2. (30 pts) Specialized Analysis of Wellbore Storage Distorted Data

These data are taken from Example 2.2 in the Lee text, *Well Testing*. These data were obtained from a "pressure buildup" test following a constant rate "drawdown" sequence performed on an oil well. Wellbore storage and skin effects are exhibited in these data.

*Reservoir properties:*
\[ \phi = 0.039 \quad r_w = 0.198 \text{ ft} \quad c_t = 17 \times 10^{-6} \text{ psia}^{-1} \quad h = 69 \text{ ft} \]

*Oil properties:*
\[ B_o = 1.136 \text{ RB/STB} \quad \mu_o = 0.8 \text{ cp} \]

*Production parameters:*
\[ p_{wf}(\text{at } \Delta t=0) = 3534 \text{ psia} \quad q_o = 250 \text{ STB/D} \quad t_p = 13,630 \text{ hr} \]

*Test Data and Data Functions: (m_{wbs} = 975 psi/hr)*

<table>
<thead>
<tr>
<th>( \Delta t, \text{ hr} )</th>
<th>( p_{w, \text{psia}} )</th>
<th>( \Delta p_w, \text{ psi} )</th>
<th>( \Delta p_w', \text{ psi} )</th>
<th>( dp_w/d\Delta t, \text{ psi/hr} )</th>
<th>( \Delta t_c, \text{ psi} )</th>
<th>( \Delta p_s, \text{ psi} )</th>
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</table>

All analyses must be performed on the \( \Delta t_c \) and \( \Delta p_s \) data functions (do not use the \( \Delta t\text{-}\Delta p_w \) data).
Required: Specialized Analysis of Wellbore Storage Distorted Data
You are required to "correct" these wellbore storage distorted test data (i.e., the Δp_w data) using the following relations: (m wbs is the slope of the Δp_w versus Δt data plot (ETR_j data only))

a. The corrected time function (Δt_c): (to be used like Δt)

\[
Δt_c = \frac{Δt - \frac{1}{m_wbs} Δp_w}{1 - \frac{1}{m_wbs} \frac{d}{dΔt}[Δp_w]}
\]

b. The corrected pressure drop function (Δp_s): (to be used like Δp_w)

\[
Δp_s = \frac{Δp_w}{1 - \frac{1}{m_wbs} \frac{d}{dΔt}[Δp_w]}
\]

Specifics:

a. You are to calculate and plot the Δt_c and Δp_s functions.

b. You are to perform a complete analysis of the Δt_c and Δp_s functions using a semilog plot of Δp_s versus log(Δt_c). It is important to note that the Δp_s - Δt_c correction approach does not tend to work well for the very earliest data.

c. You are to describe your analysis/interpretation and results in a summary paragraph.

Results: Specialized Analysis of Wellbore Storage Distorted Data

Cartesian Analysis: Early Time Data

Slope of the Δp_w versus Δt data plot (ETR_j data), m_wbs = \text{975 psi/hr}

Semilog Analysis:

Formation permeability, k = \text{7.65 md}

Near well skin factor, s = \text{5.79}

Summary Observations/Comments:

1. The early time data do not match the semilog straight line.
Cartesian Plot: Early-Time Pressure Data (Lee Ex. 2.2)

"Early Time" Cartesian Plot -- Lee Text Example 2.2
(Analysis of Wellbore Storage Dominated Data)

Regression Equations:
Wellbore Storage Equation:
\[ p_{w} (\Delta t) = 3534 + 973.33 \Delta t \]

Legend: Lee Text Example 2.2
- Pressure Data

Data for Lee Example 2.2:
Reservoir Properties:
- \( c = 17.0 \times 10^6 \) psi \(^{-1}\)
- \( r_w = 0.198 \) ft
- \( h = 69 \) ft
- \( \phi = 0.039 \) (fraction)
- \( k = 7.65 \) md
- \( s = 5.79 \)

Oil Properties:
- \( B_o = 1.136 \) RB/STB
- \( \mu_o = 0.8 \) cp

Production Parameters:
- \( q_p = 250 \) STB/D
- \( t_p = 13,630 \) hrs
- \( p_{w} (\Delta t = 0) = 3534 \) psia

Linear Portion Indicates Wellbore Storage Domination

**p_{w} (\Delta t = 0) = 3534 \text{ psia}**
Semilog Plot: Pressure Data (Lee Ex. 2.2)

Semilog Plot -- Lee Text Example 2.2
(Summary of Average Reservoir Pressure Methods)

Legend: Lee Text Example 2.2
- Pressure Data
- Corrected Data

Data for Lee Example 2.2:
Reservoir Properties:
- $c_f = 17.0 \times 10^{-6} \text{ psia}^{-1}$
- $r_w = 0.198 \text{ ft}$
- $h = 69 \text{ ft}$
- $\phi = 0.039$ (fraction)
- $k = 7.85 \text{ md}$
- $s = 5.79$

Oil Properties:
- $B_o = 1.136 \text{ RB/STB}$
- $\mu_o = 0.8 \text{ cp}$

Production Parameters:
- $q_o = 250 \text{ STB/D}$
- $t_f = 13,630 \text{ hrs}$
- $P_{wf}(\Delta t = 0) = 3534 \text{ psia}$

Wellbore Storage Effects

Radial Flow Region

$m = 70 \text{ psi/cycle}$

$P_{wf}(\Delta t = 1 \text{ hr}) = 4287.6 \text{ psia}$ (Radial Flow Trend)