Example 2: Boundary Shear Stress – Unit Analysis and Perturbation

Boundary Shear Stress (τ_0)

As a fluid flows across a bed...

... a stress that opposes the motion of the fluid exists at the bed surface.

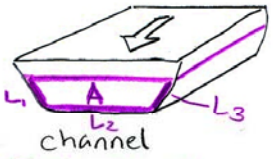
... an equal and opposite stress is imposed by the moving fluid on the underlying bed.

$$\tau_0 = \gamma R_h S$$

Where: $\gamma = \rho g$ = specific weight of fluid ("gamma")

R_h = hydraulic radius

$$= \frac{\text{cross sectional area}}{\text{wetted perimeter}} = \frac{A}{P}$$



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$P = L_1 + L_2 + L_3$

S = slope (gradient) = $\frac{dz}{dx}$

Unit Analysis

Unit Analysis:

$$\tau_0 = \rho g R_h S = \frac{M}{L^3} \cdot \frac{L}{T^2} \cdot \frac{L^2}{L} \cdot \frac{L}{L} = \frac{M}{LT^2}$$

Is this consistent with units for τ_0 $\left(\frac{\text{Force}}{\text{Area}}\right)$?

Perturbation Interrogation

Q: Will τ_0 increase/decrease when:

- the density of the moving fluid increases? (increase)/decrease
- the slope of the streambed flattens? increase/(decrease)
- the width and depth of the stream increase? (increase)/decrease

* Notes in purple are omitted from notes provided to students.