FLOW IN OPEN CHANNELS

Most efficient cross section

Chezy-Manning: \( Q = const \times AR^{2/3} \)

1) Most efficient cross section for a given cross section area \( A \): a flow rate \( Q \) will be a maximum when \( R \) is a maximum which means the perimeter \( P \) is a minimum.

2) Most efficient cross section for a given flow rate \( Q \): a cross section \( A \) will be a minimum when \( R \) is a maximum which means the perimeter \( P \) is a minimum.

Note:
For a given flow rate \( Q \), Chezy-Manning formula means that \( P = const \times A^{5/2} \)

Exercise 24

Channel: A symmetrical trapezoid, Manning's coefficient \( n=0.015 \) (asphalt), \( S=0.001 \).

What are the water velocity and flow rate?

Exercise 25

Water is to flow at a rate of \( Q = 30 \, m^3/s \) in the concrete \( (n=0.013) \) channel shown in the sketch.
Find the slope \( S \) and the required vertical drop of the channel bottom per kilometer of length.
Exercise 26

Water flows in the triangular steel channel (n=0.014) at a velocity \( V=0.9 \text{ m/s} \).

Find the depth \( d \) of flow if the channel slope is 0.0015.

Exercise 27

A metal pipe (n=0.024) of 500 mm diameter flows half-full at a slope of 0.005.

What is the flow rate for this condition?

Exercise 28

A cast iron pipe (D=0.6 m, n=0.012, S=0.0025) carries water at a depth of 0.14 m. What is the flow rate?
Exercise 29

A concrete pipe (D=0.5 m, n=0.013, S=0.002) carries water at a flow rate \( Q = 2400 \text{ liter/min} \). What is the depth of flow?

![Diagram of a concrete pipe](image)

Exercise 30

An open channel (n=0.011) is to be designed to carry \( Q = 1.0 \text{ m}^3/\text{s} \) at a slope of 0.0065.

Show that for a given flow rate, the most efficient circular section not flowing full (see the sketch above) is a semicircular section. What is the depth (d) of flow?

Solution:

Chezy-Manning: \( Q = \text{const} \times A \cdot R^{2/3} \). The most efficient cross section for a given flow rate \( Q \): a cross section \( A \) will be a minimum when \( R \) is a maximum: Express \( R \) in terms of \( \alpha \) ....

Exercise 31

Find the most efficient cross section for Exercise 30 for a triangular section.

Solution:

Chezy-Manning: \( Q = \text{const} \times A \cdot R^{2/3} \). The most efficient cross section for a given flow rate \( Q \): a cross section \( A \) will be a minimum when \( R \) is a maximum which means the perimeter \( P \) is a minimum. But for a given flow rate \( Q \), from Chezy-Manning formula, \( P = \text{const} \times A^{5/3} \). Express the area \( A \) in terms of the triangle's side (a) and the angle (\( \alpha \)) between the sides.

Exercise 32

Find the most efficient cross section for Exercise 30 for a rectangular section.