PeGn624 Homework # 18

- Assigned: Wednesday, March 25, 2009
- Due: Thursday, April 2, 2009 in class

1 Numerical Values

Calculate the numerical values of the matrix equations at the initial conditions for the project.

The primary variables are P_o, S_o, T. When $T < T_s$, $S_g = 0$ and T_s is used as the fourth primary variable. When $T \geq T_s$, S_g is used as the fourth primary variable.

1.1 Part (a): Initial Form, $T < T_s$

Calculate the numerical values for A_{11}, A_{12}, R_{11}, R_{12}, R_{13}, R_{14}, and R_{15} defined in Eq. 1.1. Use the initial conditions of $P_o = 500 psia$ and $T_R = 100°F$.

$$
\overbrace{\begin{array}{r}W:\\O:\\E:\\G:\\W:\\O:\\E:\\G:\\W:\\O:\\E:\\G:\end{array}
\left[\begin{array}{cccc|cccc|cccc}
X&0&0&0&X&0&0&0&0&0&0&0\\
X&0&0&0&X&0&0&0&0&0&0&0\\
X&X&0&0&X&X&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0\\ \hline
X&0&0&0&X&0&0&0&X&0&0&0\\
X&0&0&0&X&0&0&0&X&0&0&0\\
X&X&0&0&X&X&0&0&X&X&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0\\ \hline
0&0&0&0&X&0&0&0&X&0&0&0\\
0&0&0&0&X&0&0&0&X&0&0&0\\
0&0&0&0&X&X&0&0&X&X&0&0\\
0&0&0&0&0&0&0&0&0&0&0&0
\end{array}\right]}^{A_{11}=\mathsf{LHS}}
\times
\overbrace{\left[\begin{array}{c}
\delta P_o\\ \delta T\\ \delta S_o\\ \delta T_s\\ \hline
\delta P_o\\ \delta T\\ \delta S_o\\ \delta T_s\\ \hline
\delta P_o\\ \delta T\\ \delta S_o\\ \delta T_s
\end{array}\right]}^{\delta}
-
\overbrace{\begin{array}{r}W:\\O:\\E:\\G:\\W:\\O:\\E:\\G:\\W:\\O:\\E:\\G:\end{array}
\left[\begin{array}{cccc|cccc|cccc}
X&X&X&0&0&0&0&0&0&0&0&0\\
X&X&X&0&0&0&0&0&0&0&0&0\\
X&X&X&0&0&0&0&0&0&0&0&0\\
X&0&X&X&0&0&0&0&0&0&0&0\\ \hline
0&0&0&0&X&X&X&0&0&0&0&0\\
0&0&0&0&X&X&X&0&0&0&0&0\\
0&0&0&0&X&X&X&0&0&0&0&0\\
0&0&0&0&X&0&X&X&0&0&0&0\\ \hline
0&0&0&0&0&0&0&0&X&X&X&0\\
0&0&0&0&0&0&0&0&X&X&X&0\\
0&0&0&0&0&0&0&0&X&X&X&0\\
0&0&0&0&0&0&0&0&X&0&X&X
\end{array}\right]}^{A_{12}=\mathsf{RHS}}
\times
\overbrace{\left[\begin{array}{c}
\delta P_o\\ \delta T\\ \delta S_o\\ \delta T_s\\ \hline
\delta P_o\\ \delta T\\ \delta S_o\\ \delta T_s\\ \hline
\delta P_o\\ \delta T\\ \delta S_o\\ \delta T_s
\end{array}\right]}^{\delta}
=
$$

$$
\overbrace{\left[\begin{array}{c}X\\X\\X\\0\\ \hline X\\X\\X\\0\\ \hline X\\X\\X\\0\end{array}\right]}^{R_{11}=LHS_{P_c}}
+
\overbrace{\left[\begin{array}{c}X\\X\\X\\0\\ \hline X\\X\\X\\0\\ \hline X\\X\\X\\0\end{array}\right]}^{R_{12}=LHS_D}
+
\overbrace{\left[\begin{array}{c}X\\X\\X\\0\\ \hline X\\X\\X\\0\\ \hline X\\X\\X\\0\end{array}\right]}^{R_{13}=LHS_{\text{other}}}
+
\overbrace{\left[\begin{array}{c}X\\X\\X\\0\\ \hline X\\X\\X\\0\\ \hline X\\X\\X\\0\end{array}\right]}^{R_{14}=RHS^n}
+
\overbrace{\left[\begin{array}{c}X\\X\\X\\X\\ \hline X\\X\\X\\X\\ \hline X\\X\\X\\X\end{array}\right]}^{R_{15}=RHS^\ell}
\tag{1.1}
$$

1.2 Part (b): Revised Form, $T < T_s$

Eliminate zeros in A_{12} and adjust all terms in the appropriate rows. Calculate the numerical values for A_{31}, and R_{31} defined in Eq. 1.2. The $X^\star$ represents adjusted values based on eliminating zeros. The $0^\star$ represents the values which have been eliminated. Use the initial conditions of $P_o = 500psia$ and $T_R = 100°F$.

$$
\begin{array}{r}
W: \\ O: \\ E: \\ G: \\ W: \\ O: \\ E: \\ G: \\ W: \\ O: \\ E: \\ G:
\end{array}
\overbrace{\left[\begin{array}{cccc|cccc|cccc}
X^\star & X^\star & 0^\star & 0 & X^\star & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
X^\star & X^\star & 0^\star & 0 & X^\star & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
X & X & X & 0 & X & X & 0 & 0 & 0 & 0 & 0 & 0 \\
X & 0 & X & X & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
\hline
X^\star & 0 & 0 & 0 & X^\star & X^\star & 0^\star & 0 & X^\star & 0 & 0 & 0 \\
X^\star & 0 & 0 & 0 & X^\star & X^\star & 0^\star & 0 & X^\star & 0 & 0 & 0 \\
X & X & 0 & 0 & X & X & X & 0 & X & X & 0 & 0 \\
0 & 0 & 0 & 0 & X & 0 & X & X & 0 & 0 & 0 & 0 \\
\hline
0 & 0 & 0 & 0 & X^\star & 0 & 0 & 0 & X^\star & X^\star & 0^\star & 0 \\
0 & 0 & 0 & 0 & X^\star & 0 & 0 & 0 & X^\star & X^\star & 0^\star & 0 \\
0 & 0 & 0 & 0 & X & X & 0 & 0 & X & X & X & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & X & 0 & X & X
\end{array}\right]}^{A_{31}}
\times
\overbrace{\left[\begin{array}{c}
\delta P_o \\ \delta T \\ \delta S_o \\ \delta T_s \\ \hline
\delta P_o \\ \delta T \\ \delta S_o \\ \delta T_s \\ \hline
\delta P_o \\ \delta T \\ \delta S_o \\ \delta T_s
\end{array}\right]}^{\delta}
=
\overbrace{\left[\begin{array}{c}
X^\star \\ X^\star \\ X \\ X \\ \hline
X^\star \\ X^\star \\ X \\ X \\ \hline
X^\star \\ X^\star \\ X \\ X
\end{array}\right]}^{R_{31}}
\tag{1.2}
$$

1.3 Part (c): Extract Temperature and Pressure, $T < T_s$

Extract the pressure and temperatures from A_{41}. Calculate the numerical values for A_{41}, and R_{41} defined in Eq. 1.3. Use the initial conditions of $P_o = 500psia$ and $T_R = 100°F$.

$$
\overbrace{\left[\begin{array}{cc|cc|cc}
X & X & X & 0 & 0 & 0 \\
X & X & X & 0 & 0 & 0 \\
\hline
X & 0 & X & X & X & 0 \\
X & 0 & X & X & X & 0 \\
\hline
0 & 0 & X & 0 & X & X \\
0 & 0 & X & 0 & X & X
\end{array}\right]}^{A_{41}}
\times
\overbrace{\left[\begin{array}{c}
\delta P_o \\ \delta T \\ \hline
\delta P_o \\ \delta T \\ \hline
\delta P_o \\ \delta T
\end{array}\right]}^{\delta}
=
\overbrace{\left[\begin{array}{c}
X \\ X \\ \hline X \\ X \\ \hline X \\ X
\end{array}\right]}^{R_{41}}
\tag{1.3}
$$

1.4 Part (d): Initial Form, $T \geq T_s$

Calculate the numerical values for A_{11}, A_{12}, R_{11}, R_{12}, R_{13}, R_{14}, and R_{15} defined in Eq. 1.4. Use the conditions of $P_o = 500psia$ and $T = 500°F$.

$$
\overbrace{\begin{array}{r} W: \\ O: \\ E: \\ G: \\ W: \\ O: \\ E: \\ G: \\ W: \\ O: \\ E: \\ G: \end{array}\left[\begin{array}{cccc|cccc|cccc}
X & 0 & 0 & 0 & X & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
X & 0 & 0 & 0 & X & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
X & X & 0 & 0 & X & X & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
\hline
X & 0 & 0 & 0 & X & 0 & 0 & 0 & X & 0 & 0 & 0 \\
X & 0 & 0 & 0 & X & 0 & 0 & 0 & X & 0 & 0 & 0 \\
X & X & 0 & 0 & X & X & 0 & 0 & X & X & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
\hline
0 & 0 & 0 & 0 & X & 0 & 0 & 0 & X & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & X & 0 & 0 & 0 & X & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & X & X & 0 & 0 & X & X & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0
\end{array}\right]}^{A_{11}=\mathsf{LHS}}
\times
\overbrace{\left[\begin{array}{c}
\delta P_o \\ \delta T \\ \delta S_o \\ \delta S_g \\ \hline
\delta P_o \\ \delta T \\ \delta S_o \\ \delta S_g \\ \hline
\delta P_o \\ \delta T \\ \delta S_o \\ \delta S_g
\end{array}\right]}^{\delta}
-
\overbrace{\begin{array}{r} W: \\ O: \\ E: \\ G: \\ W: \\ O: \\ E: \\ G: \\ W: \\ O: \\ E: \\ G: \end{array}\left[\begin{array}{cccc|cccc|cccc}
X & X & X & X & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
X & X & X & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
X & X & X & X & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
X & X & X & X & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
\hline
0 & 0 & 0 & 0 & X & X & X & X & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & X & X & X & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & X & X & X & X & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & X & X & X & X & 0 & 0 & 0 & 0 \\
\hline
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & X & X & X & X \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & X & X & X & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & X & X & X & X \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & X & X & X & X
\end{array}\right]}^{A_{12}=\mathsf{RHS}}
\times
\overbrace{\left[\begin{array}{c}
\delta P_o \\ \delta T \\ \delta S_o \\ \delta S_g \\ \hline
\delta P_o \\ \delta T \\ \delta S_o \\ \delta S_g \\ \hline
\delta P_o \\ \delta T \\ \delta S_o \\ \delta S_g
\end{array}\right]}^{\delta}
=
$$

$$
\overbrace{\left[\begin{array}{c} X \\ X \\ X \\ 0 \\ \hline X \\ X \\ X \\ 0 \\ \hline X \\ X \\ X \\ 0 \end{array}\right]}^{R_{11}=LHS_{P_c}}
+
\overbrace{\left[\begin{array}{c} X \\ X \\ X \\ 0 \\ \hline X \\ X \\ X \\ 0 \\ \hline X \\ X \\ X \\ 0 \end{array}\right]}^{R_{12}=LHS_D}
+
\overbrace{\left[\begin{array}{c} X \\ X \\ X \\ 0 \\ \hline X \\ X \\ X \\ 0 \\ \hline X \\ X \\ X \\ 0 \end{array}\right]}^{R_{13}=LHS_{\text{other}}}
+
\overbrace{\left[\begin{array}{c} X \\ X \\ X \\ 0 \\ \hline X \\ X \\ X \\ 0 \\ \hline X \\ X \\ X \\ 0 \end{array}\right]}^{R_{14}=RHS^n}
+
\overbrace{\left[\begin{array}{c} X \\ X \\ X \\ X \\ \hline X \\ X \\ X \\ X \\ \hline X \\ X \\ X \\ X \end{array}\right]}^{R_{15}=RHS^\ell}
\qquad (1.4)
$$

1.5 Part (e): Revised Form, $T \geq T_s$

Eliminate zeros in A_{12} and adjust all terms in the appropriate rows. Calculate the numerical values for A_{31}, and R_{31} defined in Eq. 1.5. The $X^\star$ represents adjusted values based on eliminating zeros. The $0^\star$ represents the values which have been eliminated. Use the conditions of $P_o = 500 psia$ and $T = 500°F$.

$$
\begin{array}{r}
W: \\ O: \\ E: \\ G: \\ W: \\ O: \\ E: \\ G: \\ W: \\ O: \\ E: \\ G:
\end{array}
\overbrace{\left[\begin{array}{cccc||cccc||cccc}
X^\star & X^\star & 0^\star & 0^\star & X^\star & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
X^\star & X^\star & 0^\star & 0 & X^\star & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
X^\star & X^\star & X^\star & 0^\star & X^\star & X^\star & 0 & 0 & 0 & 0 & 0 & 0 \\
X & X & X & X & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
\hline\hline
X^\star & 0 & 0 & 0 & X^\star & X^\star & 0^\star & 0^\star & X^\star & 0 & 0 & 0 \\
X^\star & 0 & 0 & 0 & X^\star & X^\star & 0^\star & 0 & X^\star & 0 & 0 & 0 \\
X^\star & X^\star & 0 & 0 & X^\star & X^\star & X^\star & 0^\star & X^\star & X^\star & 0 & 0 \\
0 & 0 & 0 & 0 & X & X & X & X & 0 & 0 & 0 & 0 \\
\hline\hline
0 & 0 & 0 & 0 & X^\star & 0 & 0 & 0 & X^\star & X^\star & 0^\star & 0^\star \\
0 & 0 & 0 & 0 & X^\star & 0 & 0 & 0 & X^\star & X^\star & 0^\star & 0 \\
0 & 0 & 0 & 0 & X^\star & X^\star & 0 & 0 & X^\star & X^\star & X^\star & 0^\star \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & X & X & X & X
\end{array}\right]}^{A_{31}}
\times
\overbrace{\left[\begin{array}{c}
\delta P_o \\ \delta T \\ \delta S_o \\ \delta S_g \\ \hline\hline
\delta P_o \\ \delta T \\ \delta S_o \\ \delta S_g \\ \hline\hline
\delta P_o \\ \delta T \\ \delta S_o \\ \delta S_g
\end{array}\right]}^{\delta}
=
\overbrace{\left[\begin{array}{c}
X^\star \\ X^\star \\ X^\star \\ X \\ \hline\hline
X^\star \\ X^\star \\ X^\star \\ X \\ \hline\hline
X^\star \\ X^\star \\ X^\star \\ X
\end{array}\right]}^{R_{31}}
\tag{1.5}
$$

1.6 Part (f): Extract Temperature and Pressure, $T \geq T_s$

Extract the pressure and temperatures from A_{41}. Calculate the numerical values for A_{41}, and R_{41} defined in Eq. 1.3. Use the conditions of $P_o = 500 psia$ and $T = 500°F$.