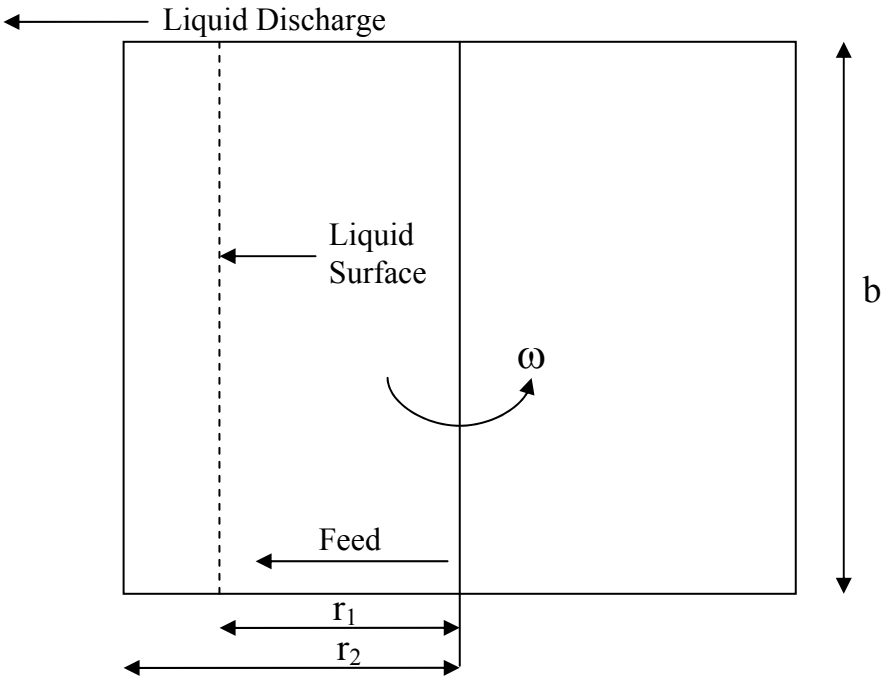
DOWNSTREAM PROCESSING

Problem Set #2

Problem 1

A key to understanding centrifugation is understanding the equations that describe it. One can begin to understand these equations by deriving the relationship between volumetric throughput, terms that describe the process medium, and terms that describe the separator design. Consider the following schematic of a sedimenting centrifuge:



where r_1 = distance between fluid outer layer and the axis of rotation

r_2 = radius of bowl

ω = angular rotation rate (radians/sec)

b = height of bowl

a) Please derive a general expression that relates volumetric throughput (Q) to the centrifuge physical dimensions, fluid properties, and characteristics of the particle being separated. In your

derivation, please consider the terminal velocity of a particle in a centrifugal field (i.e. Stoke's law in a centrifugal field).

b) For design purposes, the equations that describe centrifugation incorporate a parameter called Σ with units of m^2. For the bowl centrifuge shown above, this parameter can be defined as follows:

$$\Sigma = \frac{V\omega^2 r_2}{S_e g_c}$$

where S_e = thickness of the thin fluid layer passing through the centrifuge
V = bowl volume
r_2 = radius of bowl
ω = angular rotation rate (radians/sec)
g_c = gravitational constant

The term S_e is used in place of an explicit geometric description of the fluid layer thickness in the bowl since this layer is assumed to be extremely thin. Please take this into account and modify your answer from part a to include Σ.

c) Do you think that your answer in part b is general for all centrifuge geometries in which a Σ value is used? What is the meaning of Σ?

Problem 2

A pilot plant disc-stack centrifuge (Alfa Laval Model BTPX 205) is being used for cell harvesting of *E. coli*, which has a diameter of approximately 1 micron. For intracellular product recovery after cell disruption this centrifuge can be used to remove most of the cell debris particles before proceeding to further product purification.

Highly expressed foreign proteins in *E.coli* form inclusion bodies that have a Stoke's diameter of 0.3-0.7 micron and a density of 1.3 g/cm^3. The high density of inclusion bodies allows them to be separated from most cell debris particles using a disk-stack centrifuge. By running the centrifuge at an appropriate throughput, almost all of the inclusion bodies are recovered in the heavy phase of the centrifuge while most of the cell debris particles remain in the light phase.

a) What effective area (Σ) is necessary for *E.coli* recovery if the disk-stack centrifuge throughput is 200 L/hr?

b) At what throughput would you run the centrifuge if you wanted to separate inclusion bodies from cell debris?

Assume that broth viscosity increases by a factor of 2 after cell disruption because of the release of nucleic acids. Please state all of your assumptions.