

CE 3372 Water Systems Design
Fall 2016
Equation List

Unit conversions

$$1 \text{ meter} = 3.28 \text{ feet} \quad (1)$$

$$1 \text{ cubic foot} = 7.48 \text{ gallons} \quad (2)$$

$$1 \text{ kilogram} \approx 2.2 \text{ pounds} \quad (3)$$

$$1 \text{ acre} = 43,560 \text{ square feet} \quad (4)$$

$$1 \frac{\text{newton-meter}}{\text{second}} = 1 \text{ Watt} \quad (5)$$

Modified Bernoulli (Energy) equation.

$$\frac{p_1}{\rho g} + \alpha_1 \frac{V_1^2}{2g} + z_1 + h_p = \frac{p_2}{\rho g} + \alpha_2 \frac{V_2^2}{2g} + z_2 + h_t + h_l \quad (6)$$

Darcy-Weisbach head-loss equation

$$h_l = f \frac{L}{D} \frac{V^2}{2g} \quad (7)$$

Hazen-Williams head-loss equation (U.S. Customary)

$$h_f = 3.02 L D^{-1.167} \left(\frac{V}{C_h} \right)^{1.85} \quad (8)$$

Jain equation for pressurized pipes (U.S. or S.I.)

$$Q = -2.22 D^{5/2} \times \sqrt{gh_f/L} \times \left[\log_{10} \left(\frac{k_s}{3.7D} + \frac{1.78\nu}{D^{3/2} \sqrt{gh_f/L}} \right) \right] \quad (9)$$

Jain approximation for friction factor (U.S. or S.I.)

$$f = \frac{0.25}{\left[\log_{10} \left(\frac{k_e}{3.7} + \frac{5.74}{Re_d^{0.9}} \right) \right]^2} \quad (10)$$

Jain approximation for diameter (U.S. or S.I.)

$$D = 0.66 \left[\epsilon^{1.25} \times \left(\frac{LQ^2}{gh_f} \right)^{4.75} + \nu Q^{9.4} \times \left(\frac{L}{gh_f} \right)^{5.2} \right]^{0.04} \quad (11)$$

Manning's equation (U.S. Customary and S.I. units)

$$Q = \frac{1.49}{n} AR^{2/3} S^{1/2} \text{ (U.S. Customary)} \quad (12)$$

$$Q = \frac{1.0}{n} AR^{2/3} S^{1/2} \text{ (S.I.)} \quad (13)$$

Rational runoff equation (U.S. Customary)

$$Q_{peak} = C \times i \times A \quad (14)$$

where i is intensity in inches-per-hour, and A is drainage area in acres.

Depth-Area, -Topwidth, -Perimeter for Trapezoidal Channel (both side slopes same)

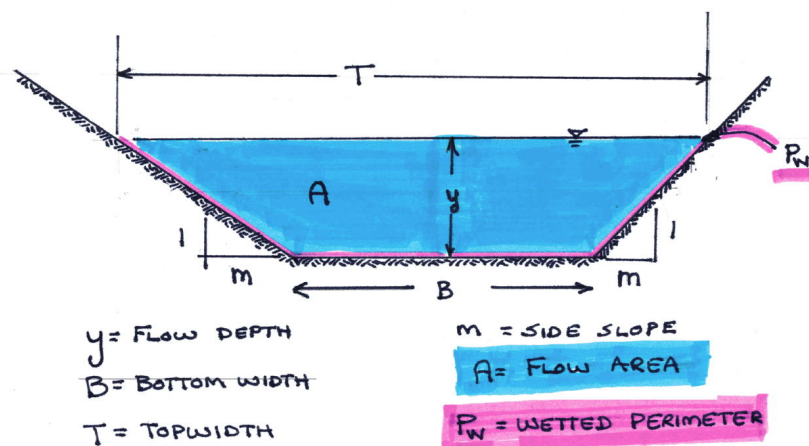


Figure 1: Definition Sketch for a Trapezoidal Channel

$$A_{\text{trap.}}(y) = By + \frac{y^2}{m} \quad (15)$$

$$T_{\text{trap.}}(y) = B + 2\frac{y}{m} \quad (16)$$

$$P_{w \text{ trap.}}(y) = B + 2y\sqrt{1 + \frac{1}{m^2}} \quad (17)$$

Depth-Area, -Topwidth, -Perimeter for Circular Conduit

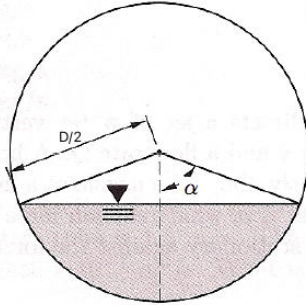


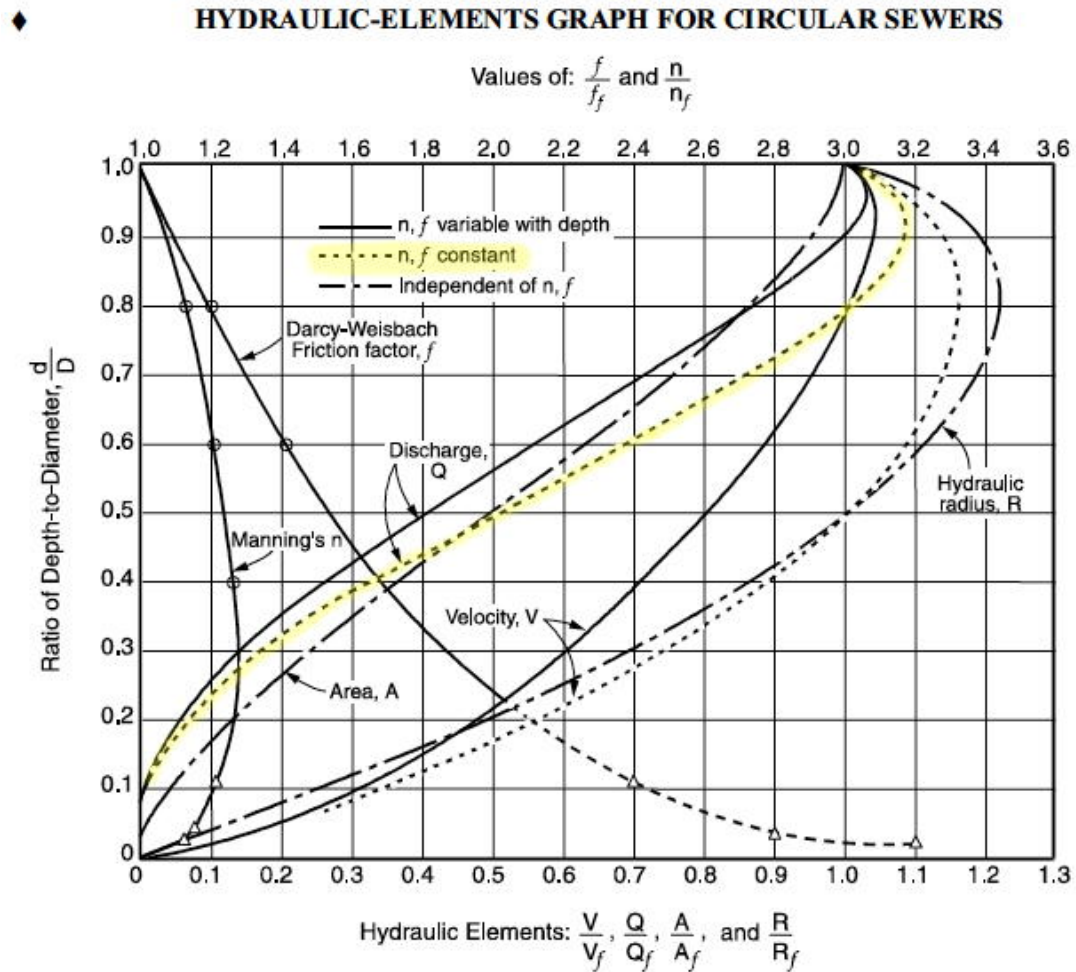
Figure 2: Definition Sketch for a Circular Conduit

$$\alpha_{\text{circ.}}(y) = \cos^{-1}\left(1 - \frac{2y}{D}\right) \quad (18)$$

$$A_{\text{circ.}}(y) = \frac{D^2}{4}(\alpha - \sin\alpha \cos\alpha) \quad (19)$$

$$T_{\text{circ.}}(y) = D \sin\alpha \quad (20)$$

$$P_{w \text{ circ.}}(y) = D \alpha \quad (21)$$



◆ *Design and Construction of Sanitary and Storm Sewers, Water Pollution Control Federation and American Society of Civil Engineers, 1970.*

Figure 3: Hydraulic element chart for a circular conduit