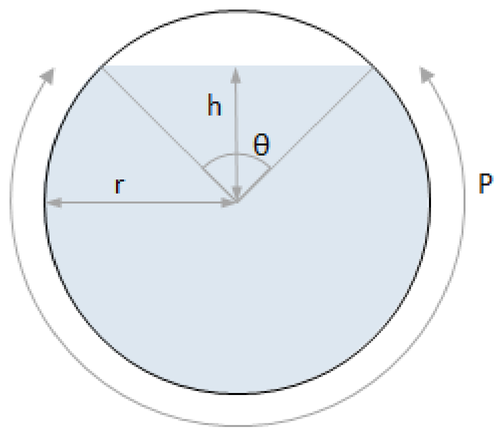
# Maximum Flow Rate in Open-Channel Flow for a Circular Pipe

This application determines the greatest attainable flowrate in a circular pipe partially filled with water.




The Manning formula is employed to calculate the open-channel flow of water:

$$Q = \frac{1.49}{n} \cdot A \cdot R^{\frac{2}{3}} \cdot S_0^{2}$$

where
- Q is the flowrate
- n is an empirical coefficient
- A is the cross-sectional area of flow
- R is the hydraulic raduis
- S is the incline of the channel

Manning formula $Q := \frac{1.49}{n} \cdot A \cdot R^{\frac{2}{3}} \cdot S_0^{\frac{1}{2}}$

Flow area for a partially filled circular pipe $A := \pi \cdot r^2 - r^2 \cdot \frac{\theta - \sin(\theta)}{2}$

Wetted perimiter and hydraulic radius $P := 2 \cdot \pi \cdot r - r \cdot \theta$

$$R := \frac{A}{P} = \frac{3.14 \cdot r^2 - r^2 \cdot (0.50 \cdot \theta - 0.50 \cdot \sin(\theta))}{-r \cdot \theta + 6.28 \cdot r}$$

The Manning formula then becomes

$$Q = \frac{\left(4.68 \cdot r^2 - 1.49 \cdot r^2 \cdot \left(0.50 \cdot \theta - 0.50 \cdot \sin(\theta)\right)\right) \cdot \left(\frac{3.14 \cdot r^2 - r^2 \cdot \left(0.50 \cdot \theta - 0.50 \cdot \sin(\theta)\right)}{-r \cdot \theta + 6.28 \cdot r}\right)^{2/3} \cdot \sqrt{S_0}}{n}$$

Parameters $n := 0.013$ $S_0 := 0.0001$ $r := 4$

Find the value of theta that maximizes Q res := Optimization:-Maximize( Q )

Maximum flow rate $Q_{maxflow} := res[1] = 98.38$

$\theta_{maxflow} := rhs(res[2, 1]) = 1.005$

Flow depth $h := r \cdot \cos\left(0.5 \cdot \theta_{maxflow}\right)$ $h + r = 7.505$

plot( Q, θ = 0..1.5 ) =