EN -644 - Two-Phase Flow and Heat Transfer

Assignment -1

1. Starting from the basic definition of x, Show that $x = \dfrac{1}{1 + \dfrac{\rho_l}{\rho_g}\dfrac{1-\alpha}{\alpha}\dfrac{1}{s}}$. Now rearrange the above expression to get $s = \dfrac{x}{1-x}\dfrac{1-\alpha}{\alpha}\dfrac{\rho_l}{\rho_g}$ and $\alpha = \dfrac{xv_g}{xv_g + s(1-x)xv_l}$
2. Show that $\beta = \dfrac{xv_g}{xv_g + (1-x)v_l}$
3. Show that $\dfrac{v_H}{v_l} = \dfrac{1-x}{1-\beta}$.
4. From the definitions, show that $u_g = G\left(xv_g + s(1-x)v_l\right)$ and $u_l = G\left(\dfrac{xv_g + s(1-x)v_l}{s}\right)$. Now proceed to show that if s = 1, $u_g = u_l = u_H = G\left(xv_g + (1-x)v_l\right)$. Now express j_g+j_l in terms of G, v_g and v_l and show that j_g+j_l = u_H, using the definition given above. Note that for steady incompressible flow (ρ_g and ρ_l independent of position) of a mixture of gas and liquid, j_g + j_l is constant at every cross section and hence the volume flux at any cross section is equal to the homogeneous velocity, even if the flow has slip.
5. A bubbly mixture flows in a 25.4 mm pipe. The gas flow rate is 5 X 10^{-4} m^3/s and the bubble velocity was determined photographically to be 30 m/s. What is the void fraction? What is the liquid velocity if the liquid flow is 2.5 litres per second.
6. 130 kg/hr of air at 25 ^oC and 1.5 bar(a) flows together with 130 kg/hr of water at the same temperature in a 32 mm diameter pipe. What is the overall volumetric flux j? If the drift flux j_{gf} is 3 m/s, what are the average velocities of the phases.
7. Steam-water mixture with 1% quality flows at 1 bar(a) in a tube. The measured void fraction is 80%. What is the slip ratio?
8. On a graph of j_2 vs j_1, show lines of constant α, if
   (a) v_1/v_2 = constant
   (b) v_{12} = constant
   (c) j_{12} = constant
   (d) $j_{12} = k\alpha(1-\alpha)^n$
9. What value of α corresponds to a close-packed array of spheres.
10. Water at 70 bar(a) undergoes phase change in a tube. The slip is estimated to be 1.2. Plot the variation of α with x, for 0 < x < 1. Repeat the same if the system pressure is 2 bar (a) and plot it in the same figure. Discuss your result.