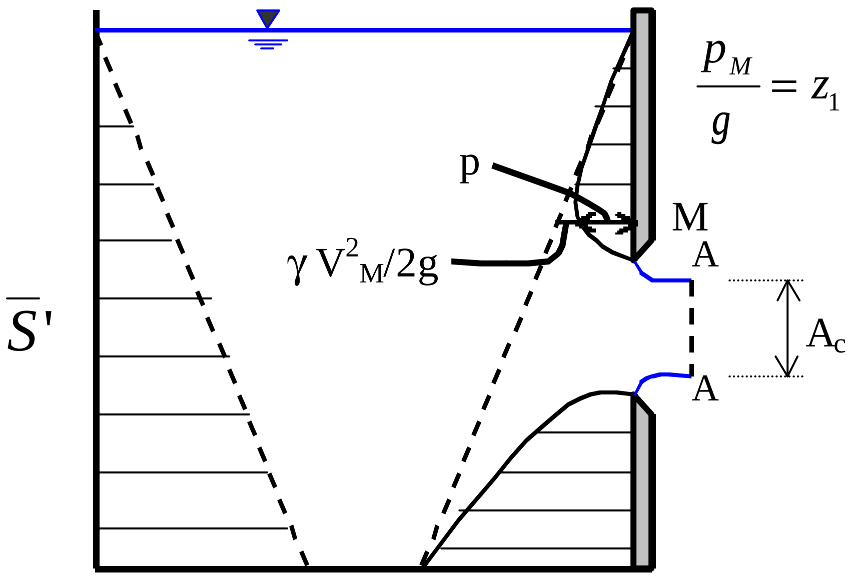
i) STATICA



$$\frac{p_M}{g} = z_1 - z_M$$

$$\overline{S} = -\overline{\Pi} = \overline{G}$$

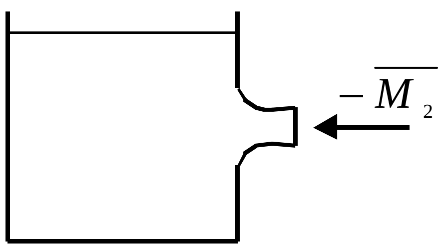
ii) MOTO



$$\frac{p_M}{g} = z_1 - z_M - \frac{V_M^2}{2 \cdot g}$$

Reazi. d'efflusso $\qquad \overline{R} = \overline{S}' - \overline{S} \qquad$ DEFINIZIONE

Hp. Luce piccola $\rightarrow$ abbassam. lento $\rightarrow$ moto $\sim$ permanente



$$\overline{G} + \overline{\Pi}' + \cancel{\overline{M}_1} - \overline{M}_2 = 0$$

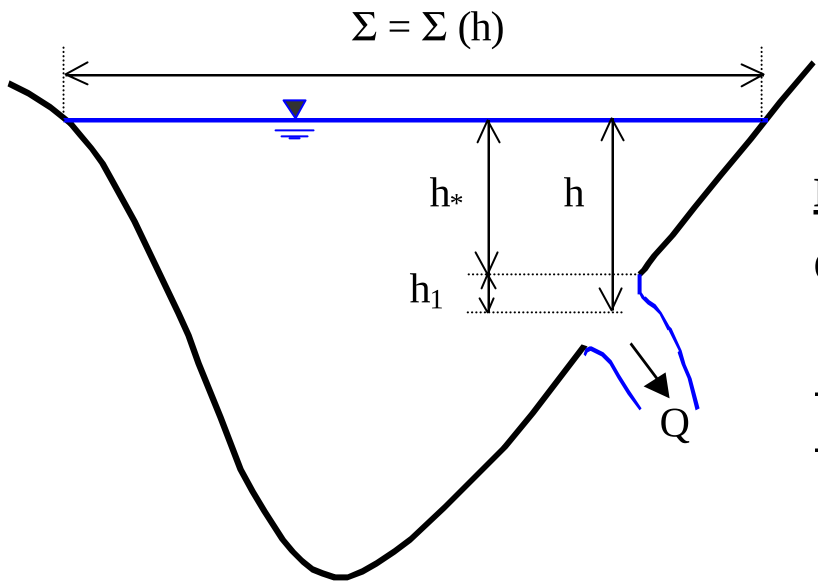
$$\overline{S}' = -\overline{\Pi}' = \overline{G} - \overline{M}_2$$

$$\overline{R} = \overline{S}' - \overline{S} = -\overline{M}_2$$

$$M_2 = r \cdot Q \cdot V_C = r \cdot A_C \cdot V_C^2 = r \cdot A_C = C_V^2 \cdot 2 \cdot g \cdot h = C_V^2 \cdot 2 \cdot g \cdot h \cdot A_C =$$

$\cong 2 \cdot (g \cdot h \cdot A_C) = 2 \cdot$ Spinta idrost. su A_C

VUOTAMENTO DI UN SERBATOIO



Hp.

Q piccola

⇓

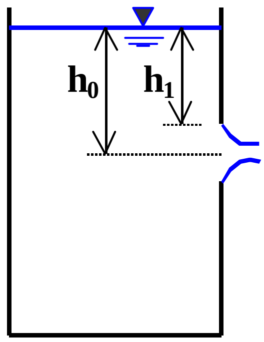
- V, Inerzie trascurabili
- moto ~ permanente

$$\begin{cases} -\Sigma\, dh = Q \cdot dt \\ Q = Q(h) \end{cases} \quad \leftarrow \text{eq. della luce}$$

+ condiz. iniziali

CILINDRO : Σ = cost = Σ_0

1) Luce a battente



$$\begin{cases} -\Sigma_0\, dh = Q \cdot dt \\ Q = m \cdot A \cdot \sqrt{2 \cdot g \cdot h} \end{cases} \rightarrow -\Sigma_0\, dh = m \cdot A \cdot \sqrt{2 \cdot g} \cdot h^{1/2} \cdot dt$$

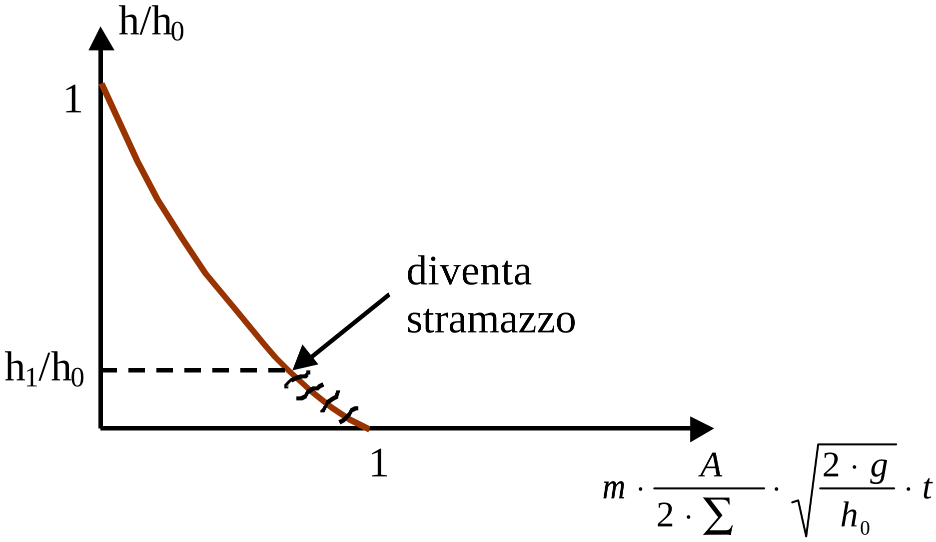
$$\int_{h_0}^{h} \frac{dh}{h^{1/2}} = -\frac{m \cdot A \cdot \sqrt{2 \cdot g}}{\Sigma} \cdot \int_0^t dt$$

$$2 \cdot \left[h^{1/2}\right]_{h_0}^{h} = -\frac{m \cdot A \cdot \sqrt{2 \cdot g}}{\Sigma} \cdot t$$

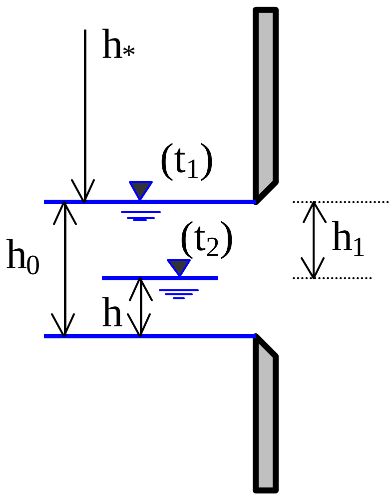
$$\frac{\sqrt{h_0}}{\sqrt{h_0}} - \frac{\sqrt{h}}{\sqrt{h_0}} = m \cdot \frac{A}{2 \cdot \Sigma} \cdot \sqrt{\frac{2 \cdot g}{h_0}} \cdot t$$

$$\frac{h}{h_0} = \left(1 - m \cdot \frac{A}{2 \cdot \Sigma} \cdot \sqrt{\frac{2 \cdot g}{h_0}} \cdot t\right)^2$$

→ $[T^{-1}]$



2) Stramazzo



$$\begin{cases} Q = m \cdot L \cdot h \cdot \sqrt{2 \cdot g \cdot h} \\ -\sum dh = Q \cdot dt = m \cdot L \cdot h \cdot \sqrt{2 \cdot g \cdot h} \cdot dt \end{cases}$$

$$\int_{h_0}^{h} \frac{dh}{h^{3/2}} = -\frac{m \cdot L \cdot \sqrt{2 \cdot g}}{\sum} \cdot \int_0^t dt$$

$$+2 \cdot \left[h^{-\frac{1}{2}} \right]_{h_0}^{h} = +m \cdot \frac{L \cdot \sqrt{2 \cdot g}}{\sum} \cdot t$$

$$\frac{\sqrt{h_0}}{\sqrt{h}} - \frac{\sqrt{h_0}}{\sqrt{h_0}} = \frac{m \cdot L \cdot \sqrt{2 \cdot g}}{2 \cdot \sum} \cdot t \cdot \sqrt{h_0}$$

$$\left(\sqrt{\frac{h_0}{h}} \right)^2 = \left(\frac{m \cdot L \cdot \sqrt{2 \cdot g}}{2 \cdot \sum} \cdot t \cdot \sqrt{h_0} + 1 \right)^2 \quad \Rightarrow \quad \frac{h}{h_0} = f(t)$$