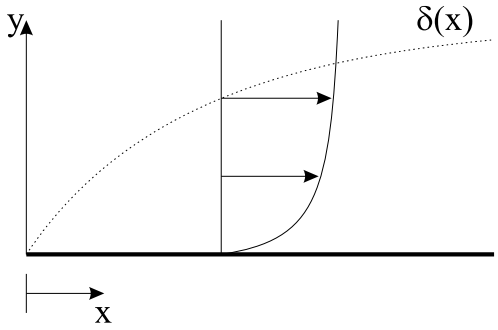
CE640 / OC512 Matlab
Homework 6 – Parameter Estimation

There are many models for turbulent boundary layer flow. There is the classic smooth 'log law' equation, and a 'rough wall' equation. In the figure below, we see a velocity profile u(y). In this assignment, you are to explore two possible curve fits to some experimental data.



The data are given by:

y (cm)	u (cm / s)
0.073	57.12
0.44	75.78
0.81	83.77
1.19	89.58
1.56	94.16
1.93	97.99
2.3	100.81
2.67	102.13
3.04	102.62

1. The easiest model to apply is the 'smooth log law, which states:

$$\frac{u}{u^*} = \frac{1}{\kappa} \log_e \left(\frac{y u^*}{\nu} \right)$$

In this equation, u is the streamwise velocity, y is the vertical coordinate (m), u* is the 'shear velocity,' (m/s) $\kappa = 0.4$ is the von Karman constant, and ν is the kinematic viscosity of water. You can assume that $\nu = 0.01$ cm^2 s^{-1}. So, what is often done in open channel hydraulics is that the shear velocity is treated as a 'fitting parameter.' Just as we 'fit' a straight line to data by computing the best slope and intercept, we can 'fit' the log equation to data by figuring out the best shear velocity. So, that is your first task! As a hint, you should come up with a shear velocity that is between 1 – 10 cm / s.

2. Ok, so now let us try a more sophisticated model. The ‘rough wall’ model also includes the effect of the roughness of the bottom of the channel. The equation here is given by

$$\frac{u}{u^*} = \frac{1}{k} \log_e \frac{y}{k_s} + 8.5,$$

Note that the 8.5 is outside of the log function. So, now, in the equation for u(y), we see that we have two parameters. The shear velocity, but also the ‘roughness’ height (k_s – given in cm). So, you could apply this model to the data and try to determine the best two parameter values. I ended up solving this with nlinfit, but there are other options as well.

I would like you to write a single m-file that will (a) determine the shear velocity value for the smooth wall case (and print it to the screen), (b) determine (and print to screen) the shear velocity and the roughness height for the rough wall case, and (c) make a single plot that shows the original data, the smooth fit, and the rough fit. Use symbols for the data and lines for the two curve fits. Please include a legend.