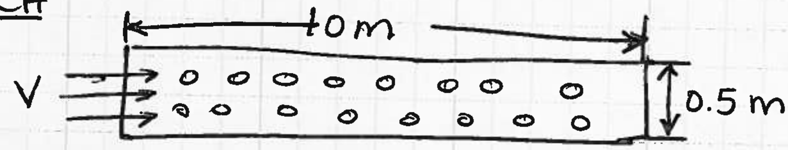
5.74) A pipe with a series of holes as shown in the figure is used in many engineering systems to distribut gas into a system.

$$Q = 0.67 A_o \left(\frac{2\Delta P}{\rho}\right)^{1/2}$$

A_o = area of the hole
ΔP = pressure difference across the hole.
ρ = density of gas

SKETCH



Known:

$$Q_{hole} = 0.67 A_o \left(\frac{2\Delta P}{\rho}\right)^{1/2}$$

$n_{hole} = 50/m = 500$ total holes
$L = 10m$
$D_{pipe} = 0.5m$
$D_{hole} = 2.5cm = 0.025m$
$T = 20°C$
$p_{pipe} = 100 Pa$ gage

Unknown:

$V_{air \text{ in pipe}} = ?$

Governing Equation:

$$Q = AV_{in} = NQ_{hole}$$

Solution:

$$N = 50 \times 10 = 500 \text{ holes}$$

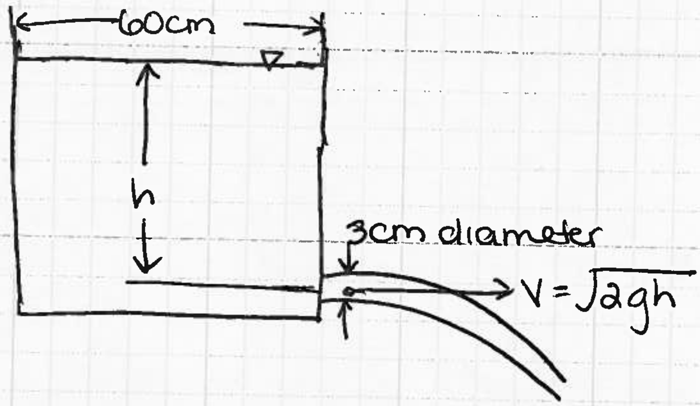
$$\rho = \frac{P}{RT} = \frac{100{,}000 + 100 kPa}{287 \frac{J}{kgK}(273+20)K} = 1.19 kg/m^3$$

$$Q_{hole} = 0.67\left(\frac{\pi}{4}(0.025m)^2\right)\left(\frac{2 \times 100 Pa}{1.19 kg/m^3}\right)^{1/2} = 0.00426 m^3/s$$

$$V = \frac{NQ_{hole}}{A} = \frac{500(0.00426 m^3/s)}{\frac{\pi}{4}(0.5m)^2} = \boxed{10.8 m/s = V_{pipe}}$$

5.80) How long will it take the water surface in the tank shown to drop from h = 3m to h = 50cm?

SKETCH:



Known
$h_1 = 3m$
$h = 0.5m$
$D_T = 0.6m$
$D_2 = 3cm$

Unknown:

time = ?

Governing Equation:

$$t = \left(\frac{2A_T}{\sqrt{2g}\,A_2}\right)\left(h_1^{1/2} - h^{1/2}\right)$$

Solution:

$$t = \frac{2\left(\left(\frac{\pi}{4}\right)(0.6m)^2\right)\left(\sqrt{3} - \sqrt{0.5}\right)m^{1/2}}{\sqrt{2 \times 9.81 m/s^2}\left(\pi/4\,(0.03m)^2\right)} = \frac{0.579\,m^{2.5}}{0.0031\,m^{2.5}/s} = 184.9\,s$$

$\boxed{t = 185\,s}$