Drawn below is a small water distribution system. Determine the flowrate in each pipe (gpm) and the pressure at each node (psi). Use the Hazen-Williams equation in your calculations. Explicitly state all assumptions and reference sources for parameter values not written here. (50 points)

Hazen-Williams Eqn:

\[ Q = 0.285 \, C \, D^{2.63} \left( \frac{H_f}{L} \right)^{0.54} \], for \([Q] = \text{gpm}, [D] = \text{in}, [H_f, L] = \text{ft}\]

\( HGL_{\text{Tank}} = 75 \, \text{ft} \)

\( Z_A = 62 \, \text{ft} \quad Dem_A = 10 \, \text{gpm} \)

\( Z_B = 63 \, \text{ft} \quad Dem_B = 26 \, \text{gpm} \)

\( Z_C = 82 \, \text{ft} \quad Dem_C = 15 \, \text{gpm} \)

\( Z_D = 93 \, \text{ft} \quad Dem_D = 55 \, \text{gpm} \)

Pipe 1: 550 ft, cast iron, 4 in
Pipe 2: 400 ft, galvanized iron, 1.5 in
Pipe 3: 300 ft, galvanized iron, 1 in
Pipe 2: 200 ft, PVC, 3 in

Pump characteristic curve: \( E_p = -0.0012 \, Q^2 - 0.125 \, Q + 175; \quad [E_p] = \text{ft}, [Q] = \text{gpm} \)
{Work space for #1}
2. For the WDS in problem 1, *do all necessary work to setup the first iteration of the Gradient Method solution for flows and heads in this network*. Your final answer should be the matrix equation:

\[
\begin{bmatrix}
\frac{n}{A_{11}} & A_{12} \\
A_{21} & 0
\end{bmatrix}
\begin{bmatrix}
\Delta Q \\
\Delta H
\end{bmatrix}
= 
\begin{bmatrix}
-dE \\
-dq
\end{bmatrix}
\]

with all matrices fully written out including numerical values where possible. That is, your final answer should look something like:

\[
\begin{bmatrix}
3 & 0 & 0 \\
1 & 2 & -1 \\
0 & 1 & 1
\end{bmatrix}
\begin{bmatrix}
\Delta Q_1 \\
\Delta Q_2 \\
\Delta H_1
\end{bmatrix}
= 
\begin{bmatrix}
21.3 \\
-9.6 \\
-0.53
\end{bmatrix}
\]

You should continue to use the Hazen-Williams equation for pipe flow head loss.

(50 points)
{Work space for #2}