ME 3007 – HW 4

1. (For this problem, the cubic root finder given on the web page may prove to be helpful.)
   a. Use the Maxwell construction to find the reduced vapor pressure data (P^{v}_{r}, $v_{f,r}$, and $v_{g,r}$) for a van der Waals fluid at $T_r = 0.4$, 0.7, and 0.9.
   b. Using these results, find Pitzer's acentric factor.
   c. Fit this data to an equation of the Clausius-Clapeyron form ($\ln(Pr) = A - B/Tr$).

2. Prove that, simultaneously:

$$f_1^L(x_1) = f_1^V(y_1)$$
$$f_2^L(x_2) = f_2^V(y_2)$$

   $T = 250$ K, $P = 400$ kPa, $z_1^V = 0.751$, $z_1^L = 0.665$.
   Substance 1: $T_C = 300$ K, $P_C = 1000$ kPa; Substance 2: $T_C = 400$ K, $P_C = 2000$ kPa.
   Use the general form of the fugacity equation:

$$\ln\phi_i = \ln\frac{v_{mix}}{v_{mix} - b_{mix}} + \frac{b_i}{v_{mix} - b_{mix}} - \frac{2\sqrt{a_i}\sum_k z_k\sqrt{a_k}}{v_{mix}R_uT} - \ln Z_{mix}$$
$$\text{where} \quad f_i = \phi_i z_i P_{mix}$$

3. Assuming Raoult's Law and the Antoine saturation pressure equations are valid, calculate the following for a mixture of benzene (1) and toluene (2):

   a. Given $x_1 = 0.33$ and $T = 100^\circ$C, find y_1 and P.
   b. Given $y_1 = 0.33$ and $T = 100^\circ$C, find x_1 and P.
   c. Given $x_1 = 0.33$ and $P = 120$ kPa, find y_1 and T.
   d. Given $T = 100^\circ$C and $P = 120$ kPa, find x_1 and y_1.
   e. For part (d), if the overall mole fraction of benzene is $z_1 = 0.33$, what molar fraction of the two-phase system is vapor?
   f. Why is Raoult's Law likely to be a good VLE model for this system at the stated conditions?