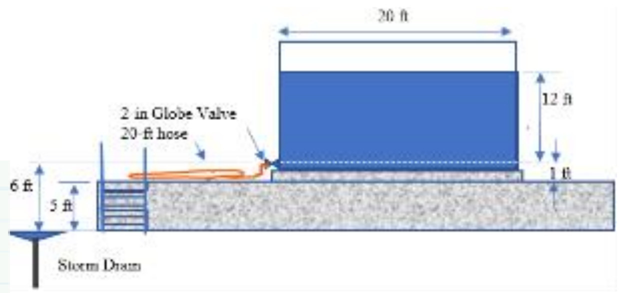
Tank Draining

2. Next week Adam, Pat, June, and you must retrofit a water tank with cathodic corrosion protection. The 20-ft diameter tank sits on a 5-ft platform with a 1 foot extension under the tank such that the 2-in globe valve drain is 1 ft above the platform. The water level in the tank is 12 ft above the drain valve. A 20-ft long piece of very rough 2-inch ID hose (f = 0.04) is hooked to the valve and laid out on the platform above a nearby storm drain as shown.
   a) Adam says they should just open the value, and 'let'r drain'.
   b) Pat says it would drain faster without the hose.
   c) June says they should lower the hose to the drain 6 ft below the bottom of the drain valve.

   Calculate how long each method will take to drain.



Governing Derived Equation

$$\pm\,(dz/dt) = \left(\frac{A_2}{A_1}\right)\left(\frac{gz}{\frac{1}{2\,\beta_2} + 2\cdot f\cdot\left(\frac{L}{d} + 340\right) + 0.5\cdot 1.5}\right)^{0.5}$$

$$\pm\,(dz/\sqrt{z}) = \left(\frac{A_2}{A_1}\right)\left(\frac{g}{\frac{1}{2\,\beta_2} + 2\cdot f\cdot\left(\frac{L}{d} + 340\right) + 0.5\cdot 1.5}\right)^{0.5} dt$$

$D := 20\cdot ft \qquad d := 2\cdot in \qquad f := 0.04 \quad \beta_2 := 1$ Assumed Turbulent - conformed

$$A_1 := \pi\cdot\left(\frac{D}{2}\right)^2 = \left(2.919\cdot 10^5\right)\ cm^2 \qquad A_2 := \pi\cdot\left(\frac{d}{2}\right)^2 = 20.268\ cm^2 \qquad L := 20\cdot ft$$

$$Fac := 2\cdot f\cdot\left(\frac{L}{d} + 340\right) + 0.5\cdot 1.5 = 37.55 \quad Fb := 2\cdot f\cdot 340 + 0.5\cdot 1.5 = 27.95$$

(a)

$$ca := \frac{A_1}{A_2}\left(\frac{\left(\frac{1}{2\cdot\beta_2} + Fac\right)}{g}\right)^{0.5} \qquad ta := ca\cdot 2\,\left(\sqrt{13\cdot ft} - \sqrt{1\cdot ft}\right) = 22.7\ hr$$

(b)

$$cb := \frac{A_1}{A_2}\left(\frac{\left(\frac{1}{2\cdot\beta_2} + Fb\right)}{g}\right)^{0.5} \qquad tb := cb\cdot 2\,\left(\sqrt{12\cdot ft} - \sqrt{0\cdot ft}\right) = 26.1\ hr$$

(c)

$$cc := \frac{A_1}{A_2}\left(\frac{\left(\frac{1}{2\cdot\beta_2} + Fac\right)}{g}\right)^{0.5} \qquad tc := cc\cdot 2\,\left(\sqrt{18\cdot ft} - \sqrt{6\cdot ft}\right) = 15.6\ hr$$

Check Re# in limiting case: hose and head of 1 inch

$$V_o := \left(\frac{g \cdot 1 \cdot in}{\frac{1}{2 \cdot \beta_2} + 2 \cdot f \cdot Fac} \right)^{0.5} = 0.27 \ \frac{m}{s}$$

$$Re_o := \frac{d \cdot V_o \cdot 1000 \cdot \frac{kg}{m^3}}{1.0 \cdot 10^{-3} \ \frac{kg}{m \cdot s}} = 1.4 \cdot 10^4$$

turbulent from start to finish

Typeset Equations for introduction

$$+/- \ (dz/dt) = \left(\frac{A_2}{A_1} \right) \left(\frac{gz}{\frac{1}{2 \ \beta_2} + 2 \cdot f \cdot \left(\frac{L}{d} + 340 \right) + 0.5 \cdot 1.5} \right)^{0.5}$$

$$+/- \ (dz/\sqrt{z}) = \left(\frac{A_2}{A_1} \right) \left(\frac{g}{\frac{1}{2 \ \beta_2} + 2 \cdot f \cdot \left(\frac{L}{d} + 340 \right) + 0.5 \cdot 1.5} \right)^{0.5} dt$$

$$c = \frac{A_1}{A_2} \left(\frac{\left(\frac{1}{2 \ \beta_2} + 2 \cdot f \cdot \left(\frac{L}{d} + 340 \right) + 0.5 \cdot 1.5 \right)}{g} \right)^{0.5}$$

As is

$$ta := \frac{2 \cdot \left(\frac{A_1}{A_2}\right) \left(\frac{1}{2 \cdot \beta_2} + 2 \cdot f \cdot \left(\frac{D}{d} + 340 + 31\right) + 0.5 \cdot 1.5\right)^{0.5}}{g^{0.5}} \left((13 \cdot ft)^{0.5} - (1 \cdot ft)^{0.5}\right) = 23.395\ hr$$

Remove hose

$$tb := \frac{2 \cdot \left(\frac{A_1}{A_2}\right) \left(\frac{1}{2\ \beta_2} + 2 \cdot f \cdot \left(\frac{0 \cdot D}{d} + 340 + 31\right) + 0.5 \cdot 1.5\right)^{0.5}}{g^{0.5}} \left((12 \cdot ft)^{0.5} - (0 \cdot ft)^{0.5}\right) = 27.172\ hr$$

Use hose but drape it over the edge of the platform

$$tc := \frac{2 \cdot \left(\frac{A_1}{A_2}\right) \left(\frac{1}{2 \cdot \beta_2} + 2 \cdot f \cdot \left(\frac{D}{d} + 340 + 31\right) + 0.5 \cdot 1.5\right)^{0.5}}{g^{0.5}} \left((18 \cdot ft)^{0.5} - (6 \cdot ft)^{0.5}\right) = 16.101\ hr$$

Remove the hose and valve

$$td := \frac{2 \cdot \left(\frac{A_1}{A_2}\right) \left(\frac{1}{2 \cdot \beta_2} + 2 \cdot f \cdot \left(\frac{0 \cdot D}{d} + 0\right) + 0.5 \cdot 1.5\right)^{0.5}}{g^{0.5}} \left((12 \cdot ft)^{0.5} - (0 \cdot ft)^{0.5}\right) = 5.462\ hr$$

Use a shorter, smoother hose (10' and f=0.004) and remove the valve

$$te := \frac{2 \cdot \left(\frac{A_1}{A_2}\right) \left(\frac{1}{2 \cdot \beta_2} + 2 \cdot 0.004 \cdot \left(\frac{0.5 \cdot D}{d} + 0\right) + 0.5 \cdot 1.5\right)^{0.5}}{g^{0.5}} \left((18 \cdot ft)^{0.5} - (6 \cdot ft)^{0.5}\right) = 3.326\ hr$$

1c

$$\rho := 1000 \cdot \frac{kg}{m^3} \qquad D2 := 4 \cdot cm \qquad W(v2) := v2 \cdot \pi \cdot \left(\frac{D2}{2}\right)^2 \cdot \rho$$

$W($

$f(1$

$$v0 := 10 \cdot \frac{m}{s} \qquad v := \mathbf{root}\left(f(v0), v0, 0 \cdot \frac{m}{s}, 30 \cdot \frac{m}{s}\right) = ?$$

$$W(v) = ? \qquad FR := \frac{W(v)}{\rho} = ?\ \frac{l}{s}$$

$\frac{W(V)}{\rho}$

$A = 1$