**Problem Related to Water Reservoir**

**Time Calculation**

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# Theory



If a tank and orifice are both at atmospheric pressure and the liquid is above the top of the orifice, the discharge (flow rate) out of the orifice is,

Q = aC√2gh

The above equation is valid if both the tank and orifice are at the same pressure, even if the pressure is not atmospheric.

For a tank with a constant cross-sectional geometry A in the plan view (i.e. as you look down on it), substitute:

Q = -A (dh/dt)

Integrate h from Hi to Hf and integrate t from 0 to t, then solve for time t, which is the time required for the liquid to fall from Hi to Hf,

t = (A/aC) (√Hi - √Hf) {√(2/g)}

Here, a = Orifice cross-sectional area (m2)

A = Tank cross-sectional area (m2)

C = Orifice discharge coefficient 0 < C < 1.0. C depends on the orifice geometry and in some cases the type of liquid

g = Acceleration due to gravity, 9.8066 (m/s2)

h = Vertical distance from centerline of orifice to liquid surface (m)

Hf = Final vertical distance from centerline of orifice to liquid surface (m)

Hi = Initial vertical distance from centerline of orifice to liquid surface (m)

Q = Discharge (flow rate) at any depth (m3/s)

t = Time for liquid in tank to change from a depth of Hi to a depth of Hf (sec.)

## Orifice Discharge Coefficient



# Problem of the Equation

1. If h drops below the top of the orifice (for instance if Hf is below the top of the orifice), the method will give shorter emptying times than in reality. The program assumes that liquid is flowing out through the entire orifice area. However, when the liquid drops below the top of the orifice, flow is out of an area less than the full orifice area.
2. The tank and orifice discharge are assumed to be at the same pressure.
3. The tank is assumed to be of sufficiently larger area than the orifice so that friction effects from the tank wall are negligible.

(1. LMNO Engineering, Research, and Software, Ltd, 2015)

# Problem Related to the Equation

10 m

20 m

15 m

10 cm φ

1 m

Calculate the required time to empty the overall water tank.

a = (πd2 / 4) = 7.853981634 x 10-3 m2

A = 20 x 10 = 200 m2

g = 9.8066 m2

C = short tube = L – 2.5d = 1 – 2.5 (10/100) = 0.75

h = 15 – (5/100) = 14.95 = Hi

Hf = 0 [We want the tank fully emptied]

So, t = (A/aC) (√Hi - √Hf) {√(2/g)}

= 44464.81378 sec.

= 12.352 hours.

# Reference

1. LMNO Engineering, Research, and Software, Ltd. (2015, August 25). *Time to Empty or Drain a Tank, Pond, Reservoir Containing Water or other Liquid*. Retrieved November 18, 2015, from lmnoeng.com: http://www.lmnoeng.com/Tank/TankTime.php