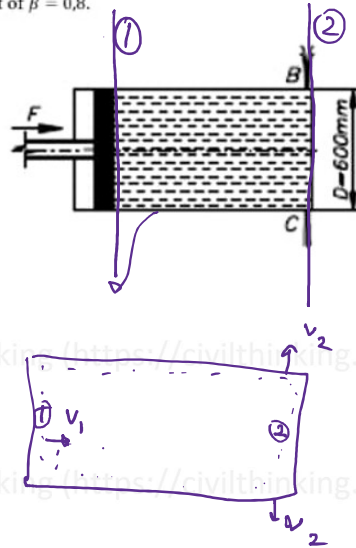


Hydrodynamics Bernoulli and continuity Problem Solution

At what velocity does water flow out of the depicted cylinder through the openings B and C if the force acting on the piston is $F = 1500\text{ N}$? How far does the piston move within a minute if the cross-sectional area of each opening is $A = 3\text{ mm}^2$? Assume a contraction coefficient of $\beta = 0.8$.



$$\frac{p_1}{\rho g} + \frac{v_1^2}{2g} + z_1 = \frac{p_2}{\rho g} + \frac{v_2^2}{2g} + z_2$$

$$v_1 \approx 0, z_1 = z_2, p_2 = p_{\text{atm}} = 0 \text{ [Gauge pressure]}$$

$$\frac{p_1}{\rho g} = \frac{v_2^2}{2g} \Rightarrow v_2^2 = \frac{2p_1}{\rho}$$

$$\Rightarrow v_2 = \sqrt{\frac{2p_1}{\rho}} \leftarrow \text{we need } p_1 \text{ \& } \rho$$

$$p_1 = \frac{F}{A} = \frac{1500 \text{ N}}{\frac{\pi}{4} \times 0.6^2} = 5305.16477 \text{ N/m}^2 \text{ (or Pa, pascal)}$$

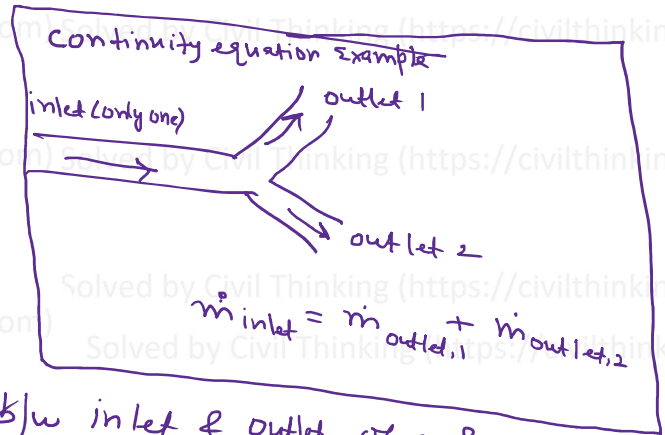
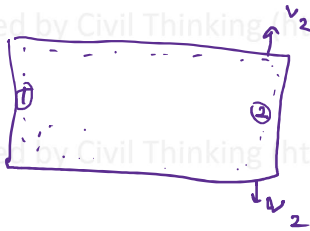
$$\Rightarrow v_2 = \sqrt{\frac{2 \times 5305.16477}{1000 \text{ kg/m}^3}} \approx 3.26 \text{ m/s [Theoretical]}$$

$$v_{2, \text{actual}} = \beta \times v_2 = 0.8 \times 3.26 = 2.608 \text{ m/s} \quad \underline{\underline{\text{ANS.1}}}$$

Distance travelled by piston in a minute (60 s) :



Continuity equation example



continuity equation b/w ① & ②

↳ equal mass flow rate b/w inlet & outlet of a system
(kg/s)

$$\sum \dot{m}_{\text{inlet}} = \sum \dot{m}_{\text{outlet}}$$

we have one inlet & two outlets

$$\rho_1 A_1 v_1 = \rho_2 A_2 v_2 + \rho_2 A_2 v_2 \quad [\because \text{velocity \& area of both outlets is same, } v_2, A_2]$$

$$\rho_1 = \rho_2 \quad [\text{incompressible fluid}]$$

$$\Rightarrow A_1 v_1 = A_2 v_2 + A_2 v_2 = 2 A_2 v_2$$

$$\Rightarrow A_1 v_1 = 2 A_2 v_2$$

$$A_2 = 3 \text{ (mm)}^2 = 3 \times 10^{-6} \text{ m}^2 \quad \left\{ \begin{array}{l} 3 \times (10^{-3} \text{ m})^2 \\ = 3 \times 10^{-6} \text{ m}^2 \end{array} \right.$$

$$v_2 = 2.608 \text{ m/s}$$

$$\Rightarrow \frac{\pi}{4} 0.6^2 \times v_1 = 2 \times 3 \times 10^{-6} \times 2.608 =$$

$$\Rightarrow v_1 = 0.55 \times 10^{-4} \text{ m/s}$$

$$\text{Velocity} = \frac{\text{Distance}}{\text{time}}$$

$$\Rightarrow \text{Distance travelled} = \text{Velocity} \times \text{time}$$

$$= 0.55 \times 10^{-4} \text{ m/s} \times 10$$

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$$\Rightarrow \text{Distance travelled} = \text{Velocity} \times \text{time}$$

$$= 0.55 \times 10^{-4} \frac{\text{m}}{\text{s}} \times 60 \text{ s}$$

$$\approx 3.32 \times 10^{-3} \text{ m} = 3.32 \text{ mm}$$

Ans. 2

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