Problem 1

Uniform steady flow in an open channel is governed by the classical shear stress formula

(1) $$\tau_0 = \rho g R_h S_0$$

In which $R_h = A/P$ is the hydraulic radius (units: length) and S_0 is the slope of the channel.

Expressing τ_0, the average shear stress along the wetted perimeter P, by the Darcy-Weisbach formula, the cross-sectional average velocity U is obtained as

(2) $$U = \sqrt{8gR_h S_0 / f}$$

where f is the Darcy-Weisbach friction factor. A common formula for expressing the Darcy-Weisbach friction factor is

(3) $$f = 0.18(k_N / D)^{1/3}$$

where k_N is the characteristic roughness length and D is the diameter of pipe. An alternative and very popular engineering formula, the Manning Equation, expresses the cross-sectional average velocity in the form

(4) $$U = \frac{1}{n} R_h^{2/3} S_0^{1/2}$$

where n (Manning's "n") is only a function of the boundary roughness k_N (units: length).

a) Determine the units of the constant 0.18 in (3).
b) Combining (2), (3), and (4) determine an expression for Manning's n in terms of the relative roughness of the channel.
c) In several textbooks, you will find the value of $n = 0.01$ listed for glass-walled channels. Calculate the roughness associated with this Manning's n. Does it make sense with the observation $k_{N_{glass}} \sim 1$ µm? If not, why?

Problem 2

You been asked to monitor Steamboat Slough (just outside Everett) to identify the potential for sediment transport during a tidal cycle. You deploy a tripod in the slough with a current meter anchored at 50 cm above the bed. You retrieve the following data for two different times during the tidal cycle (t_1 and t_2):

$U(t_1) = 20$ cm/s, $H(t_1) = 6$ m

$U(t_2) = 30\,\text{cm/s}, H(t_2) = 2\,\text{m}$

U is the measured mean streamwise velocity, *H* is the total water depth. Assume a roughness length of 1 cm.

a) Calculate the shear velocity in the channel for each condition (t_1 and t_2).
b) One of your calculations is incorrect (or impossible to estimate correctly from the information given). Which one? Why? What would you need to know to properly solve the problem?

Problem 3

You are asked to do a study of the suspended material derived from the Squire Creek Slide in rural Snohomish County. You decide to break up the suspendible material up into three broad size classes:

1) $\overline{D}_1 = 5\,\text{mm}$, which has a $CSF = 0.5$, $P = 2$
2) $\overline{D}_2 = 0.5\,\text{mm}$, which has a $CSF = 0.7$, $P = 2.2$.
3) $\overline{D}_3 = 0.05\,\text{mm}$, but the shape and angularity could not be determined because you do not have access to a microscope.

a) Calculate the settling velocity for the first two size classes.
b) Should you buy a microscope to resolve the *CSF* and *P* of the smallest size class? If not, why not?