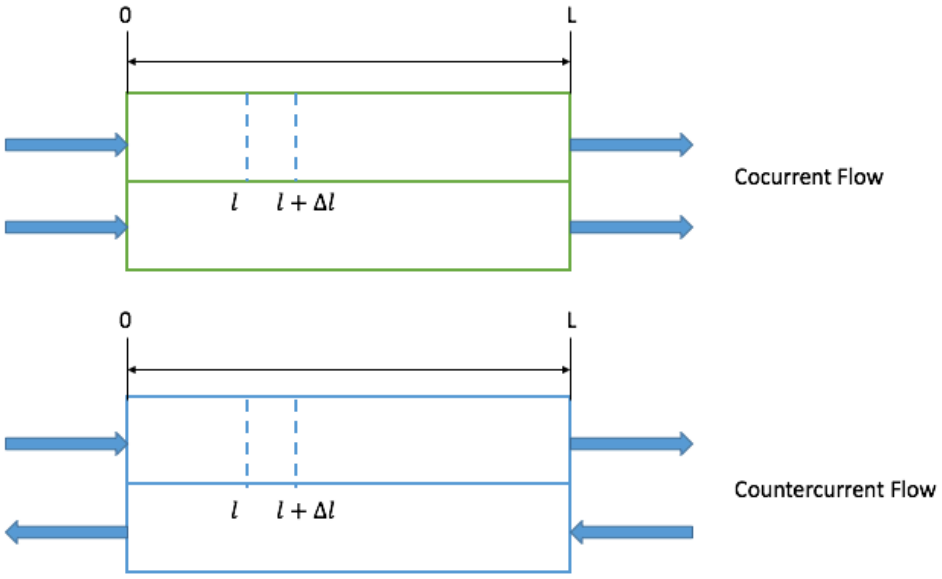
ABE 202 Homework 5. 2017

Due: March. 2, 2017 before class

To cool a large bioreactor, you are designing a heat exchanger wherein heat flows between two fluid streams brought into thermal contact through a barrier, such as a pipe wall and you have some decisions to make. One of the design considerations you need to make is whether to operate the device in the cocurrent (both fluid streams flowing in the same direction DESIGN A- the TOP GREEN ONE) or countercurrent (streams flowing in opposite direction DESIGN B- the BOTTOM BLUE ONE) configuration; schematic diagrams are given here.



the heat flow rate from fluid 1 to fluid 2 per unit length of the heat exchanger, $\dot{q}$, is proportional to the temperature difference (T_1 — T_2):

$\dot{q}$ = (Heat flow rate from fluid 1 to fluid 2 per unit length of heat exchanger)=κ(T_1 — T_2). In the picture above, this is the line that separates the top stream from the bottom stream.

where κ is a constant of proportionality with units of J/(m s K). The fluids in the two streams are the same and their flow rates are equal. The initial and final temperatures of stream1 will be 35°C and 15 °C, respectively, and those for stream 2 will be -15 °C and 5 °C

a. Write the balance equations for each fluid stream in a portion of the heat exchanger of length dL and obtain differential equations by letting dL—> 0.

b. Integrate the energy balance equations over the length of the exchanger to obtain expressions for the temperature of each stream at any point in the exchanger for each flow configuration. Also compute the length of the exchanger, in units of $L_0 = \dot{M}C_p/2\kappa$

(where $\dot{M}$ is the mass flow rate of either stream), needed to accomplish the desired heat transfer. WHICH DEVICE IS SMALLER?

c. Write an expression for the change/of entropy of stream1 with distance for any point in the exchanger.