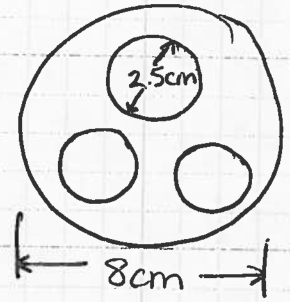
5.32) The cross section of a heat exchanger consists of three circular pipes inside a larger pipe. The internal diameter of the 3 smaller pipes is 2.5 cm, and the pipe wall thickness is 3 mm. The inside diameter of the larger 8 cm. If the velocity of the fluid in region between the smaller pipes and larger pipe is 10 m/s, what is the discharge in m³/s?

SKETCH:



KNOWN:

$V = 10\ m/s$
$D_{small} = 2.5cm$
$t_{wall} = 3mm = 0.3cm$
$D_{large} = 8cm$

UNKNOWN:

$Q_{large} = ?$

GOVERNING EQUATIONS:

$Q = AV$

SOLUTION:

$$A_{out} = \frac{\pi}{4}(2.5+0.6)^2 = 7.55cm^2$$

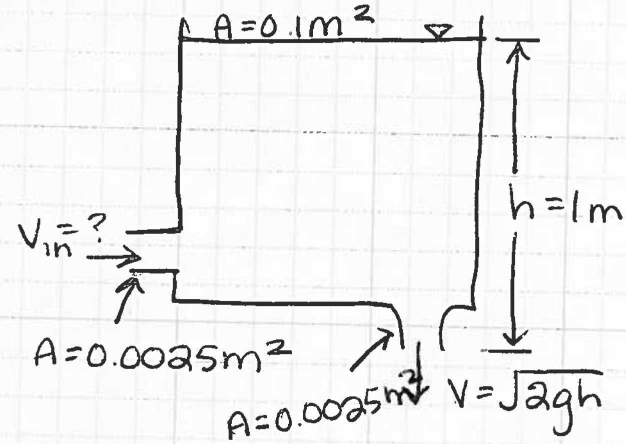
Area between large pipe and small pipes

$$A = \frac{\pi}{4}(8)^2 - 3(7.55cm^2) = 27.61cm^2 = 0.002761\ m^2$$

$$Q = AV = 0.002761\ m^2 \times 10m/s = \boxed{0.02761\ m^3/s = Q}$$

5.55) A tank has a hole in the bottom with a cross-sectional area of $0.0025 m^2$ and an inlet line on the side with a cross-sectional area of $0.0025 m^3$ as shown. The cross-sectional area of the tank is $0.1 m^2$. The velocity of the liquid flowing out the bottom hole is $V=\sqrt{2gh}$, where h is the height of the water surface in the tank above the outlet. At a certain time the surface level in the tank is 1m and rising at the rate of 0.1 cm/s. The liquid is incompressible. Find the velocity of the liquid through the inlet.

SKETCH:



KNOWN:

$A_{out} = 0.0025 m^2$
$A_{tank} = 0.1 m^2$
$h = 1m$
$\frac{dh}{dt} = 0.1 m$
$V = \sqrt{2gh}$

Assumption: incompressible flow.

UNKNOWN:

$V_{in} = ?$

GOVERNING EQN:

$Q = AV$ continuity EQN.

SOLUTION:

$$\dot{m}_o - \dot{m}_i = -\frac{d}{dt}\int_{CV} \rho \, d\forall$$

$$-\rho V_{in} A_{in} + \rho V_{out} A_{out} = \frac{-d}{dt}(\rho A_{tank} h)$$

5.55 (continued)

$$-V_{in}A_{in} + V_{out}A_{out} = -A_{tank}\left(\frac{dh}{dt}\right)$$

$$-V_{in}(0.0025) + \sqrt{2g(1)}(0.0025) = -0.1(0.1)\times 10^{-2}$$

$$V_{in} = \frac{\sqrt{19.62}(0.0025) + 10^{-4}}{0.0025}$$

$$\boxed{V_{in} = 4.47\ m/s}$$