EENS 6310 **Problem Set 1** Due at 3:30 pm, Feb. 14th 2022

1. Consider a two-dimensional flow for which the sediment flux is given by

$$q_s(x) = q_{s0} + a\eta(x)$$

Where the q_s is sediment flux (units: L^2/T), q_{s0} is a constant (units: L^2/T), η is bed elevation above a fixed datum, and a is a coefficient (units: L/T). Let the initial bed configuration (*t* = 0) be given by $\eta = b\sin(kx)$.

   1.1 What are the physical meanings of *b* and *k*?

   1.2 Using

q_{s0} = 0.22m²/hr	*a* = 1.1 m/hr	*b* = 0.2m	*k* = 2/m	Δx = 0.1 m

   Calculate and plot the bed topography η, the sediment flux q_s, and the instantaneous rate of deposition or erosion $\partial\eta/\partial t$ along the bed. Find $\partial\eta/\partial t$ using conservation of sediment mass expressed as the Exner Equation.

   1.3 Calculate and plot the evolution of the bed from *t* = 0 hr to a short time, ∂t, later.

   1.4 Using a sketch, describe the relation between the sediment flux and topography if we introduce a "lag distance" l between the sediment flux and the topography such that

$$q_s(x) = q_{s0} + a\eta(x - l)$$

   Repeat 1.3 both for a value of l >0 and l <0. Give a physical interpretation of the results.

2. Sketch the sediment-flux vector field given by (**<u>For Graduate Students Only</u>**)

$$q_{sx} = q_{s0}e^{-(x/L)}e^{-(2y/\varpi)^2}$$

$$q_{sy} = 0.1q_{s0}e^{-(2y/\varpi)^2}\sin(\pi y/2\varpi)$$

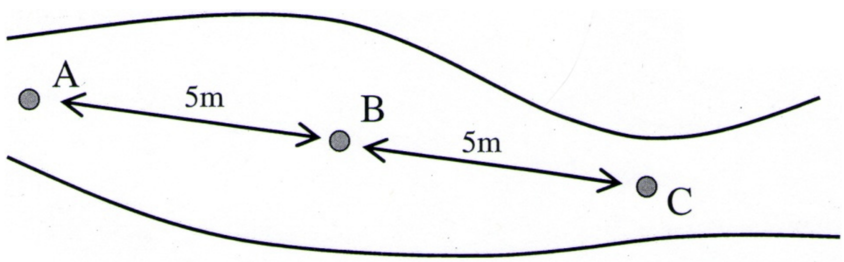
Over the domain 0 < *x* < *L* and $-\varpi < y < \varpi$, where $\varpi = 0.1Le^{x/L}$.

   2.1 Can you give physical interpretations of *L* and ϖ?

   2.2 What kind of sedimentary system could this be?

2.3 Find the rate of change of bed elevation $\partial\eta/\partial t$ as a function of position within the domain using the Exner Equation and the two equations above, and show how the deposition/erosion is distributed spatially.

3. You hope to develop a kayaking course on a stretch of the Cannon River shown in the map view below. As the first step in course design you decide to measure the accelerations experienced as one moves around the designated stretch of river. You install current meters at three points as shown below:



You obtain the following record:

t (s)	u_a (m/s)	u_b (m/s)	u_c (m/s)
0	1.02	0.38	1.84
2	1.08	0.46	2.00
4	0.92	0.44	2.12
6	1.00	0.36	2.10
8	1.12	0.42	2.04
10	1.08	0.44	2.26

Consider both possible forms of acceleration in a flowing fluid, find the maximum positive and negative acceleration a body would experience traveling through this section of river. How do these accelerations compare with gravitational acceleration?

4. A hydrologist has been studying a 10 km long section of river for 10 years and has measured no change in average bed elevation and average channel width $\langle b\rangle$ and depth $\langle h\rangle$ during this time. In addition, the average streamwise sediment flux $\langle q_{sx}\rangle$ and water-surface slope S have not varied (all presented below). The hydrologist concludes that the channel has developed an equilibrium or steady state profile under these conditions. What is the predicted spatial change in $\langle q_{sx}\rangle$ for this state assuming no subsidence? What is the value realizing the entire reach is subsiding $\langle\sigma\rangle$ at the rate listed below? What is the error incurred in the reported value for total sediment transport if subsidence is not accounted for?

$\langle q_{sx}\rangle$ = 0.22 m^2/hr	$\langle h\rangle$ = 0.5 m	$\langle b\rangle$ = 100 m	$S = 1.3\times10^{-3}$	$\langle\sigma\rangle$ = 1.5 mm/yr