Flow Mechanics: Velocity Profiles Exercise

Complete the following exercises during lab or before the next class meeting. The exercise is intended to give you practice working with the relationships you have seen derived in class *before* you are asked to analyze field data from the Baker River. You may work together as you practice the mechanics involved, but turn in your own work as it will be graded.

Problem 1. Derive the relationship between C_f (the generalized non-dimensional Darcy-Weisbach friction factor) and the ratio $\bar{u}/u_*$.

Problem 2. Using the relationships for C_f, u(z), $\bar{u}$, τ_b, and u_* to derive the relationship between C_f and the roughness parameter z_o, for the case of a very wide, rectangular channel. Comment briefly on the relationship (i.e. is there any obvious weakness in the bulk friction factor C_f?).

Problem 3. Derive the relationship between C_f and Manning's n. Comment briefly on Manning's n.

Problem 4. Using the above relationships, the Law of the Wall, and assuming steady, uniform flow, determine the following from the data given below: Slope (S), average velocity ($\overline{u}$), basal shear stress (τ_b), shear velocity (u_*), roughness height (z_o), friction factor (C_f), and Manning's n. Assume hydraulically rough flow over a plane-bed gravel channel (i.e. that $z_o = D_{84}/30$). How does the value of n compare to the tables given in your handout? How does the value of C_f compare to Leopold's relationship for *f* as a function of grainsize and flow depth (see attached graph and equation)?

Grainsize D_{84} = 128 mm (large cobbles)
Flow depth = 1.0 m

Measured Velocity Profile (cm/s):

u(0.1) = 180; u(0.3) = 210; u(0.5) = 300; u(0.7) = 270; u(0.9) = 240

S =

$\overline{u}$ =

τ_b =

u_* =

z_o =

C_f =

n =

Confirm that the assumption of hydraulically rough flow (HFR => $z_o = D_{84}/30$) is valid (see your roughness handout).